ENGINEERING PROFESSIONAL APPRENTICESHIP CAREER TRACT (E-PACT) & BASIC ENGINEERING COMMON CORE ADVANCED (BECC ADVANCED)
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To accomplish any mission safely and successfully, every ship needs qualified personnel. Because Sailors transfer or discharge often, it is essential to have qualified personnel ready to assume the responsibilities of these Sailors at a moment’s notice. In addition, a fully qualified command shares the workload among its personnel more efficiently.

Terminal Objective - Use the Personnel Qualification Standards or P.Q.S. book to become qualified for various jobs on the ship.
- Enabling Objective - Identify the purpose and general provisions of Personnel Qualification Standards.
- Enabling Objective - Differentiate among the parts of the P.Q.S. book.
- Enabling Objective - Identify the P.Q.S organization.

PURPOSE AND PROVISION OF THE PQS PROGRAM
The Personnel Qualification Standards (PQS) program is not a training program, but rather a qualification program designed to help officer and enlisted personnel obtain the minimum level of skill required to perform specific duties. This program also helps you learn new concepts about individual ratings, which can increase your chances for advancement. It also ensures personnel demonstrate the minimum knowledge and skills necessary to be qualified to stand watches or perform other specific routine duties. These watches and duties are necessary for the safety, security, or proper operation of a ship or system. It standardizes qualification requirements for all Sailors. A completion date is given and progress is tracked by the work center training petty officer. Progress is reported weekly via your chain of command to the division officer. Sailors must obtain signatures from designated qualifiers after demonstrating knowledge and/or completing certain tasks. Completion of all line items for a specific watch station is a prerequisite for the associated written and/or oral test. After successful completion of any and all tests that are required you will be recommended by the chain of command for qualification. The Commanding Officer (CO) or his/her designated representative will endorse your qualification. Qualifications allow you to be assigned to a position on a watch team and contribute to the mission of the ship. The program places the responsibility for learning in your hands.

PQS BOOK
Each book is designed to guide trainees toward qualification by telling them exactly what they must learn to achieve that goal. It is a crucial part of the program. It contains: Table of Contents (TOC), Acknowledgements, Introduction, Summary of changes, Watch-station re-qualifications, Acronyms, Fundamentals (100 section), Systems (200 section), Watch-stations (300 section), Qualification progress summary, References, and Feedback form.

- The Table of Contents (TOC) page, like in any manual or publication, is a map to the information contained inside that book. This TOC contains all the elements of the PQS book.
- The Introduction page is designed to briefly explain the purpose and provisions of the PQS program, who is involved, and the level of their involvement. It gives a brief explanation of the content within.
- The Summary of Changes page describes the change history of the document. It lists any changes, including content changes due to modifications to equipment, operating procedures, and publication changes driven by safety or efficiency issues. An immediate interim change requires that all applicable publications are denoted with the change message and correctly marked. An errata change only affects any publications printed in the future.
- Section 100 (Fundamentals) contains the fundamental, or basic knowledge, principles, and vocabulary needed to understand the specific equipment or duties required by the watch-stations. This section serves as a great self-study section.
- Section 200 is about systems and builds on what you have learned in Section 100. It describes systems important to this watch-station and breaks the system into components. Sometimes these components are further broken down into parts. This section only lists the items that are required for proper operation and/or maintenance of the system. Learning how equipment functions helps identify and understand potential problems before they occur.
- Section 300 guides Sailors in categorizing, analyzing, and performing the step-by-step procedures required to qualify for a watch-station. It helps demonstrate knowledge gained from the previous two sections and also contains the time and total points required to complete each watch-station. Your Chain of Command establishes the time allowed for you to qualify.

After successful completion of all line items and applicable tests, you are eligible for qualification, using the Final Qualification page. Your Chain of Command routes this page for eventual approval by the Commanding Officer, or his/her designated representative. The practical sections are as follows:
- Prerequisites – Items that must be completed before you begin this watch-station. These can include particular schools, Section 100 (Fundamentals) items, Section 200 (Systems) or possible other watch-stations.
- Tasks – These are the tasks you need to complete to become qualified in this watch-station.
- Infrequent Tasks – Just as the name implies, any infrequent tasks associated with the watch-station are contained here.
- Abnormal Conditions – Abnormal conditions must be addressed to help you understand the procedures in dealing with them.
- Emergencies – This section covers possible emergencies that you may encounter in the performance of this watch-station.
- Watches – This section lists the watches you are required to perform for qualification.
- Examinations – If required, either written, oral, or both types of examinations may be given.

ORGANIZATION
The PQS program takes many people and processes to ensure the smooth operation of the system and ship. The Final Qualification page documents the required signatures needed for qualification. This document requires signatures from your Supervisor, Division Officer/CPO, Department Head, and Commanding Officer before a service record entry is made and you become qualified on that particular watch-station.
- Qualifier – are experts in a specified area of qualification and designated in writing by the CO to sign off on specific watch-stations. They normally hold the rank of E-5 or above and, as a minimum, must have completed the PQS they are authorized to sign off.
- Work Center Supervisor – The supervisor indoctrinates the trainee to the program and recommends and monitors the goals for that individual.
- Division Officer/CPO – Coordinates with the Division Chief Petty Officer to establish PQS goals, monitors PQS progress weekly, and verifies appropriate service record entries.
- Department Head – Supervises the execution of the PQS program within the entire department.
- PQS Coordinator – The PQS Unit Coordinator serves as the point of contact within the command on all matters of PQS administration.
- Executive/Training Officer – Acts as an overall training supervisor and monitors the PQS Program through the PQS Coordinator.
- Commanding Officer – The final qualification authority for the command.
BECC 2.0 Student Workbook

BECC 10
SAFETY FUNDAMENTALS

The Navy has taken great measures to help protect you from injury. This lesson provides you information to preserve your sight, hearing, and respiratory system. The Navy has unmatched hearing conservation, sight conservation, and respiratory protection programs. It is important that you are able to identify the purpose, requirements, equipment used, and responsibilities of each of these programs, so that you can preserve your health while working in hazardous environments.

Terminal Objective - Recognize Hearing, Sight, and Respiratory Conservation Programs and the relevant safety protection devices.

- Enabling Objective – Identify the purpose of the Hearing Conservation Program and training requirements.
- Enabling Objective – Identify hearing test requirements.
- Enabling Objective – Identify actions to be taken for a Significant Threshold Shift (STS).
- Enabling Objective – Identify basis for mandatory use of hearing protection devices.
- Enabling Objective – Identify noise hazardous areas and equipment.
- Enabling Objective – Identify the elements and training requirements for the Sight Conservation Program.
- Enabling Objective – Identify organizational responsibilities of the Shipboard Sight Conservation Program.
- Enabling Objective – Identify the various types and uses of respiratory protective equipment.

PURPOSE OF HEARING CONSERVATION PROGRAM

It is important to have a firm understanding of hearing conservation, because it assures auditory fitness among all Navy personnel. The Hearing Conservation Program provides training that is invaluable to you at work and at home by helping you to preserve your hearing. Sometimes, hearing problems develop as a result of our work environment if precaution is not taken. These environments include potentially hazardous noise levels from many sources such as, engine room operations, main machinery, deck preservation tasks, and carrier deck operations.

The purpose of the Hearing Conservation Program is to prevent occupational noise related hearing loss and to maintain a combat ready fleet. All Navy personnel assigned to duties in potentially hazardous noise environments are covered under this program.

The Hearing Conservation Program consists of:

- Surveying work environments to identify potentially hazardous noise levels and personnel at risk.
- Modifying the environment (workstation) and equipment where technologically and operationally feasible.
- Employing administrative controls including the use of hearing protective devices.
- Periodic hearing testing, and education/training.

You will receive training prior to working in noise hazardous areas or with noise hazardous equipment to ensure the program is effective. Additionally, you receive appropriate refresher training annually. Your training records are maintained by both the work center and the safety office. The Hearing Conservation Program has several training requirements in place to prevent hearing loss.

HEARING TEST REQUIREMENTS

Upon entry into Naval Service, there are hearing test requirements that every sailor must receive. Sailors that do not have a reference audiogram filed in their health record are not assigned to duty in a designated hazardous noise area; therefore, all military personnel receive a reference hearing test. It is important for you to be able to identify hearing test requirements to understand how significant changes in hearing capability are determined. You should have already received a hearing test upon entry into the Navy. This establishes your baseline or initial hearing capability. A subsequent test is conducted annually while in the Hearing Conservation Program and anytime you are experiencing hearing difficulties. The Hearing test performed at Military Entrance Processing Stations (MEPS) is not used as a reference hearing test.

You also receive a hearing test upon termination of service. Significant hearing loss can greatly diminish some of the things you enjoy the most, such as the ability to hear your favorite music or the simple act of communicating with a friend or family member. Hearing loss can also limit the careers you pursue once you leave the Navy.

ACTIONS TO TAKE FOR SIGNIFICANT THRESHOLD SHIFTS (STS)

A Significant Threshold Shift (STS) is a change of 15 decibels (dB) or greater at any test frequency from 1000 to 4000 Hz in either ear or a change in hearing averaging 10 dB or more at 2000, 3000 and 4000 Hz in either ear as compared to baseline audiogram. An STS implies that the hearing protective equipment used may be inadequate to protect your hearing. Therefore, physical exclusion may be required. Physical exclusion is referred to as auditory rest. If your annual audiogram shows a STS, the medical department will take the appropriate actions.

Hearing test monitoring is conducted to track program effectiveness and to detect the onset of an STS. An annual test is administered to all personnel assigned to duties in designated noise hazardous areas and personnel operating noise hazardous equipment. Early detection is the Navy’s goal. The Navy has designed the Detailed Surveillance Program with your hearing in mind. It was designed to prevent progressive hearing loss and optimize auditory fitness for duty. The Detailed Surveillance Program accomplishes the following:

- Discovers reason for STS.
- Recommends a course of action.
- Determines best interest of the Navy and the individual.

If the annual audiogram shows a significant threshold shift toward deteriorated hearing, then the individual must be re-tested following at least 14 hours of exclusion from noise levels in excess of 80 dB. If the second follow-up test continues to show STS relative to the reference audiogram, the health care provider will refer the individual for diagnostic evaluation or consultation with an audiologist.

MANDATORY USE OF HEARING PROTECTION DEVICES

Every Sailor is issued a set of earplugs. You must always wear single hearing protection protective devices, if you enter or work in an area where continuous noise levels are 84 dB (or greater) and/or impulse/impact noise levels are 140 dB or greater. Protection is even more vital when you are exposed to continuous noise levels that exceed 104 dB. In these areas is mandatory to wear a combination of insert type and circumaural type hearing protective devices (double hearing protection).
NOISE HAZARDOUS AREAS AND EQUIPMENT

To conserve your hearing, many parts of the ship are designated Noise Hazard Areas and are visibly marked with warning labels. It is important to become familiar with hazardous noise warning labels and decals displayed outside work areas and on equipment, so that you are aware of which precautions to take to protect your hearing. Hazard labels are found in areas and on equipment where noise levels or, sound pressure levels, exceed more than 84 dB and peak at 140 dB. Normally, labels are posted on the outside of doors and hatches leading into a noise hazardous area. Labels cannot be posted in and around weather surfaces of a ship. Instead, if these particular areas are deemed a hazardous noise area, labels are placed on the inside of the weather deck door or hatch.

Hazardous noise areas are those areas designated by a professional who assesses environmental hazards in the workplace that could cause injury, also known as an industrial hygienist, or occupational audiologist based on the following criteria:

- The work area has a continuous or intermittent sound level that is routinely great than 84 dB.
- The work area has impulse or impact noise routinely exceeding 140 dB.
- Hazardous noise area, heavy equipment, and hand tools, are labeled with the same warning.

The following general warning sign is posted in noise hazardous areas, on tools, and on other equipment: “HAZARDOUS NOISE AREA – HEARING PROTECTION REQUIRED”. Displaying hazardous noise warning labels and decals in the area and on equipment is very important. Around the ship, sounds can reach pressure levels of greater than 84 dB and peak at 140dB. These sounds can result in significant hearing loss when you are not protected.

ELEMENTS AND TRAINING REQUIREMENTS FOR THE SIGHT CONSERVATION PROGRAM

Many eye injuries are not repairable, but all are preventable. It is important to ensure you are equipped with the proper equipment and trained to protect your eyesight. It is up to not only you, but also your command to take the proper precautions to protect your eyesight. If you have ever gotten something like a grain of sand in your eye, think back to how painful it was. Now consider battery acid or a molten chunk of steel entering your eye. These types of eye injuries are usually preventable by following the Sight Conservation Program. Every command is required to have a working Sight Conservation Program in effect. Each command in the Navy requires a slightly different program, but all sight conservation programs must contain the same basic elements.

Each command implements a sight conservation program that determines eye hazardous areas, processes, and operations. Once an area or activity is found to be a possible eye hazardous zone, the area, tool, or station, receives an eye hazardous warning label. Each command is responsible for issuing and maintaining sight protective equipment and installing emergency eyewash facilities. Each local command determines the procedure for use and application of temporary eyewear. Finally, your command ensures you are properly trained and adhere to the prescribed Sight Conservation Program.

You received an eyesight screening test while at MEPS and more eye tests are ahead. Shore based medical facilities are a crucial element of all sight conservation programs. Normally, prescription protective eyewear is obtained through medical support activities. The Navy Supply System may be used to obtain refractive services and prescription safety lenses in cases of operational necessity. If you require corrective eye protection, it is issued to you and becomes your responsibility to maintain and keep from command to command. It is your responsibility to keep your corrective eyewear in operational condition. All personnel receive an additional eye test prior to exposure in eye-hazardous processes and operations or when exposed because of an emergency onboard.

Training and constant evaluation are key to an effective Sight Conservation Program in order to keep all shipboard personnel up to date on how to protect their sight and to keep the program effective. Within the initial arrival and update training, you receive information on the types of eye hazards found onboard your ship and of course, the type of eye protection required for each hazard. Based upon the command, the training highlights the work center supervisor’s and crewmembers responsibilities in protecting your eyesight. Additionally, your training includes effective first aid procedures and eyewash locations and usage. Wearing your eye protective devices ensures you never feel the pain of hot metal slicing your eyeball.

Protective eyewear is required in areas designated by yellow signs with black letter stating (CAUTION, Eye Protection Required in This Area). The deck around an immediate eye hazard is marked with a 3-inch black and yellow striped or checkerboard tape. Sailors requiring corrective lenses, also wear plano, goggles, or face shields, while awaiting arrival or replacement of proper corrective lens protective eyewear. Any Sailor working near an eye hazardous activity must also wear sight protective gear, even if he or she is not actively involved with the task.

ORGANIZATIONAL RESPONSIBILITIES OF THE SIGHT CONSERVATION PROGRAM

-Commanding Officer ensures an effective Sight Conservation Program is established and followed within his/her command.
-Safety Officer evaluates areas and processes for sight hazards. If in doubt, the officer enlists the assistance of an Industrial Hygienist to help identify eye hazards. The Safety Officer maintains a listing of hazardous areas or processes, which require eye protection, and/or eyewash stations. The Safety Officer ensures the Sight Conservation Program is followed and maintains records of any eye injuries occurring within the command. Additionally, the Safety Officer periodically evaluates the Sight Conservation Program for effectiveness.
-Medical officer or medical department representative oversees sight screening examination and refractive services. The message of sight conservation comes down from the highest ranks in the Navy. They must ensure that all areas identified as sight hazardous are properly marked and must verify the availability and use of proper eye protective devices. The best eye protection devices in the world are of little use without proper maintenance and training.
-Department Heads and Division Officers ensure that you receive specific training in the need for and the care of protective eyewear. In addition, they ensure you understand the proper procedures for an eyewash station, just in case you or a shipmate fall victim to careless eye protection. Your Department Heads and Division Officers also ensure the eyewash stations receive scheduled Planned Maintenance System (PMS) checks as required.

All Hands must comply with eye hazardous warning labels by properly wearing assigned sight protective equipment when in eye hazardous areas or performing eye hazardous evolutions. You must also undergo sight tests when directed. Eye protection is used to keep foreign objects, chemical splashes, or UV light out of your eyes. Some shipboard activities requiring eye protection are handling hazardous materials, using portable power tools, shipping, caulking, brazing, cutting, and welding.
When grinding—mon tasks and not restricted by a proper respirator for the onally, the user must active equipment so that rece worn by y important to protect des of boilers, or using sanding equipment, tibility of eye health hazards air is specifically tested and certified to meet ensure the air that enters your lungs is approved Grade D air. Breathing air must meet at least the minimum requirements for Grade D breathing air. Grade D is clean and pressure (LP) air system. The ship's low pressure air system is not suitable for breathing unless i.

Along with selecting the proper respiratory device for the task at hand, you must also identify some criteria concerned with using the ship’s low pressure (LP) air system. The ship’s low pressure air system is not suitable for breathing unless it is specifically tested and certified to meet purity standards. Breathing air must meet at least the minimum requirements for Grade D breathing air. Grade D is clean and pure air that has been certified for use in breathing devices such as scuba diving tanks and SCBAs. To breathe air from the LP system can cause injury; always ensure the air that enters your lungs is approved Grade D air.
While working aboard ship, you will be exposed to many hazards that can injure you. The Navy supplies Personal Protective Equipment (PPE) to keep you safe from these hazards. The PPE program provides you with procedures and provisions for the use of this equipment. By using PPE properly, you greatly reduce your chances of injury. It cannot be overstressed; to keep a safe working environment use the supplied PPE.

**Terminal Objective** - Identify the purpose and use of Personal Protective Equipment.

- **Enabling Objective** - Identify the various types of Personal Protective Equipment.
- **Enabling Objective** - Identify the use of Personal Protective Equipment.

**PPE TYPES**

**Use PPE to keep you safe for every job and every part of the body.** You will use different types of PPE every day, so it is very important that you understand all the particular equipment and what parts of the body each protect. This will help you select the right PPE for the right job.

Head protection in the form of helmets and hard hats, depending on the type and usage; help protect your head from short duration flame exposure, heat, impact of falling and flying objects, impact with low overheads, and on a limited basis, from electric shock and burn. Certain evolutions such as: underway replenishment; when the ship is in the shipyard; and battle conditions require mandatory use of these types of headgear.

Hearing protection is provided and it is required to be worn. The Navy provides hearing protection and has a double hearing protection requirement in certain areas, above 104 dB (decibels). This consists of an insert type and a circumaural (muff) type hearing protection, worn simultaneously. The common types of hearing protection are:

- **Insert type** – These hearing protection devices are worn in the ear, and are comprised of two basic types: personal insert type and the disposable foam type. Both are designed for prolonged wear with comfort and are also both used inside the ear in concert with the circumaural type to satisfy the double hearing protection requirement.

- **Circumaural (muff) type** – These are worn over the ears, with an attaching strap across the top of the head. You will wear these over your ears with an insert-type worn in your ears for double hearing protection. The wearing of glasses may interfere with the proper fit of the ear pieces.

- **Ear cap type** – These hearing protection devices feature an easy-to-use set of ear caps, joined by a headband. Although they are easy to carry and put on, they may become uncomfortable during prolonged use. These can only be used independently.

Eye protection is supplied to keep your vision safe. Eye injuries are largely preventable and that is the most important reason to use the correct eye PPE for the conditions. Eye protection is used to keep foreign objects, chemical splashes, or UV light out of the eyes.

- **Safety Glasses** - The most commonly used form of eye protection; they keep foreign objects out of your eyes.

- **Welding Goggles and Helmets** - These devices prevent the high intensity UV light discharged by welding and brazing from causing flash burns on your eyes. They also protect from flying debris.

- **Chemical Goggles** - These goggles protect your eyes from harmful liquids, splashes, mists, and sprays.

- **Face Shield** - The face shield protects your face and neck from flying debris and liquids. They must be worn with goggles to provide adequate eye protection.

- **Chipping Goggles** - These goggles protect your eyes from large flying debris generated from machining metal parts, grinding tools, or chiseling metal.

Respirators protect your nasal passages and lungs from harmful contaminants. When working in spaces where harmful gas, vapor, dust, or mist is generated, such as cleaning, painting, and sanding, wear a respirator. Additionally, you need to complete an initial and an annual fit-test to ensure that you understand the correct way to wear a respirator and that you are using the correctly sized respirator.

- **Self-Contained Breathing Apparatus (SCBA)** - Allows you to be totally independent from a stationary air source. It is a compressed air cylinder, worn on the back and part of an integral harness, which supplies breathing air. It is similar to the respirator that civilian fire fighters and divers use.

- **Supplied Air Respirator** - Also known as a continuous flow airline respirator provides breathable air from a stationary source.

- **Air Purifying Respirator** - These respirators use filters, cartridges, or canisters to remove particulate contamination from inhaled air. The air purifying respirator cannot be used in oxygen deficient spaces, as it supplies no oxygen, but instead, purifies the existing air. The cartridges are color coded for the type of contaminant they remove. These also include dust masks for some evolutions.

A variety of clothing protects you in many ways such as protecting you from burns, preventing falls, and keeping you afloat.

- **Working Uniforms** - The working uniform protects your body from incidental contact with sharp objects and very brief periods of heat.

- **Coveralls** - Like the working uniform, the standard coveralls protect your body from incidental contact with sharp objects and very brief periods of heat. Flame-retardant coveralls are required for work in engineering spaces, and differ significantly from the standard coveralls.

- **Rubber Aprons** - A rubber apron protects your body from burns caused by corrosive chemicals.

- **Life Preservers** - These buoyancy devices protect you from drowning. Ship evolutions that require the use of life preservers include working over the side, heavy weather operations, replenishment at sea, or working in small boats. They are available in many different varieties. One type is inherently buoyant, while the MK-1 type (float coat) is inflatable.

- **Safety Harnesses** - A safety harness prevents you from falling while working aloft, over the side, and anywhere where adequate porting and handholds are not present.

- **Anti-Flash Hood and Gloves** - Anti-flash clothing protects personnel from transient, elevated air temperatures resulting from the use of high explosive weapons and from burns caused by fire. The importance of protecting personnel from burns caused by weapons explosions or fire is a lesson learned from combat action.

Because of the amount of time you are going to be working with your hands, gloves become a major component of PPE usage. There are three types of gloves that are provided to keep your hands and fingers safe.

- **Leather Gloves** - Leather gloves protect your hands from sharp objects, molten metal, and other hazards. Use these gloves when handling sharp objects, welding, or working around hot steam lines.

- **Chemical Gloves** - Chemical gloves protect your hands from chemical burns that can occur when handling acids and other harmful chemicals.

- **Electrical Gloves** - Electrical gloves protect you from electrical shock when using portable electrical tools or performing electrical maintenance.
Working around heavy loads requires special protection for your feet. Safety shoes, also known as steel-toed boots, have steel inserts in them covering the toes. This prevents crushing or amputation injuries to the toes and feet. You are required to wear them when working in machinery spaces, main decks, flight decks, and when handling stores.

**PPE USAGE**

Many situations aboard ship require the use of PPE. Due to a variety of different situations that present unique hazards, different types of protection are required to stay safe. Not only must you choose the correct PPE, but also wear it in the correct manner, adhering to all safety precautions.

While working aloft or over the side, personnel always wear full-body safety harnesses to prevent serious injury or death. Working aloft is defined as working on any mast or other structure where the possibility for a fall exists, and there are not sufficient walkways, railings, or handholds. Working over the side refers to working over the side of the ship where a possibility exists to fall into the water, lower deck, or sponson.

Before handling a hazardous material, check the Material Data Safety Sheet (MSDS) for the important safety precautions and required PPE. When you handle hazardous materials, keep safety in mind at all times. Wear the proper PPE for the material, as listed by the MSDS sheet. Avoid prolonged exposure to any hazardous material.

Working with electrical or electronic equipment is a dangerous job. Obey all warning signs and labels, wear electrical grade rubber gloves, and ensure all installed electrical equipment is de-energized and tagged out before maintenance is performed. When using portable electric tools, wear leather gloves when working with sharp objects, along with safety goggles, glasses or a face shield for face and eye protection. Additionally, when using portable electric tools in hazardous areas, (e.g., wet decks, bilge areas, etc.) you will wear electrical rubber gloves. Utilize a rubber mat whenever working on energized electrical equipment to isolate you from ground.

Painting is an ever-present evolution aboard ship. Use the appropriate respirator for the type of paint and the environment in which you are painting. For instance, when spray painting in confined spaces, you must wear a supplied-air respirator; however, in some ventilated spaces, an air-purifying respirator is acceptable. Follow the provisions of the MSDS sheet for the product you are working with. Always provide adequate ventilation.

During replenishment at sea evolutions, a variety of hazards exist requiring unique protection. All personnel at fueling stations wear the proper clothing, helmets, and life jackets. Again, it is not only important to identify the appropriate protective gear, but to wear it correctly. Heavy weather and the accompanying rough sea state require specific PPE. Strong winds and large swells mandate the usage of safety harnesses and life jackets for personnel required to be present on weather decks during these conditions.

Welding, cutting, and brazing present special hazards. Welding produces extreme heat and intense ultra-violet (UV) light. Welding helmets and goggles provide eye protection against the UV light produced by welding, and they come in many different varieties. Brazing and cutting metal also produce extreme heat and flying debris. To protect against the hot, molten metals that may become airborne during these processes, welding helmets, welding goggles, leather gloves, and other protective welding clothing are to be worn.

While working with lubrication oil, personnel must wear a face shield and chemical goggles, a rubber apron, and chemical gloves. Certain evolutions require specific PPE, to take a lubrication oil sample, you must protect yourself, and you must outfit yourself with the appropriate PPE.
An emergency escape breathing device (EEBD) is located in or near your workspace or rack. EEBDs are not worn to enter a hazardous area or to fight a fire. EEBDs are worn only for escape from hazardous conditions. In this lesson, you will learn to use emergency breathing equipment to escape a hazardous situation safely and without harm. The importance of knowing the proper use and care of your emergency breathing equipment is imperative; it can save your life.

**Terminal Objective** - Use emergency breathing equipment to escape a hazardous situation safely and without harm.

- **Enabling Objective** - Identify the location, operating characteristics, and procedure for donning the EEBD.
- **Enabling Objective** - Identify the safety and maintenance procedures for emergency breathing equipment.
- **Enabling Objective** - Demonstrate an understanding of the location, operating characteristics, and procedures for operating emergency breathing equipment in a simulated engineering environment.

**LOCATION, OPERATION, AND DONNING**

In a life-threatening environment, portable emergency breathing equipment provides a lightweight source of emergency air to escape. The OCENCO M-20.2 emergency escape breathing device (EEBD) is featured in this lesson. The EEBD must not be used for purposes other than those outlined in the technical manual and should be read and referenced for proper care, maintenance, and usage.

The EEBD is used for evacuating a space when breathable air is insufficient. Naval ships are equipped with enough EEBDs to total 150% of its crew complement and 100% of other embarked personnel. It can be wall-mounted in orange cases. They are also contained in metal boxes and are permanently mounted at each and every rack. Main engineering spaces are equipped with enough EEBDs to support twice the watch stander requirement of that space. EEBDs are placed in work spaces, offices, berthing, main machinery rooms, pump rooms, and the galley. Stowage containers are international orange or mounted on gray-beige metal boxes with glow-in-the-dark stickers that read EEBD. It is used as respiratory protection in atmospheres containing toxic gasses or smoke and also used in low-oxygen atmospheres. It provides enough air through a mouthpiece for escape. It is rated for a minimum of ten minutes of use. It is a single use, disposable unit with a service life of 15 years.

It’s normal operating temperatures should stay between 10° Fahrenheit to 140° Fahrenheit. Upon inspection, and before use, if the tamper indicating ball has been tampered with or is missing, the unit should be removed from service. It consists of nine functional components that should be reviewed prior to its use.

- The Teflon hood is an optional component provided to help protect the face and eyes from smoke and chemical vapor. If visibility is hindered or toxic, this transparent face shield will provide protection.
- The relief valve is a one-way valve that automatically allows excess air inside the breathing bag to vent. The relief valve is located on the breathing bag.
- The oxygen regulator starts the flow of oxygen and regulates the oxygen flow during high work rates.
- The gauge indicates the amount of oxygen in the cylinder. The green zone indicates the unit is ready for use. The red zone indicates the cylinder is low on oxygen and should be removed from service.
- Once the EEBD is opened and its container is pulled apart, the activation cable is automatically disconnected from the bottom case forcing oxygen to flow immediately.
- The oxygen cylinder holds 27 liters of oxygen and is located on the base of the device.
- The flange on the mouthpiece seals between the lips and gums.
- The yellow nose clip is permanently attached to the mouthpiece. It prevents breathing through the nose while using the EEBD.
- The breathing bag is the air reservoir that receives oxygen from the oxygen regulator and exhaled air from the scrubber.

Check the EEBD before donning it. The presence of a stainless steel ball bearing located in the center of the yellow lever indicates that the unit has not been opened. Once it has been confirmed that the unit has not been opened, the EEBD can be donned and activated in 10 seconds.

**Step 1:** Remove the EEBD from the orange case.

**Step 2:** Lift yellow lever and discard cover.

**Step 3:** Remove unit from the case by pulling yellow neck strap upwards and over the head.

**Step 4:** Insert yellow mouthpiece into mouth.

**Step 5:** Place yellow nose clip on nose.

**Step 6:** Inhale through mouth and escape. (If visibility is hindered or toxic: Fit and adjust neck strap and transparent face shield.)

Upon reaching safety, donning the EEBD is easy by following these simple steps:

**Step 1:** Loosen the neck strap and face shield.

**Step 2:** Unclasp the nose clip and remove the mouthpiece.

**Step 3:** Pull the EEBD forward over the head.

**Step 4:** Dispose of the EEBD unit by following established guidelines set forth by the ship.

**EEBD SAFETY AND MAINTENANCE**

As with any piece of equipment used aboard the ship, there are safety precautions that must be followed. When using emergency breathing equipment, note the following safety precautions: Never use the EEBD for firefighting, entering voids, or any other use that requires a respirator. Use an EEBD only while in contaminated atmospheres or while awaiting rescue. The EEBD hood can only withstand a few seconds of direct exposure to flames. Ensure the unit is cool before throwing it away. Do not expose hair to open flames for several minutes after using an EEBD because the oxygen saturation makes it very susceptible to catching on fire.

Every two years, upon deployment, the wall-mounted EEBD should be inspected for indications of high-force impacts and that the oxygen cylinder pressure gauge is in the green zone. Verify the unit does not have case cracks, burns, deformities, excessively worn parts, dirt, a damaged latch, a damaged cover band, a bent gauge, a broken indicator needle, debris or moisture visible through the gauge window, or a missing tamper indicating ball. If there is any indication of high force impact on the carrying case, or if the oxygen cylinder pressure gauge is in the red zone, remove the unit from service. If there is a missing or damaged EEBD, Damage Control Central must be notified immediately.
If there is a fire onboard a ship it is important to know how to get to a nonhazardous location safely. In this lesson, you learned how to use emergency breathing equipment to escape a hazardous situation safely and without harm. You also demonstrated an understanding of the location, operating characteristics, and procedures for operating the EEBD.
During your daily duties, you will perform many different types of maintenance, using a wide variety of tools. You must select the right tool for the job and use it correctly to perform your job safely, accurately, and quickly. This lesson will provide you with information and knowledge of basic hand tools and precision measuring tools that will assist you in the performance of your job. It will also explain the Calibration Program that has been implemented to ensure that certain tools are accurate and ready for use. Safety is a primary concern when working with all types of tools. You must always follow safety guidelines. Using tools in their prescribed manner and wearing all appropriate personal protective equipment will keep you and your fellow Sailors safe during maintenance activities. **SAFETY MUST BE PRACTICED AT ALL TIMES!**

**Terminal Objective** - Identify the purpose and function of tools and their uses.
- **Enabling Objective** - Identify common tools used in engineering spaces.
- **Enabling Objective** - Identify the use of precision measuring tools, including torque requirements, in the workspace.
- **Enabling Objective** - Identify the requirements of the Calibration Program.
- **Enabling Objective** - Recognize the safety precautions used when working with precision and power tools.

**COMMON HAND TOOLS**
You will perform maintenance using common hand tools. These tools include pneumatic tools, portable electric tools, lifting and jacking devices, general hand tools, wrenches, and ratchets and sockets. These common hand tools, normally found in engineering spaces, are essential for completing your tasks. Always use the correct tool in the correct manner. These tools do not require any type of calibration; however, you always need to ensure that your tools are in good condition.

Control of your tools is accomplished through proper storage. Each ship has its own policy regarding the handling of hand tools, but proper use and storage is a key element of every tool program. Electrical tools are issued and maintained in the electrical tool issue space. Here are some guidelines for the use and care of tools:
- Use each tool for the job that it is designed for.
- Keep each tool in its proper storage space.
- Keep your tools within easy reach while working, and ensure they are secure, so they cannot fall on personnel, or become lost in the bilges.
- Return all broken tools to your work center supervisor.

- **Safety wire pliers** – These are three-way pliers that hold, twist, and cut. They are designed for twisting safety wire that prevents fasteners from coming loose due to vibration. They may also be used to install flange shields.
- **Tubing benders** – Used to bend tubing to desired shapes without crimping the tube. There are various designs.
- **Gasket cutters** – These devices are designed to cut gasket material to desired shapes. They come in a variety of designs, and cut gaskets from rubber, leather, and paper sheets. Bench top models cut holes from one to 20 inches using a pivot point and a knife, while small holes are made using a hollow gasket punch that is struck with a hammer.
- **Tube flaring tool** – The flaring tool is used to put the proper 45 degree flare in the end of tubing, so that it will seal correctly. There are two parts to the flaring tool, the frame and the block. The frame houses the anvil and performs the flaring operation, while the block firmly holds the tube in place to avoid deformation.
- **Tube cutters** – The tube cutter normally cuts soft tubing to desired lengths. The cutting wheel is secured to the tube by tightening the knob on the bottom of the cutter which screws the cutting wheel up or down, depending on the direction the knob is turned. The tool is spun around the tube, while the knob is gradually tightened, cutting the tube more and more with each pass, until the tube is completely severed.
- **Packaging extractor** – This tool is used to remove packing from the inside of pumps and valves. The steel shaft has a corkscrew on the end with a fine point. Another tool that can assist in this process is a scribe.
- **Gear puller** – This tool allows you to remove press-fitted gears and bearings from shafts. There may be instances where the piece is frozen on the shaft, so you will use penetrant to soak into the part, making the extraction process easier.
- **Flexible retrieval tool** – The flexible retrieval tool is used to grab small articles that fall into hard-to-reach areas, such as under and behind components, or in spaces too small for hands or arms.
- **Inspection mirror** – This mirror allows you to see in hard-to-see areas and is extremely helpful in locating material and performing inspections.
- **Tap and die** – These tools are used to clean existing threads and cut new threads in metal, plastics, or hard rubber. Taps are used to make internal threads, such as bolt holes, while the six-sided dies are used to make external threads, such as the ones found on bolts.
- **Screw extractor** – The screw extractor, or easy-out, is used to remove broken screws, bolts, and studs. After soaking the fastener with penetrant, an appropriately sized hole is drilled into the fastener, deep enough for the extractor to grip the inside of the broken fastener. The extractor will be inserted into the drilled hole, tapped slightly with a hammer, and then the extractor is turned counterclockwise with the appropriate handle to remove the broken fastener.
- **Ratchet and Sockets** – Ratchet handles use detachable sockets to turn nuts or bolts. Ratchets move back and forth, but only drive in one direction, as selected on the back of the ratchet handle. Sockets are round metal sleeves with a square or drive opening on one end (ranging in size from one quarter to one inch), and a six- or twelve-point opening on the other that is paired to the size of the desired nut or bolt to be turned. Sockets are either common (short) or deep (long) lengths. Sockets can also be turned with speed handles, sliding T-bar handles, hinged handles, or breaker bars.
- **Slugging wrench** – This is used when large metal fasteners are encountered and ordinary tools will not suffice, e.g., foundation bolts, boiler hand-hole plugs, or boiler manhole cover bolts. This wrench has one end designed to fit over the nut or bolt, and the other end has an area suitable for being hit with a hammer or mallet. For more stubborn fasteners, a sledgehammer is used to deliver heavy blows.
- **Strap wrench** – This tool is designed for pieces of equipment that ordinary wrenches will mar or damage, or there is not another suitable tool designed to tighten or loosen it. Examples include breaking pipe joints and turning cylindrical parts. It has a rubber or leather strap that tightens around the part while the operator exerts twisting force on the handle.
- **Spanner wrenches** – These wrenches are generally used to tighten or loosen fittings on fire hoses. There are three types, and the one you use is dependent on the fitting you are turning.
  - Used for large diameters, often used to remove protective cover plates.
  - It contains a pin that fits into holes in the coupling or plate.
  - This wrench has a fixed or adjustable head with a hook-type feature at the end that attaches to the end of the coupling.
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- **Strap wrench** – This is used for pieces of equipment that ordinary wrenches will mar or damage, or there just is not another suitable tool designed to tighten or loosen it. Examples include breaking pipe joints and turning cylindrical parts. It has a rubber or leather strap that tightens around the part while the operator exerts twisting force on the handle.

- **Spanner wrenches** – These wrenches are generally used to tighten or loosen fittings on fire hoses. There are three types, and the one you use is dependent on the fitting you are turning.
  - **Adjustable face spanner wrench** – Used for large diameters, often used to remove protective cover plates.
  - **Pin-type spanner wrench** – It contains a pin that fits into holes in the coupling or plate.
  - **Hooked spanner wrench** – This wrench has a fixed or adjustable head with a hook-type feature at the end that attaches to the end of the coupling.

- **Disk sander** – A portable electrical disk sander is used to remove paint and rust. It can also be used to dress various types of materials.

- **Electric drill** – A portable electric drill uses many different sized drill bits to drill holes.

- **Paint scraper** – A portable electric paint scraper is used for removing paint.

- **Die grinder** – Portable grinders are used to grind away excess material and come equipped with a grinding wheel. This may also be replaced with a rotary wheel wire -brush or a rotary cup wire brush.

- **Pneumatic drill** – A pneumatic (or air powered) drill is used to drill holes, using many different sized drill bits.

- **Impact wrench** – An impact wrench is used to remove a large quantity of nuts or bolts, such as in boiler casing panels.

- **Paint chipper (needle gun)** – A paint chipper, or needle gun, is also referred to as a portable pneumatic descaler. They are used to remove paint and rust. They can also be used to dress concrete or masonry. They come in different configurations, but perform the same basic task.

- **Chain hoist** – Chain hoists are used to permit small movements and gentle handling of loads. Chain hoists may be hand or motor operated.

- **Ratchet lever hoist** – Hand operated ratchet lever hoists are used to permit small movements and gentle handling of loads, similar to the chain hoist; however, they use a ratchet handle to move the load instead of a chain.

- **Hydraulic jack** – Jacks are used for pushing, pulling, lifting, pressing, bending, spreading, and clamping operations.

**PRECISION MEASURING TOOLS**

Many maintenance tasks will require working with components with exact tolerances or specific torque requirements. This will require the use of precision measuring tools, including torque wrenches. This section helps you identify the use of precision measuring tools, including torque wrenches, in the work space. These measurements are often critical, so keen attention to detail is required when using these tools.

Precision measuring tools need to be stored correctly and carefully. They must also be handled with care. These tools include general precision tools such as machinist’s rules, sounding tapes, calipers, micrometers, and torque wrenches. Keep in mind that a majority of these tools are precisely calibrated, and improper handling may result in damage to the tool or an inaccurate reading.

- **Machinist’s scale** – This device is simply a steel measuring stick. A 12-inch steel machinist’s rule has four different scales to indicate fractions of an inch, from 1/8 to 1/64.

- **Feeler gauges** – Used to measure small openings, such as contact points or narrow slots. It can also be used for the alignment of couplings and the tune up of diesel engines. This tool has 2 to 26 blades, graduated into thousandths of an inch.

- **Dial indicator** – The dial indicator measures movement of close tolerance items. It can be used to measure run-out (out of round) or axial clearance (end play) of a shaft. This tool is comprised of several components:
  - Magnetic base – Used to secure the dial indicator to the item to be measured. There is a base unlocking device that is used to turn the magnet on and off.
  - Tool post – This is the main support in the mounting bracket.
  - Tool post clamp – This secures the cross piece to the tool post.
  - Tool post thumb screw – This screw tightens or loosens the tool post clamp.
  - Dial Indicator – the pointer needle, along with the moveable bezel, enable the operator to make measurement readings
  - Sensor button – This button comes in contact with the item that is being measured for movement.

- **Sounding tape** – Used to measure the depth of fuel tanks. It has a non-sparking plumb bob attached to a measuring tape that is wound on a drum or reel. When it is lowered to the bottom of the tank, a measurement is made, in feet and inches, at the level of the fuel or other liquid.

- **Telescoping gauges** – The telescoping gauge is intended to measure inside holes and dimensions where measurements cannot be taken with a standard micrometer. These gauges come in a variety of sizes, up to 6 inches. The procedure to use these gauges is extremely critical.
  - Make sure the plungers move freely
  - Compress the plungers and lock them by turning the knurled screw.
  - Insert the telescoping gauge into the center of the hole to be measured.
  - Unlock the knurled screw to release the plungers.
  - You must take various measurements within the hole.
  - Lock the knurled screw.
  - Take multiple readings within the hole, taking the gauge and tilting one side of the plunger down approximately 20 degrees. Begin to level out the gauge. The plunger should fit snugly inside the hole, consistent at various locations
  - Remove the telescoping gauge, and take a reading of the plungers using an outside micrometer.

- **Mechanical calipers (inside calipers and outside calipers)** - Usually used by a machinist, these tools are used to measure both inside and outside dimensions or the thickness of an object. After the measurement is taken with the calipers, it is then read by placing the calipers on a machinist’s scale, and reading the measurement.
**-Dial Slide Caliper** – Similar to Vernier slide calipers in function, these calipers utilize a dial to read the measurement. It can read inside and outside dimensions with a high degree of accuracy. The dial is calibrated in increments of 0.001 inch. A dial bezel is provided to zero the calipers before use. A bezel clamp is used to lock the dial in place once the adjustment is made. There is also a depth rod provided to take depth measurements. Another unique feature is the caliper’s ability to be used to scribe parallel lines. Simply lock the moveable jaw to the required dimension and use the front edge of the fixed jaw as the scribing surface.

**-Vernier Slide Caliper** – These calipers are used to determine close tolerance measurements. Using these calipers can be tricky, so close attention to detail is required.

- Loosen the two locking screws, allowing the movable jaw to slide along the rule to the desired position, ensuring there is no drag felt as the jaw is being adjusted.
- The locking screw adjacent to the adjustable roller is then tightened, and any fine adjustments can be made using the adjustable roller.
- Secure the other locking screw, and read the calipers.
- To read the calipers, begin by reading the number of full inches that show from zero on the main scale to zero on the Vernier.
- Next, read the number of the main scale to the 0.025 of an inch beyond the last full inch to the zero on the Vernier scale.
- Next, to read the Vernier scale, read along the scale until you find the line on the Vernier scale that lines up exactly with the line above, on the main scale
- Finally, add these readings together to find the measurement.

**-Outside Micrometer** – The micrometers are used to measure the outside diameter and thickness of objects to within .001 of an inch using the standard scale. A popular feature of the outside micrometer is the ratchet speeder because it speeds opening and closing, applies uniform pressure from the ratchet, and allows for using the thimble for individual “feel.”

**Components:**
- Frame – Supports the anvil and is permanently attached to the sleeve.
- Anvil – This component has a flat, precision ground face. This is one of two surfaces that make up the final measurement.
- Thimble – This allows for close adjustment of the spindle.
- Locknut – The locknut is used to lock the spindle after the measurement has taken place.
- Sleeve – The spindle’s internal threads mate to this hollow barrel.
- Spindle – Contains external threads that thread into the sleeve.
- Ratchet stop – This is used when the correct pressure of the spindle against the part being measured is reached. The ratchet stop will slip to prevent over-tightening.

**Size Selection**
- Outside micrometers are built in several different ranges. Range refers to the measuring ability of the micrometer. This is the maximum distance between the anvil and the spindle. Commonly used micrometers have a range of one inch. Therefore, a one-inch micrometer will measure between zero and one inch, and a six-inch micrometer will measure between five and six inches.

**Use**
- First, ensure the calibration label is up to date and the tool is working properly.
- The anvil is held tight against the object and the spindle is tightened until it makes contact with the object.

**Reading**
- First, use a machinist’s scale to find the approximate distance you are measuring, to help you select the correct micrometer. For example, if you are measuring a metal rod, and it is approximately 1.5 inches in diameter you will use a two-inch micrometer.
- Read the highest figure visible on the sleeve. Each number is equal to 0.100 inch.
- Determine the number of lines visible on the barrel between the highest fully visible figure and thimble edge. Each subdivision represents 0.025 of an inch.
- Next, determine which line on the thimble coincides with the long line on the sleeve. Each line represents 0.001 of an inch.
- Finally, add all of these measurements together.

**-Micrometer** – This micrometer is used to measure the depth of holes or slots from zero to 12 inches in one inch increments, using interchangeable spindles. There are two indentations on the base to place your fingers on, to firmly secure the depth micrometer to the item being measured. The base cannot be tilted in any way and must be level with the object. Always ensure the tool and the items being measured are clean and free of debris.

- To read a depth micrometer, use a machinist’s scale to measure the object to the nearest whole inch.
- Read the highest figure visible on the sleeve, and subtract one. (The numbers on the depth and inside micrometers are listed backwards from the outside micrometer. Each number represents 0.100 of an inch.
- Next, determine the number of lines visible on the barrel between the highest visible number and the thimble edge. Each subdivision represents 0.025 of an inch.
- You must read the number on the barrel that corresponds to the spindle. It is graduated in .001 of an inch.
- Finally, add all of these measurements together.

A torque wrench is used to measure the degree of tightness of a fastener, by measuring the torque (twisting force) applied to them during tightening. These wrenches commonly read torque in foot-pounds or inch pounds. Torque wrenches are precision tools and need to be periodically calibrated to ensure accuracy. Care must be taken in the proper selection and application of the torque wrench. There are different kinds of torque wrenches.

- **The dial torque wrench** utilizes a dial and pointer to indicate the torque achieved.
- **A beam-type torque wrench** uses a deflecting arm and a stationary beam to read torque.
- **A clicker type wrench** gives the user an audible and felt “click” when the torque value set on the wrench is achieved.

When using an extension that changes the overall length of the torque wrench, as measured from the fastener to the end of the handle, a formula must be used to calculate the torque that must be used to tighten the fastener. This will amend the listed torque value. Any extension that makes the torque wrench longer, from the end of the handle to the fastener requires that you use less indicated (selected) torque. The following formula must be used.
TACT = Applied torque required
TIND = Torque indicated or selected on the torque wrench
L1 = Length of the torque wrench
L2 = Length of the extension

Torque requirements must be given special attention. Certain applications and specific fasteners have specific torque values that must be adhered to. These are found in drawings, work procedures, or technical manuals, and are used in preference to general guides for torquing, such as the one found in the NSTM 075. The table found in the NTSM 075 provides an extensive list of torque values, and you will use this when the drawings, work procedures, or technical manuals do not identify the torque requirements.

Parts can be warped or broken if torque is not applied to the fasteners in the correct sequence. Normally, you will start in the center and work your way to the outside, switching back from side to side as you go. If you are torquing a circle, start at one point, and then tighten opposite the bolt, move adjacent to the first bolt, then opposite, and so on. Anti-Seize lubricants shall be used wherever specified by the appropriate drawings, work procedures, or technical manuals to prevent galling and to facilitate the proper application of torque.

CALIBRATION PROGRAM
Most precision instruments require periodic calibration to ensure the measurements they make are accurate and precise. Before using these instruments, they must be checked out. They are kept in a controlled area to ensure that these tools are maintained in proper working order, the calibrations are performed within the required period, and the tools operate within the prescribed limitations. It is critical that you understand the requirements of the Calibration Program.

Prior to checking out a calibrated tool, inspect the calibration sticker. This sticker contains important information about the tool’s calibration. Normally, the calibration sticker contains the tool’s name (ID), initials of the person certifying the calibration (BY), the date calibrated (DATE), and the due date for subsequent calibration (DUE). They are typically white in color. Information about the tool must be registered in the log book whenever checking a controlled tool in or out. This includes the date, check-out time, check-in time, the tool name, due date from the calibration sticker, comments about the condition of the tool, and the initials of the person checking out the tool.

TOOL SAFETY
Safety is everyone’s responsibility. Hand tools are a common part of your job and make maintenance tasks easier, but these tools also possess great potential for harm if used improperly. One way to minimize the risk of injury to you and your shipmates is to recognize and adhere to the safety procedures and policies outlined in drawings, work procedures, and technical manuals. Another important aspect of safety is situational awareness. Always be aware of where you are and what you are doing.

General hand tool safety requires YOUR involvement. Follow these guidelines at all times:

- Always use the appropriate tool in the manner for which it was intended. A great number of hand tool mishaps are the result of misuse. For example, using a screwdriver as a pry-bar or a chisel.
- Do not use tools that are excessively worn or broken.
- Obey all warning signs and read equipment labels prior to using that equipment.
- Familiarize yourself with the operating procedures of tools before using them.
- Always use the appropriate Personal Protective Equipment (PPE) when using hand tools.

Electrical tool safety requires the same vigilance. At all times, you will adhere to the following safety instructions:

- Be alert to the presence of dangerous voltages and avoid striking such equipment with tools of any kind.
- Always remove rings, watches, jewelry of any kind, and any other item that may become caught or entangled, or possibly become a shock hazard while working with hand tools.
- All portable electric tools shall be checked out from Electrical Tool Issue, where qualified electricians inspect them prior to issue.
- Do not operate any tool that has the potential to produce sparks, including portable electric tools, in spaces where flammable vapors, gases, liquids, or explosives are present.
- Ensure metal-cased portable electric tools are equipped with a three-pronged (grounded) plug, and use them with rubber gloves and other applicable PPE to prevent electrical shock.
To build a solid keel foundation for your training, you must learn about Quality Assurance (QA) and the QA Program. The QA program is designed to protect the ship and everyone onboard. On October 30, 1990, a major steam leak occurred in the fire room onboard the USS IWO JIMA. Ten of our watch-standers were killed. Naval investigators determined that the ship and shipyard crews failed to verify if the replacement fasteners that held the steam valve together met the technical manual and drawings requirements. The QA Program became more important than ever before. Understanding the requirements of QA Program, the administrative and technical procedures, the duties of the program participants, and the use of QA forms is critical. Familiarity with controlled materials, the Material Control Program, and the three material control divisions is important in building a thorough understanding of the QA program.

**Terminal Objective** - Demonstrate an understanding to provide procedures and guidance to ensure, with a reasonable level of confidence, that work performed on or for Navy ships is accomplished with first time quality.

- **Enabling Objective** - Identify administration procedures and requirements of the QA Program.
- **Enabling Objective** - Identify technical procedures and requirements of the QA program.
- **Enabling Objective** - Identify the Fleet Maintenance Activity Quality Assurance organization and their responsibilities.
- **Enabling Objective** - Determine the use of QA forms applicable to the QA Program.
- **Enabling Objective** - Recognize controlled materials, the Material Control Program, and the scope of boundaries for the three Material Control Divisions.
- **Enabling Objective** - Differentiate between the two levels of essentiality for non-nuclear systems.

**ADMINISTRATION PROCEDURES AND REQUIREMENTS OF THE QA PROGRAM**

The Navy developed the QA Program to ensure maintenance is performed in accordance with technical specifications. Neglecting any part of the program may result in death and destruction which can limit the capability of your ship to accomplish its mission. The QA Program is either pass or fail; it does not recognize degrees of success. Completed maintenance either does or does not meet specifications; therefore, making it important to be able to identify the administration procedures and requirements of the QA Program. Specifications are the standards to which components are purchased, installed, tested, and maintained, the rule for all maintenance is that technical specifications must be met at all times.

The two key elements of the QA program are:

- **Administrative Procedures** - QA documents, forms, records, audits and surveillance.
- **Technical Procedures** - Fabrications, installations, and repairs.

**Administrative Procedures** consist of the following:

- Formal Training and Qualification.
- Audit and Surveillance.
- QA Forms and Records.
- Departure from Specifications.
- Technical Work Documents.

The formal training and qualification procedure states that all hands shall receive QA awareness training during initial indoctrination and annually thereafter. It also specifies that all QA personnel, from craftsmen to Quality Assurance Officer (QAO), must qualify through the PQS program. The audit and surveillance procedure determines if the ship is complying with the QA directives. These audits and surveillances may be internal, conducted by ships force personnel and assigned by the QAO, or external, conducted by the Immediate Superior in Command (ISIC). QA forms and records enable you to prove that repairs and alterations were accomplished according to specifications. It should be no surprise that all ships are designed and constructed to specific technical and physical requirements, and that every effort is made to maintain all the systems and components to their designed specifications. Sometimes specifications cannot be met and a Departure from Specifications document (DFS) is used to maintain precise control of the ship's configuration. DFS documents must be recorded and approved by the appropriate authority.

**Technical work documents** are important because many maintenance procedures require that you complete one. These two document packages play an important role in completing maintenance procedures. The following are two important document packages: Formal work package and Controlled work package.

**Technical Work Documents (TWD)** consists of the following three general types: Maintenance Procedures (MP), Formal Work Packages (FPW), and Controlled Work Packages (CWP).

**Maintenance Procedure (MP)** may be fully usable in their existing form. The minimum requirements to perform any work are a valid MP and permission to perform maintenance. Examples of MPs include: Planned Maintenance System (PMS) Maintenance Requirement Cards, Component Technical Manuals, Naval Sea Systems Command (NAVSEA) drawings which include disassembly and reassembly instructions, Steam and Electric Plant Manual.

The two document packages used when an MP is not sufficient or does not exist are Formal Work Packages (FWPs) and Controlled Work Packages (CWP). An FWP coordinates in a single document material, initial conditions, MP, test and inspections, and system restoration for the selected maintenance task. In some instances, the maintenance task does not have an existing MP. This then requires the activity to develop an FWP in order to ensure first time quality accomplishment of the maintenance task. The FWP Procedure includes instructions on how to accomplish the work. These instructions are made available thru the bold letters. Each letter represents important information regarding an FWP.

- **R** – verification or inspection, or a combination of both
- **S** – member of ship’s Force has verified the section
- **C** – craftsman has completed a cleanliness inspection
- **I** – section has been inspected by a Quality Assurance or Non-Destructive Testing Inspector
- **Q** – Critical Quality Control Points (Q-Points) for that section
- **V** – section verified by craftsman
- **G** – Government notification is required for that section
There are five steps in the FWP revision process:

- **First step** occurs after you identify the need to revise the FWP. When this occurs, stop work immediately and notify either the Leading Petty Officer or the Work Center Supervisor, or in some cases, both of them.
- **Second step**, the originating Work Center initiates the revision and the Division Officer responsible for the revision work reviews it.
- **Third step**, usually, you make the revision by page substitution. Revisions are lettered consecutively, starting with the letter “A.” The revision letter or number is written on all affected sheets of the FWP. Superseded pages are retained until the FWP is closed.
- **Fourth step**, attach a cover sheet for the revision. The FWP revision sheets are placed on top of the previous cover sheet, with the most current cover sheet on top.
- **Fifth step**, route the FWP to the divisions affected by the revision process where it is authorized.

Rework is the unplanned repetition of a step, or a series of steps in a FWP. A rework addendum specifies the steps that must be repeated in an FWP and which ones may be used in place of a revision when work is required and the scope of the original work cannot change. Any additional actions that were not included in the originally approved FWP constitute a change in scope or work boundaries and must be issued as a revision to the FWP. A rework addendum is used when an inspection fails prior to completing a maintenance procedure and particular procedural steps must be repeated.

A CWP is simply an FWP with all the associated QA forms attached. The attached QA forms serve as the Objective Quality Evidence (OQE) for the work. Use a CWP only when you must supply OQE. Certain steps of the procedure require signatures referred to as Critical Quality Control Points, or Q-Points, a positive assurance that the step was actually performed or completed in a prescribed manner. Signatures are also required for assurance of critical requirements, critical measurements, or requirements for OQE. If a step calls for you to complete a data form such as a hydrostatic test data sheet, sign the data form, not the procedural step.

**TECHNICAL PROCEDURES AND REQUIREMENTS OF THE QA PROGRAM**

The Q.A. Program Technical Procedures include the quality of the product, inspection tasks, repairs, installations, testing, and recertification. The Technical Procedures include an extremely detailed work process that must meet required specifications. There are five types of Technical Procedures:

- **Critical Quality Control Points** Critical Quality Control Points (Q-Points) are steps in the work process that are critical to the first-time quality of the product. These steps require high skill levels, proficiency, knowledge, the ability to work within narrow tolerances, and close supervision, due to difficult environmental conditions. Inspections critical to the successful completion of the task must be accomplished by an individual other than the craftsman doing the work. This individual must be qualified as a Quality Assurance Inspector (QAI).
- **Fabrication and Repair** only fully qualified individuals using approved procedures and materials should perform these repairs and installations. Cleanliness requirements must be fulfilled in accordance with both MPs and work packages. These requirements are considered fabrication and repair procedures.
- **Material Control Requirements** Throughout the installation or repair process, materials that are used must be identified, verified, and regulated to ensure that the end product meets the required specifications. These technical procedures are referred to as material control requirements.
- **Objective Quality Evidence** Use OQE to document the critical attributes of the maintenance. It must be completed during the work process. The time spent to complete these documents is negligible when compared to the time spent to correct suspected improper work resulting from insufficient or improper documentation.
- **Testing and Recertification** is an important technical procedure. Testing is the method used to certify or recertify the work that was accomplished. It ensures that the system or component has been returned to its normal operational state and will function as designed. An example of a test is “Blue Check,” during which contact between two mating surfaces is checked prior to and after maintenance.

**FLEET MAINTENANCE ACTIVITY QUALITY ASSURANCE ORGANIZATION’S RESPONSIBILITIES**

There are numerous members involved in the Quality Assurance (QA) organization. Understanding the roles and responsibilities of each member is critical to effective QA communications, procedures, and documentation. The QA members have very specific roles.

- **The Commanding Officer (CO):** Designates the Quality Assurance Officer (QAO); Certifies all QA personnel qualifications; When required, approves TWDDs or DFSs.
- **The Executive Officer (EO):** Monitors the QA Officer’s job performance (the manner in which the QAO administers the ship’s QA surveillance, training, and qualification programs); Periodically attends or monitors the QA training to verify it is meeting standards; Assigns an E-6, or above, to be the Assistant Quality Assurance Officer (AQAQ) for the QAO.
- **The Department Head or Engineering Officer:** Reviews and approves the Formal Work Package (FWP) and the Controlled Work Package (CWP). Ensures personnel in their departments participate in QA training; Verifies that the department maintains a sufficient number of the qualified Quality Assurance Inspector (QAI) and Controlled Material Petty Officer (CMPO) positions; Requires participation in an oral examination of the shipboard Quality Assurance Supervisor (QAS) and the QAI assigned to their departments; Ensures that personnel within the departments perform all their assigned duties including QA surveillance, qualification, and training. Reviews and signs off on any DFS.
- **The Supply Officer:** Turns the material certification documentation over to the requester; Returns defective material to the Navy supply system; Ensures that the supply department personnel receive controlled material certification and training on procurement, receipt inspection, and stowage requirements.
- **The Quality Assurance Officer (QAO):** Administers the ship’s QA program. Reviews and approves the CWP; Verifies that completed test results for controlled work fully satisfy test requirements, and initiates corrective action if not; Reviews and closes out every CWP; Maintains every completed CWP, QA assessment, surveillance, deficiency correction, controlled material, and DFS permanent file; Submits DFS clearance reports when work is done to correct a specific DFS; Manages the ship’s internal QA surveillance program; Ensures that QA training is conducted as required; Implements a formal qualification program for each QAI, CMPO, Cleanliness Inspector-Certifier, and QAS (if assigned); Conducts oral qualification interviews for the QAI, QAS, CMPO, and Cleanliness Inspector-Certifiers; Maintains a current master list of all personnel qualified for the position of QAI, CMPO, Cleanliness Inspector-Certifier, and QAS (if assigned).
- **The Controlled Material Petty Officer (CMPO) and the Controlled Material Handler (CMH):** Ensure all material under their cognizance is stored and controlled in accordance with applicable references; Maintains custody of controlled material in segregated stowage in accordance with applicable references; Inspects controlled material storage areas of their work center semi-annually, as a minimum.
- **The Craftsman:** Performs all maintenance actions in accordance with the approved procedure; Seeks clarification from the work center or shift supervisor if the procedure is incorrect or unclear and signs their name and date all completed QA forms; Ensures that Test, Measuring and Diagnostic Equipment (TMDE) that have current calibration stickers and records attached (or available) are used for production, acceptance, and testing.
-The Non-Destructive Testing Inspector (NDT): Verifies every CWP that includes an NDT inspection; Ensures that NDT inspections are completed correctly; Ensures inspection reports are technically complete and accurate; Ensures that measuring devices have current calibration stickers or records, or a combination of both (attached and available); Monitors the welder and brazzer qualification and training when an NDT examiner is not assigned.

-The Division Officer (DO): Reviews CWP's and FWP's, as required; Verifies that controlled work is accomplished in accordance with an approved CWP; Ensures personnel assigned to their divisions perform QA surveillance, qualification, and training; Supervises QA training of division personnel; Updates the QA 14 Log in a timely manner, indicating root cause analysis and actions taken.

-The Work Center Supervisor: Reviews the FWP as required; When designated the Lead Work Center (LWC), verifies that the FWP provides the correct written instructions (both in sequence and requirements) to satisfactorily accomplish the controlled work; Ensures the procedure steps that require signatures are signed by personnel performing the step; Ensures that all controlled work is in accordance with an approved CWP; Confirms proper work authorizations are obtained prior to starting work; Ensures tools (measuring and test equipment) are properly calibrated; Maintains a Tool Accountability log to track tool loss and damage.

-QA Form 3: Use for receipt inspection, certification and traceability of new controlled material. This includes procurement, receipt inspection, classification, and identification of received material or material from another area.

-QA Form 17 for Pneumatic Test Record, is used to document hydrostatic/pneumatic tests on piping systems, or portions of a system, to ensure meeting required pressure and tightness. It is important to understand when to use and how to document completing the test in the proper fashion, the forms provide a record of completed corrective action.

-QA Form 14, the Surveillance/Monitoring/Audit Discrepancy Record, provides a method or means of reporting both the discrepancies found not noted during audits and surveillances, and corrective actions taken by the work center or division. It also documents the results of internal audits and record discrepancies, reworks, and processing action until final clearance. When maintained in an audit trail, the forms provide a record of completed corrective action.

-QA Form 17, the Department of Quality Assurance (QA) for Test and Inspection Record, is a report form for work, tests, and inspections not covered by other QA forms. Use this form for flushes, operational testing, shop inspections, cleanliness inspections, and the generic material identity test. Additionally, use QA Form 17 for other tests, inspections, and information deemed necessary.

-QA Form 20, the Welding In-Process Control/NDT Record, is used to document in-process controls for welding and Non-Destructive Testing (NDT) of a completed work.

-QA Form 26, Hydrostatic/Pneumatic Test Record, is used to document hydrostatic/pneumatic tests on piping systems, or portions of a system, to recertify the system after maintenance.

-QA Form 34, Joint/Component Torque and Assembly Record, is a standard form that is used to document the assembly and torqueing of mechanical joints and assemblies.

CONTROLLED MATERIALS, THE MATERIAL CONTROL PROGRAM, AND THE SCOPE OF BOUNDARIES FOR THE THREE MATERIAL CONTROL DIVISIONS

The material control program defines responsibility and provides guidance for material control. This includes procurement, receipt inspection, stowage, issue, in-process control, and records for controlled material used in maintenance. It is important to understand Controlled Materials, the Material Control Program, and the Scope of Boundaries for the Three Material Control Divisions. The Scope of Certification (SOC) Material Control Divisions (MCD) is designated "MCD A, B, or C."

The term Controlled Materials is used for materials removed from, or designated for use in, the Scope of Certification (SOC) boundary. These controlled materials are either one of the following: In the custody of the end-user work center, division Controlled Material Petty Officer (CMPO) and Undergoes receipt inspection.

Any material in a manned Deep Submergence System (DSS), whose single failure would result in either the loss of a DSS with DSS personnel on board, or the death of DSS personnel, is designated as Material Control Division A material. As such, any component for which back-up protection is not feasible, and, therefore, even a single failure is unacceptable, is assigned to MCD-A.
Material Control Division B (MCD-B) material is any material or component for which failure would require the following: Immediate emergency corrective action, activation of an emergency system, an emergency return to surface.

Material Control Division C (MCD-C) material includes the following: Emergency electrical power distribution systems, portions of the main electrical power distribution system, electrical components not classified as MCD-A or MCD-B, and soft goods such as O-rings, gaskets, and seals.

**TWO LEVELS OF ESSENTIALITY FOR NON-NUCLEAR SYSTEMS**

Not all materials or repair parts used in a process require the same level of control; therefore, a determination should be made as to the level of control. In order to do so, the level of essentiality for the system or component must first be known. Understanding these levels of essentiality is required to make these determinations.

Review the following two levels of essentiality: Materials used in systems within the first level of essentiality category provide a high degree of assurance that their chemical composition and mechanical properties meet specified requirements. Materials used in systems within the second level of essentiality category provide confirmation of a satisfactory completion of tests and inspections required by the ordering data (e.g., liquid Penetrant Testing (PT), dimensions, hydrostatic strength and porosity).
Poor maintenance practices caused excessive wear and will eventually result in premature failure of engines, systems and associated equipment. The Navy uses the Maintenance and Material Management or 3-M System to manage equipment maintenance aboard every ship and applicable shore stations. This is to ensure that engines and other systems always operate properly. As an Engineer, you must understand the 3-M System to perform your duties.

**Terminal Objective** - Demonstrate an understanding of the Maintenance and Material Management (3-M) System.

- **Enabling Objective** - Identify the purpose and structural components of the Maintenance and Material Management (3-M) System.
- **Enabling Objective** - Identify the 3-M responsibilities of personnel within the chain of command.
- **Enabling Objective** - Identify the components of the Maintenance Data System (MDS).
- **Enabling Objective** - Identify the purpose and use of Planned Maintenance System (PMS) schedules.
- **Enabling Objective** - Identify the steps associated with performing maintenance utilizing the Work Center Planned Maintenance System (PMS) Manual (3P1).
- **Enabling Objective** - Identify the characteristics of maintenance evaluations.
- **Enabling Objective** - Identify the characteristics of Inactive Equipment Maintenance and PMS feedback reports.

**3-M SYSTEM OVERVIEW**

The purpose of 3-M is to manage shipboard maintenance to ensure maximum equipment and system operational readiness. It also provides efficient uniform methods of conducting and recording preventive and corrective maintenance in a manner that allows easy access to the collected data. This is accomplished through standardization, efficiency, documentation, analysis, configuration status, and scheduling. Most maintenance performed in the Navy is planned and performed in a specific manner guided by overarching principles of the 3-M System. For the fleet to maintain readiness, the 3 M System must meet the following six objectives:

- **Standardization** - achieves uniform maintenance standards and criteria.
- **Efficiency** - allows for the effective use of available manpower and material resources.
- **Documentation** - provides a consistent and standard recording of maintenance and maintenance support efforts to establish a reliable material history.
- **Analysis** - improves the maintainability and reliability of a system or equipment, and to reduce cost of material ownership.
- **Configuration** - status accounting (CSA) is used to report and record changes in the installation, configuration specifications, and location of equipment onboard ships.
- **Scheduling** - standardizes the method for planning, managing, executing and tracking maintenance requirements and accomplishments. This includes component requirements from the Class Maintenance Plans (CMP) and the Integrated Class Maintenance Plan (ICMP).

The 3-M System is a maintenance management tool that provides efficient and standard methods to manage, schedule, and control maintenance of equipment and systems. It is comprised of two component tool sets; the Planned Maintenance System (PMS) and the Maintenance Data System (MDS). The PMS is a standardized method for planning, scheduling, and accomplishing preventive maintenance. The MDS is the means by which maintenance personnel can report applicable maintenance requirements and configuration changes of equipment. The MDS is constructed so that maintenance personnel record maintenance data only once.

**3-M SYSTEM ROLES AND RESPONSIBILITIES**

Many individuals in the chain of command from the CO to the Maintenance Person have specific 3 M System responsibilities. The NAVSEAINST 4790.8 Series 3-M Manual provides a basis for fleet personnel to manage, schedule, and perform maintenance. The NAVSEAINST 4790.8 Series 3-M Manual provides a basis for fleet personnel to manage, schedule, and perform maintenance. The 3-M Manual also provides information concerning fleet maintenance and maintenance support experience to organizations responsible for logistics support. As part of this purpose, this manual assigns the 3-M System responsibilities for the personnel in the chain of command. Select each image to learn more about the roles and responsibilities of 3-M personnel:

- **Commanding Officer (CO)** - is responsible for ensuring that the ship's maintenance is accomplished following the 3-M System and quality maintenance procedures, that the 3-M system functions effectively within the command, and for conducting one command PMS spot check weekly.
- **Executive Officer (XO)** - is responsible to the CO for properly managing the ship's 3-M System and for conducting one command PMS spot check weekly.
- **3-M Coordinator (3MC)** - is responsible to the XO for the coordination and direct supervision of all administrative facets of the 3-M System. The 3MC conducts five command PMS spot checks weekly. This position is designated in writing by the CO.
- **Department Head** - responsible to effectively operate the 3-M System within their department and for conducting weekly PMS spot checks in each division within their departments.
- **Department 3-M Assistant (3MA)** - The department head may assign an officer or Chief Petty Officer, trained in and knowledgeable of the 3-M System to serve as the Department 3MA. This individual provides help with the coordination and supervision of the department’s 3-M program.
- **Division Officers** - Assist the Department Head in managing the maintenance required for equipment within their division and conduct weekly spot checks in each Work Center within the division.
- **Group Supervisor** - The ship divisions may have Chief Petty Officers who are responsible for two or more work centers. These Chief Petty Officers are referred to as “group supervisors.” Group supervisors shall be responsible for the proper performance of the 3-M System functions within their respective Work Centers.
- **Work Center Supervisor (WCS)** - Usually the Senior Petty Officer in the Work Center. This person schedules the weekly maintenance and supervises its proper accomplishment. They ensure that the work center maintenance status is reflected correctly on PMS schedules and maintains an adequate supply of 3-M materials. The WCS updates the supervisors of the 3-M activity in the Work Center and ensures the prompt documentation of all material deficiencies in Ship’s Force Work List/4790 2K. They also ensure the Current Ship’s Maintenance Project (CSMP) accurately describes the work center's material condition and ensures that all 3-M documents from the work center are correct, legible, and submitted promptly. Additionally they maintain an accurate and current List of Effective Pages (LOEP) by comparing documentation with the actual equipment and they review the Maintenance Requirement Cards or MRCs and submit PMS Feed Back Reports (FBR) to document errors, changes, etc.
**-Maintenance Person** - The non-supervised Maintenance Person, as it relates to the 3-M System, follows and monitors the weekly PMS schedule and performs assigned scheduled maintenance in accordance with Maintenance Requirement Cards (MRC) and Equipment Guide Lists (EGL). They are also responsible for reporting to the WCS when they complete or cannot complete a planned maintenance action (MA), and when any corrective maintenance is required so that the action can be documented.

**COMPONENTS OF THE MAINTENANCE DATA SYSTEM (MDS)**

The MDS provides information for fleet maintenance and maintenance support. MDS is used by various areas and levels of management throughout the Navy, particularly at the shipboard level. The MDS produces automated CSMP reports, automated work requests (4790/2K) from deferred maintenance actions for submission to activities outside the ship, and automated deficiency documents for use by Inspection and Survey (INSURV) Boards. It enables the fleet to report configuration changes, allows repair activities to inform Navy managers of estimated or actual expenditures, and gathers maintenance history. It provides an automated input into the Ships Force Overhaul Management System for coordination and management of ship’s force work during an overhaul.

The CSMP provides shipboard 3-M managers with a consolidated listing of deferred maintenance to manage and control accomplishment. The intent is to record all outstanding deferred maintenance in the CSMP and to produce a report that lists deferred maintenance and alterations identified through the submission of OPNAV 4790/2K and 4790/CK.

3-M requires all afloat activities to report deferred and completed maintenance actions, configuration changes, configuration file corrections, and Consolidated Ship’s Allowance List (COSAL) Feedback Reports. The configuration and maintenance forms used for reporting are the Ship's Configuration Change Form OPNAV 4790/CK, the Ships Maintenance Action Form OPNAV 4790/2K, and the Work Candidate and the Supplemental Form, OPNAV 4790/2L.

With the exception of the Work Candidate and the Supplemental Form, OPNAV 4790/2L, these forms are now accessed and completed via computer and up-line reported by using applicable software. Software instructions are developed and distributed by the 3-M Central Design Activities (CDAs) and supplemented by TYCOM instructions as required. Options are available in the systems to print simulated OPNAV 4790/2K, OPNAV 4790/CK and Work Candidate forms when desired. With an automated information system, the computer will provide on-line access to the data for identifying equipment and ordering parts. When documenting requirements, many of the data elements required for corrective maintenance and configuration change reporting, such as the APL, EIC, Equipment Name, and Location, will be pre-filled and displayed when the applicable equipment is identified.

The OPNAV 4790/CK Form is used for reporting a completed maintenance action that was related to an alteration, or resulted in a configuration change. For the purpose of reporting configuration changes, all alteration directives, deletions, turn-ins, modifications, additions, installations, or replacements of equipment are included in the term “maintenance action,” whether or not corrective maintenance is actually performed.

The OPNAV 4790/2K Form is used for reporting deferred maintenance actions and the completion of those maintenance actions that do not result in a configuration change. To report completion of a configuration change, refer to the instructions for using the OPNAV 4790/CK Form. A deferred maintenance action is:

- A maintenance requirement that requires assistance from an activity external to the ship to accomplish.
- A ship’s force job requiring assistance from outside the originating work center (for example parts required).
- A job that is not expected to be accomplished by ship's force within the time frame prescribed by the TYCOM.
- An uncorrected deficiency reported by INSURV or other inspecting activity.
- A job required to correct a condition, which has caused, or may cause injury to personnel or damage to material.

The Work Candidate and the Supplemental Form, OPNAV 4790/2L, is used to provide amplifying information, such as drawings and listings, related to a maintenance action that is reported on a OPNAV 4790/2K Form. The 2L form may be used to list multiple serial numbers and locations for items with identical maintenance requirements in other activities. Additionally, you can use the form to list drawings and sketches that may help accomplish maintenance.

Each work center conducts equipment validations on a weekly basis to ensure proper logistics support of the shipboard equipment. The force goal is to validate all equipment in a five-year period. To do this, one equipment validation per week per work center is required for each 250 equipment files assigned to that work center. For each equipment validation conducted for Shipboard Non-tactical Automated Data Processing (SNAP) systems, the Ship's Equipment File Detail Print, and for Organizational Maintenance Management System – Next Generation (OMMS-NG) systems, the validation aid are printed and annotated with corrections and notes. Notify the WCS of all changes annotated on the equipment validation sheet. The WCS then notifies the 3MC of the updates to the equipment so the necessary changes can be submitted. Equipment validations are kept on file for at least 18 months.

**PLANNED MAINTENANCE SYSTEM (PMS) SCHEDULES**

There are two basic types of maintenance in the Navy. The first type, preventive maintenance, is performed to prevent equipment from breaking. The second type, corrective maintenance, is performed to repair equipment that actually has a problem. The purpose of the ship’s PMS is to maintain equipment to operate as designed by preventing problems through preventive maintenance, and to identify and correct potential problems. When you get to the fleet, your will be required to qualify as a 3-M Maintenance person and review the NAVSEAINST 4790.8 Series 3-M Manual.

The 3-M Manual provides each ship, department, and supervisor with the tools to plan, schedule, and control all planned maintenance effectively. The Work Center PMS Manual (43P1) provides a ready reference of the planned maintenance requirements for the WCS. The PMS provides the procedures for planned maintenance of systems and equipment. It also provides the minimum requirements for preventive maintenance such as what maintenance needs to be accomplished on the equipment and how often maintenance must be accomplished; this is known as periodicity. It provides schedules of maintenance tasks, maintenance assignments, and a description of the methods, materials, tools, and personnel needed for the task. The PMS also addresses the prevention or detection of hidden failures or malfunctions, which is a trend analysis and test procedure to determine material or equipment readiness.

The WCS is responsible for preparing the cycle, quarterly, and weekly PMS schedules. A PMS schedule shows the maintenance requirements scheduled between overhauls on a regular schedule including quarterly and weekly requirements. The quarterly schedule, which is updated weekly, provides a ready reference to the current status of the PMS within a Work Center.
The Cycle PMS schedule displays the planned maintenance requirements performed during the period between the major overhauls of the ship. The cycle schedule is divided into quarters.

The Quarterly PMS schedule displays the Work Center's PMS requirements performed during a specific three month period corresponding to that particular quarter on the cycle schedule. The quarterly schedule is divided into weeks.

The Weekly PMS schedule is what a Maintenance Person is most concerned with in the performance of daily maintenance planning. This PMS schedule includes the Work Center Code, Date of the Current Week, Approval Signature, Maintenance Index Page (MIP) Codes, Component Names, Maintenance Responsibility, and Assigned by Name.

The WCS uses an electronic version of the weekly PMS Schedule to monitor the accomplishment of the required tasks by Work Center personnel. The WCS maintains a 13 week record of PMS performance for all associated personnel. You obtain PMS assignments from the weekly PMS schedule, a paper version, and then report to the WCS that you fully accomplished or did not accomplish the work. When satisfied that the work is completed, the WCS will “X” the scheduled maintenance requirements on the quarterly schedule. Schedules that were not fully accomplished are circled and rescheduled. At the end of the Quarter the WCS will print the Quarterly and Cycle boards for submission to the Division Officers Review and the Department Heads signatures.

As a Maintenance Person, you are responsible to your WCS. You are required to qualify as a 3-M Maintenance person within six months of reporting on board. Remember your performance is critical to the safety of your shipmates and the effective and continued operation of the ship’s equipment. When performing maintenance, you must notify your WCS promptly when:
- You don’t understand an MRC.
- The MRC appears incorrect.
- The task can’t be completed as written.
- Tools and materials required are missing.
- You lack the capability, training or experience to do the job.
- There is a dangerous situation.
- Any equipment deficiencies or casualties.

PERFORMING MAINTENANCE USING THE WORK CENTER PMS MANUAL (43P1)

The PMS Master File is a duplicate set of all the 3-M requirements and information for all the work centers on the ship. It contains the maintenance requirements information that pertains to all of the equipment of a command. It also includes supplementary information, such as the 3-M Manual, and various updates and reports.

The Work Center PMS Manual (43P1) contains the planned maintenance requirements that specifically apply to a particular work center. It provides a ready reference of planned maintenance requirements for the Work Center Supervisor, and stays next to the Weekly PMS Schedule. The Work Center PMS Manual contains a List of Effective Pages (LOEP), which provides a listing of all the Maintenance Index Pages (MIPs) applying to a particular work center. The LOEP serves as a ‘Table of Contents’ for the work center PMS Manual. Each line item on this list is assigned a SYSCOM MIP Control Number, which is the same number found at the top right corner of the corresponding MIP.

The Maintenance Index Page (MIP) contains a listing of all maintenance requirements for a specific piece of equipment or system. Each equipment or system category has its specific MIP. Each MIP is designated by the SYSCOM MIP Control Number. The MIP provides a brief description of each maintenance requirement. Each maintenance requirement listed on the MIP is assigned a SYSCOM MRC Control Number.

The MRC Control Number should match the number of the corresponding Maintenance Requirement Card. In the last column on the MIP, “Related Maintenance” three types of entries may be found. These include:
- Mandatory related maintenance: are maintenance requirements that must be accomplished concurrently with another maintenance requirement.
- Convenience related maintenance: are maintenance requirements that can be accomplished concurrently with another maintenance requirement.
- No related maintenance: is indicated as “None.”

The Maintenance Requirement Card provides detailed maintenance procedures. The MRC describes who, what, how, and with what resources a specific requirement is accomplished. The front of the card contains a lot of important information and instructions:
- SYSCOM MRC/Control Number: This block contains the code (SYSCOM MRC Control number) used in cataloging MRCs. The set of numbers is located in the top right corner of the MRC. The number must match the corresponding number located on the Maintenance Index Page (MIP).
- Date: The Date block contains the month and year when the MRC was prepared.
- MRC Code: This block contains the Maintenance Index Page (MIP) series code and the maintenance requirement periodicity code. Periodicity is how often a specific maintenance requirement is performed. When more than one maintenance requirement of the same periodicity exists in the same MRC set, the MRCs (in most cases) are numbered consecutively, for example, “D-1,” “D-2,” ”D-3,” or “M-1,” “M-2,” and so on.
- Location: This block contains the specific location of the equipment requiring maintenance. If this maintenance is to be performed on more than one piece of equipment, an Equipment Guide List (EGL) may be attached.
- Ship System, System, Subsystem, and Equipment: These blocks identify the specific system, or equipment involved.
- Rate: The Rate identifies the recommended skill level of the person(s) considered capable of performing the maintenance requirements. Qualified personnel other than the rate/rating specified may be assigned. When a Navy Enlisted Classification (NEC) Code is assigned, substitution of other personnel is not allowed.
- Man-hours (M/H): The average time per equipment required of each rate listed in the rates block to perform the maintenance, listed in hours and tenths of an hour. When more than one person in the same rate is required and time requirements are equal, man-hours listed are the sum of their requirements. When more than one person in the same rate is required and time requirements are not equal, man-hours are listed for each person separately. Total man-hours is the sum of all entries in the Man-hours block, not including time for tool preparation and return, tag out, or time needed for removal and/or replacement of interference. The “Elapsed Time” is the actual time required to complete the maintenance requirement form.
- Maintenance Requirement Description: This is a brief description of the Planned Maintenance System (PMS) action to be completed.
- Safety Precautions: The Safety Precautions block provides a listing of precautions and references that direct attention to possible hazards to personnel and equipment while completing the maintenance.
- **Materials, Tools, Parts, Test Equipment:** This block lists the tools, parts, materials, and test equipment necessary to perform the maintenance. Standard maintenance tools, parts, and materials like grease and oils are referenced to the Standard PMS Materials Identification Guide (SPMIG).
- **Procedure:** This block details the sequence of steps followed in performing the maintenance action. Reference to other approved procedures may be included in the MRC. On the MRC, safety precautions are listed prior to applicable steps and/or procedural action. The specific categories are:
  - **Warning:** Death or injury may result if the operating/handling procedures and practices are not followed correctly.
  - **Caution:** Damage to equipment may result if the operating procedures and practices are not followed correctly.
  - **Note:** This word will precede procedural advisories. It is used to alert personnel of essential information, project a final result, or highlight a particular condition.

An MRC is considered missing if any pages are missing, torn, mutilated, or is too dirty to read. To replace a missing MRC, inform your WCS. The WCS then goes to the SKED 2, which is the onboard computer scheduling software, and print out a new card. To print a replacement card, use the MIP SYSCOM Control number to locate the MIP and then the MRC SYSCOM Control number to locate the specific MRC on the MIP.

When an MRC applies to a number of identical items, an EGL is attached to the MRC. The EGL lists the serial number and location for each one of the items. This EGL cannot require more than eight hours of work. If more hours are required, there is a second EGL. Multiple EGLs for the same MRC are kept in a separate holder near the PMS deck or attached directly to the MRC.

It is important that you verify each MRC as the correct one to use when performing the proper maintenance procedure on a piece of equipment. Basically, you are confirming that you have the proper MRC, and it contains the most recent updates available. Your starting point for most maintenance tasks is the weekly schedule. The weekly schedule identifies your maintenance responsibilities and the MIP reference number, which leads you to the next steps. To verify the MRC, perform the following:

- On the weekly schedule, find your name and locate the MIP control number and periodicity code of the maintenance requirement you are scheduled to perform.
- On the LOEP, check the Force Revision date on the top. The date should be the date of the last Force Revision and be current to within the last six months. Force Revisions are updates performed every six months to the entire PMS Program.
- On the LOEP, locate the full MIP number.
- Locate the MIP and match the MIP number on the LOEP to the MIP Control Number on the MIP.
- Locate the periodicity code on the MIP and locate the MRC No. that corresponds to that periodicity code.
- Locate the MRC and match the MRC No. on the MIP to the SYSCOM MRC control number located in the top right corner of the MRC.
- If all the numbers match, you have a current card and can use it to perform the maintenance. If any of the numbers do not match, do not perform the maintenance and notify your Work Center Supervisor of the discrepancy.

**CHARACTERISTICS OF MAINTENANCE EVALUATIONS**

Shipboard evaluations are conducted by onboard personnel in accordance with OPNAVSEAINST 4790.8 series, 3-M Manual. Also, the TYCOM can visit during an Assist Visit or when requested by the ship or activity. If you performed the PMS, the inspector may ask you to repeat the PMS check you performed earlier. The inspector checks to verify that all required tools are available, safety precautions are followed, and that the procedures are applicable, possible, and completed on the equipment. When needed, the inspector provides training and instructional assistance, including advice concerning management of PMS, MDS, and other 3-M related problems. PMS is very serious. An inspection is not the time to ask for advice, as the TYCOM can ground a ship for failing an inspection.

Spot checks and inspections are an important part of maintaining a quality maintenance program. Individual maintenance requirements are spot checked periodically to determine the effectiveness of the PMS accomplishment. Once a week, maintenance requirements that have been “X” off as being fully accomplished are selected at random to be spot checked by the Group Supervisor, Division Officer, Department Head, 3MC, XO, or the CO. During the spot check on a maintenance requirement that you performed, you must describe or demonstrate all or some of the maintenance procedures that you performed and you must know how to verify the MRC.

Each ship is required to have an aggressive spot check program involving all levels of the chain of command from WCS to CO. Individual maintenance requirements will be spot checked periodically in order to determine the effectiveness of PMS accomplishment. The following spot check periodicities are the MINIMUM required for the command:

- **CO** 1 per ship Weekly
- **Executive Officer** 1 per ship Weekly
- **3-M System Coordinator** 5 per ship Weekly
- **Department Head** 1 per Division Weekly
- **Division Officer** 1 per WC Weekly
- **Group Supervisor** 1 per WC Weekly

If the assessor is completely satisfied that you performed the maintenance requirement correctly, the maintenance requirement is graded as Fully Accomplished. A grade of Not Accomplished may be given if you cannot demonstrate familiarity with the procedure; the tag-out was not completed properly, or if there was something that prevented you from fully completing the check. If there is evidence that the work was not completed and you said that it was completed, you will be accused of Gun-decking.

**CHARACTERISTICS OF INACTIVE EQUIPMENT MAINTENANCE AND PMS FEEDBACK REPORTS**

PMS provides the maintenance of the ship’s equipment when a ship or equipment is operational. However, a modified maintenance program is needed to prevent equipment deterioration during inactive periods, when complete PMS support is neither desirable nor practical. The objective of Inactive Equipment Maintenance (IEM) is to reduce PMS to the minimum during a prolonged inactive period without degrading material condition, or jeopardizing future operational reliability.
PMS provides the maintenance of the ship’s equipment when a ship or equipment is operational. However, a modified maintenance program is needed to prevent equipment deterioration during inactive periods, when complete PMS support is neither desirable nor practical. The objective of IEM is to reduce PMS to the minimum during a prolonged inactive period without degrading material condition, or jeopardizing future operational reliability. The two types of IEM status are:

- **Status I** – Equipment that will remain on board and will be inactive for thirty days or longer, and is not scheduled for corrective maintenance or overhaul.
- **Status II** – Equipment that is inactive for thirty days or longer and is directly subject to corrective maintenance, overhaul, or removal for safe storage or replacement.

IEM procedures are added to the end of existing MIPs and are separated from operational PMS by double horizontal lines. The IEM procedures are categorized using four codes, which tell you the kind of maintenance to perform.

- **Lay-up (LU)** maintenance actions prepare the equipment for periods of prolonged idleness, and are usually performed only once at the beginning of the inactive period. The periodicity code for Lay-up Maintenance is LU. Examples would be LU-1, LU-2, and so on.

- **Periodic maintenance (PM)** actions are accomplished on a recurring basis during the inactive period to prevent equipment deterioration. The periodicity code for Periodic Maintenance is PM. Examples would be PM-1, PM-2, and so on.

- **Start-up (SU)** maintenance actions ensure that the equipment is in a condition suitable for operation or to reactivate an equipment or system that has been inactivated for a prolonged period. The periodicity code for Start-up Maintenance is SU. Examples would be SU-1, SU-2, and so on.

- **Operational test (OT)** actions are those conducted to determine the operational condition of the equipment, its ability to function as designed, and to be integrated with other equipment to form a system. The periodicity code for the Operational Test is OT. Examples would be OT-1, OT-2, and so on.

PMS feedback reports (FBR) are official reports usually generated by either the 3MC or the TYCOM concerning PMS maintenance actions or discrepancies. There are three types of PMS Feedback Reports. Select each feedback report to learn about each one.

- **Category A (Non-Technical) FBR:** Category A feedback reports are intended to meet PMS needs that do not require a technical review. These reports are used to replace missing or mutilated MIPs and MRCs that are classified, or that cannot be generated from CD-ROM maintained on board. These reports go directly from the ship's 3-M Coordinator to the TYCOM. If unresolved by the TYCOM, the FBR continues routing to other applicable activities depending on the problem.

- **Category B (Technical) FBR:** Category B feedback reports are intended for technical discrepancies that inhibit PMS performance. They are used to get assistance in clarification of 3-M instructions and for notification of the shifting of maintenance responsibility from one Work Center to another. The Category B FBR is submitted to the applicable TYCOM by the ship's 3MC.

- **Urgent FBR:** Urgent feedback reports are related to PMS that involves the safety of personnel, the ship, or when potential damage to equipment is likely. These are forwarded by naval message, and describe the unsafe procedure or condition.
In the past, a staggering number of personnel suffered injuries or death from the improper operation or isolation of malfunctioning equipment. To minimize these accidents and mitigate the costs associated with repairing the damaged equipment, the Navy created the Tag-Out Program. The Tag-Out Program provides a standard, mandatory process for isolating a system, parts of systems or equipment that is malfunctioning and in need of maintenance or repair. It is important to familiarize yourself with the Equipment Tag-Out Program, associated roles and responsibilities, tags and labels, the Tag-Out Log and Records procedures, the Shift Operations Management System (SOMS) and applicable standards.

Terminal Objective - Demonstrate an understanding of the Equipment Tag-Out Program.
- Enabling Objective – Identify the roles and responsibilities of those associated with the Equipment Tag-Out Process.
- Enabling Objective – Identify the purpose of all tags and labels used as discussed in the Tag-Out User’s Manual.
- Enabling Objective – Identify the function of all the Tag-Out Log and Records.
- Enabling Objective – Demonstrate an understanding of the procedures for performing a tag-out.
- Enabling Objective – Identify the purpose of the SOMS.
- Enabling Objective – Identify the tag-out standards.
- Enabling Objective – Perform a simulated tag-out.

TAG OUT ROLES AND RESPONSIBILITIES
The tag out process is designed to increase safety and proper operation of all systems and components on a naval ship. You will now learn the roles and responsibilities of the individuals involved in the process. Many sailors and levels of leadership participate in the tag-out process, including: the CO, Department Heads, Authorizing Officer, Repair Activity (RA), RA Representative, Work Center Representative and the Ship’s Force personnel. Each has a different role and level of responsibility within the tag out process. Select each image to learn more about the roles and responsibilities of ship personnel involved in the Tag-out process.

-Commanding Officer is responsible for the safety of the entire command and ensures compliance with the Tag-Out User’s Manual. Permission must be obtained from the CO for using single barrier protection and for some tag-outs. These instances include tag-outs with live electrical switchboards, load centers, power panels, circuit breakers, electrical circuits, single valve protection to sea or to any seawater system that represents a significant flooding risk, fire-main to sprinklers for magazines containing live ammunition or deluge systems, all installed firefighting systems for one or more main spaces, and opening and closing of main engines.

-Department head reports directly to the CO. In the tag out process, Department Heads take responsibility for ensuring personnel assigned to their department understand and comply with the procedures of the Tag-Out User’s Manual.

-Authorizing Officer, designated by billet or watch-station, is the Watch Duty Officer for the propulsion plant who has final authority of the Tag-out Log. This includes authorizing tags or labels for issue and clearance. It is the Authorizing Officer’s responsibility to ensure that persons assigned to perform tag outs are qualified per the completion of 3-M 301, Maintenance Person, PQS. The Authorizing Officer is responsible for ensuring sufficient tags are used to ensure that the system and or equipment is in a condition that allows work to be accomplished without injury to personnel or damage to equipment.

- RA is any activity other than Ship’s Force that is involved in the construction or maintenance of the ship. The RA is responsible for ensuring the safety of repair personnel and must comply with the Tag-Out User’s Manual.

- RA Representative represents the repair activity and is authorized to witness and verify checking of posted tags, signs the tags, initials the Tag Out Record Sheet (TORS) and is the RA person responsible for ensuring the accuracy and adequacy of tag-outs.

- Work Center Representative is normally the Petty Officer in Charge (POIC) of a specific work item or the Work Center Supervisor of the work center performing the work item. Where a Work Center Representative signature is required, the signature also may be made by the Authorizing Officer or a superior in the performing Work Center Supervisor's chain of command who has personal knowledge that the work item is complete.

- Ship’s Force Personnel are those sailors assigned to the ship. This force is responsible for the maintenance and operation of the ship’s systems and equipment.

TAG OUT TAGS AND LABELS
It is important to tag and label malfunctioning equipment in order to minimize safety hazards to personnel and endangerment to equipment, systems and components. There are four different types of tags and labels used in to protect personnel and equipment: Danger tag, Caution tag, Out-of-Comission label, and Out-of-Calibration label.

Danger and Caution tags indicate equipment should not be operated or removed, or that specific instructions must be followed for its operation. Out-of-Comission and Out-of-Calibration labels identify instruments, such as meters and gauges that are not functioning within normal specifications. Danger tags are red. When posted, they prohibit the operation or removal of equipment which could endanger you and your shipmates, or cause serious damage to equipment, systems or components. Equipment should not be used when tagged with a danger tag. Caution tags are yellow. When posted, they provide temporary special instructions or indicate unusual action which must be exercised to operate the equipment. The instructive information on the tag provides the specific reason why the tag is installed and why you must exercise caution. This includes any special operating instructions required. If you see a Caution tag on a piece of equipment, make sure you read and understand the information provided before operating that piece of equipment.

Out-of-Comission labels are red. They are used if an instrument error is large or inconsistent. These instruments are defective or isolated from the system. An instrument with this red label is not reliable and must be repaired and recalibrated before reconnection to the system. Out-of-Calibration labels are orange. They identify instruments that do not have accurate readings. They should be used when the instrument error is small and consistent. You must apply the correction factor of the known instrument error to obtain an accurate reading.

TAG OUT LOG AND RECORDS
The Tag-Out Log administers the entire tag-out procedure and serves as the record of authorization of each effective tag out action. Therefore, it is important to be able to identify the function of the Tag-Out Log and records. While in port, the Tag-Out Log is normally kept in the Engineering Log Room and while underway, it is kept in the Damage Control Central. The log contains five sections, which have been bookmarked by tabs one through five.
The Tag-Out Log contains five sections:

- **Section 1** of the Tag-out log contains the Tag-Out User’s Manual and other amplifying instructions for administering the tag out process. This section also contains the list of Authorizing Officers.

- **Section 2** the Danger/CAution Tag-Out Index and Record of Audits - Commonly referred to as the Tag-out Index sheet, the form provides a ready reference of exiting tag-outs, while ensuring the sequential issuing of tag-out serial numbers for all tag-outs issued. It is also used by the Authorizing Officer to record the results of tag-out program audits.

- **Section 3** active Tag-Out Record Sheets (TORS) - The TORS are used to list all the tags associated with the tag-out of a specific system or component. It is also used to record discrepancies (including corrective actions) found during the audit of the particular tag-out action.

- **Section 4** Instrument Log - It has a sequential listing of all the labels for Out-of-Commission and Out-of-CALibration instruments.

- **Section 5** Cleared TORS and index pages - They are required to remain in this section until the next tag-out audit is completed.

### TAG OUT PROCEDURES AND PROCESSES

Understanding the tag-out process is an important part of being able to perform tag-outs in accordance with Navy instructions for routine maintenance or casualty isolation. To help you understand the tag-out process, we’ll break down the process into five basic actions: Preparation of tag-out, Independent Review, Authorization of tag-out, Posting of Tags, Checking Posted Tags.

There is more to the tag-out process than installing and removing tags. As tag-outs are critical for the safety of the crew and prevent damage to equipment, tag-out audits are conducted periodically for all active tag-outs. For example, ships that are in active, overhaul, conversion, or restricted availability require audits of the propulsion plant tag-out logs to be conducted weekly. The purpose of the audit is to ensure all tags/labels are applied correctly and are not damaged or missing. To conduct an audit, visually check all outstanding tags on each TORS to ensure that they are attached and the tagged items are in their prescribed position. Report all discrepancies in the check of actual position to the Authorizing Officer and RA Representative before proceeding any further with the tag audit. Take appropriate action to ensure the continued protection of personnel and equipment. Record the results of tag-out audits on the back of the TORS under the last tag listed and on the Tag-Out Index and Record of Audits. Also record the date completed, any discrepancies noted, and the signature of the person conducting the audit on these forms.

Missing or damaged tags can be discovered at any time, not just during an audit. If you notice a missing or damaged tag, immediately report it to the Authorizing Officer and the R.A. Representative, when applicable, so that prompt corrective action can be taken. The Authorizing Officer and the R.A. Representative are responsible for taking appropriate preventive measures to preclude changes to the item until it can be re-tagged. Also, if necessary, they recommend to their representative further action be taken based on their evaluation of the circumstances surrounding a missing or damaged tag. When a missing tag is discovered, the Authorizing Officer and RA Representative, when applicable, take the following actions:

- **Step 1:** Stop work affected by the missing tag and takes appropriate action to ensure the continued protection of personnel and equipment until a replacement tag is posted.

- **Step 2:** Evaluate and take additional actions if necessary.

- **Step 3:** Fill out a replacement tag and add it to the associated TORS. The replacement tag will be assigned the same number as the original tag.

- **Step 4:** Review the entries on the replacement tag and TORS for adequacy, completeness, and accuracy, and then sign the associated blocks on the replacement tag.

- **Step 5:** Have the replacement tag posted and verify the component’s position. Be sure to follow the procedure of paragraph 1.7.4.b (2) (b) in the Tag-out User’s Manual when verifying the position. When a manual tag-out system is used, after the replacement tag has been posted, write the number of the next tag on the next line containing blocks 14-22. This will prevent the reuse of tag numbers when new tags are added to the tag-out.

- **Step 6:** Indicate that the tag was missing on the tag line using blocks 19 through 20b of the TORS, for example, write “missing – replaced.”

- **Step 7:** Then the authorizing officer fills in/signs blocks 21 and 22 of the TORS for the missing tag.

When a tag is damaged, the Authorizing Officer and RA Representative, when applicable, shall take the following actions.

- **Step 1:** Cause a replacement tag to be filled out and added to the associated TORS using the same number as the original tag.

- **Step 2:** Review the entries on the replacement tag and TORS for adequacy, completeness, and accuracy, then sign the associated blocks on the replacement tag.

- **Step 3:** Cause the posting of the replacement tag. If verification of the affected component’s position is required, follow the procedure of paragraph 1.7.4.b(2)(b) in the Tag-out User Manual. When a manual tag-out system is used, after the replacement tag has been posted, write the number of the next tag on the next line containing blocks 14-22. This will assist in preventing reuse of tag numbers when new tags are added to a tag-out that has a replacement tag added.

- **Step 4:** Indicate that the tag was damaged in block 19 on the tag line, for example, write “damaged – replaced.”

- **Step 5:** The Authorizing Officer and RA Representative, when applicable, sign blocks 20a and 20b of the TORS to authorize clearing the damaged tag, after the replacement tag is posted.

In rare instances, there may be a time where a danger tagged component is out-of-position or a danger tag on the wrong component. In these cases, there are procedures you need to follow in order to ensure proper action is taken to correct these deficiencies. This ensures that personnel working near tagged components do not get injured or nearby functional components do not sustain damage. There may be times when you encounter a tag placed on the wrong component. This can be identified by the tag nomenclature differing from the actual component ID, for example. In the instances of a tagged component out-of-position or a danger tag on a wrong component, the following actions are taken.

- **Step 1:** Report the condition immediately to the Authorizing Officer and RA Representative, if applicable.

- **Step 2:** Stop the affected work, notify the Department Head and appropriate RA Representative, and take appropriate action to ensure the continued protection of personnel and equipment.

- **Step 3:** The Authorizing Officer and RA Representative shall authorize clearing the tag on the component found out-of-position or wrongly tagged, and the tag is cleared. The Authorizing Officer shall ensure the component is placed in the appropriate position.

- **Step 4:** Have a replacement tag authorized and posted.

- **Step 5:** Conduct an investigation to determine the circumstances surrounding a danger tagged component found out-of-position or wrongly tagged.

- **Step 6:** The Authorizing Officer and the RA Representative, when applicable, shall verify plant conditions/system status and determine any effects on plant conditions/system status.

- **Step 7:** Recommend work when authorized by the appropriate Ship’s Force Department Head and the appropriate RA Representative.
SHIFiT OPERATIONS MANAGEMENT SYSTEM (SOMS)

Experience has shown that the manual tag-out process is a tedious and time-consuming task in plant operations management. Use of a computerized system to assist in Tag-Out activities can result in a significant saving of time and money by making the process more efficient. Computerized tag-out systems can also assist to enhanced protection of plant personnel and equipment by eliminating or minimizing costly errors due to oversight, or overwork. The purpose of the Shift Operations Management System (SOMS) is to automate many of the tag-out tasks, making our jobs a lot easier. The SOMS generates equipment tag-outs and prints tag-out forms. It also tracks work orders as well as the personnel working under the protection of tag-outs. It even provides status reports on tag-outs, equipment, work orders, and personnel.

All the requirements of the Tag-Out Program per the Tag-Out User’s Manual are incorporated by the SOMS. The basic authorization and procedures to conduct a tag-out in SOMS is the same as the manual tag-out, except that record sheets and tag labels are developed and tracked electronically instead of written manually. This automation saves a lot of time and helps to eliminate errors. The SOMS provides a variety of functions in addition to the traditional Tag-Out Program. The SOMS is a Line Item Driven Tag-Out. The software issues electronic tags and keeps track of all the jobs per component. Only one physical tag is assigned to a component, even if multiple tag-outs for that isolation point are active. The software only authorizes the removal of the physical tag when the last job on that component is completed and released.

The SOMS contains three separate, but interactive databases of tag-outs.

- The Master Tag-Out database acts as a template for Active Tag-Outs. Master Tag-Outs can be entered from scratch, or created automatically by copying previously prepared Active or Archived Tag-Outs.
- The Active Tag-Out database is used to take equipment out of service, and place the equipment back into service. Active Tag-Outs can be entered from scratch or created automatically by copying previously prepared Master and or Archived Tag-Outs.
- The Archived Tag-Out database maintains a record of all tag-outs that have been closed or released.

Equipment entries are automatically verified for accuracy against the central equipment database. Equipment can be added to the database as necessary. Electronic sign-on/off for authorization and validation. Varying levels of security are provided to allow user rights and permissions. The SOMS warns the users if equipment to be tagged or released is in conflict with other clearances, active procedures, or equipment deviations. Temporary lifts can be used to track activities associated with equipment testing and manipulations. Tracking of equipment clearance configuration activities can be performed via mobile computers or printed forms. A variety of reports can be generated to track tag-outs and create audit sheets.

TAG OUT STANDARDS

While the tag-out process is largely standardized, there are additional standards when conducting mechanical, electrical, and common industrial maintenance tag-outs. Being able to identify these tag-out standards is important to understanding the expectations for ensuring that tags relating to these specific types of tag-outs are conducted correctly.

For mechanical tag-outs, the System/Component Identification block on tags and the TORS normally only include the valve number. For valves and operators with no valve number on the label plate, such as a mechanical hand crank operator for the main ballast tank vent valves, the function of the component and its location are used. There are three types of mechanical valves and various associated temporary equipment applicable to mechanical tag-outs.

For manual valves, ensure the tag posted is readily apparent to anyone who may attempt to operate or remove the valve once tagged; the tag should be posted on the valve operator, if installed, or the valve stem. If these locations are inappropriate for some reason, the tag may be attached to the valve yoke, bonnet, or another readily apparent location. Tags attached to Quick Throw type valve handles must be securely attached to prevent the tag from sliding off the smooth, un-tapered handle. For valves with multiple operating hand-wheel/stations, danger tags must be posted at each location.

Control valves, such as hydraulic directional control valves, may be used to provide control fluid isolation to secure a system valve operator, such as a hydraulic actuator of a main seawater system valve, in a reduced position (e.g., shut, open, port C to A, etc.). You must ensure the control valve is in the required position and all modes of operation (e.g., manual, mechanical, electrical, etc.) are secured and danger tagged to prevent inadvertent repositioning.

For control valves with a manual operating lever, post the tag on the associated control valve-operating lever to provide control fluid isolation to the associated component/actuator. For mechanically operated control valves, means must be provided to secure and tag the valve mechanical operator to prevent inadvertent operations. Hydraulic control valves have operating levers in high traffic areas that can be easily bumped or mistakenly grabbed. When tagging them out, they must have the levers physically secured in the required position with lock-wire or a pin. When utilizing remotely operated valves for pressure barriers, the tag must reflect the position of the remote operator and the valve that it operates.

For temporary equipment: blanks, freeze seals, and restraining devices such as mast shoring and clamps, etc. Danger tags will be used to indicate the presence of, and the requirements for, all of these temporary mechanical safety devices.

There are specific electrical tag-out standards for electrical breakers and switches. Electrical breakers with remote operating capabilities are tagged both at the breaker and at the operating stations. You may use breaker clips or covers to prevent inadvertent operation of tagged breakers.

There are three types of switches that have unique standards, switches with multiple positions, switches inside panels, and push-button switches. For switches that have multiple positions, the switch is danger tagged in a position that isolates the required circuit and still provides power to operate the remaining active circuit. Tagging of ground isolate switches that are located internal to a panel is minimized. Tags may be attached to the external portion of the panel to ensure that the close proximity of the panel internals, and the presence of the tag, do not present a repositioning hazard. For push-button switches, danger tags are only used in cases where it is possible to positively verify the push button position by use of other indications.

Ship’s Force must understand that all of the applicable line entries make the isolation complete. This concept must be thoroughly understood when there is the need to revise/change one of the respective tag-outs (e.g., proper Petty Officer/officer checking of tag-out line entries). If a permanent label-plate is not installed, a temporary label-plate/tag is installed with a two party independent check/verification. It must be installed, signed, and dated by the second knowledgeable party. The temporary label-plate/tag must have sufficient information to clearly identify the component. A danger tag may only be posted after the required component is properly labeled. For availabilities involving shipyards,
work items may be added to an existing Work Authorization Form (WAF) rather than to the TORS. Item must be within the boundaries and scope of the WAF.

All ships ensure appropriate barriers are established and maintained during the performance of maintenance. All barriers used for maintenance, except for certain check valves, must be danger tagged to prevent inadvertent operation or removal of barrier protection. All valve control devices used to disable the barrier valve must be danger tagged. There are different tasks for valves/actuators that are operated electrically and those that are operated with air. If the control valve or an actuator is electrically operated, the fuses must be removed and the circuit danger tagged or the electrical connector must be disconnected and danger tagged so that the control valve or actuator cannot be accidentally energized. If the control valve or actuator is air operated, the air supply isolation valve must be shut and danger tagged so the control valve or actuator cannot be accidentally operated by air.
HAZARDOUS MATERIALS

Hazardous material, or HAZMAT, is any material or substance that may pose a substantial hazard to human health or the environment. Using caution while working with HAZMAT is common sense, however, it is easy to forget the proper safety precautions associated with certain substances.

**Terminal Objective** – Use hazardous material on a daily basis safely and effectively.

- **Enabling Objective** – Identify hazardous material and the training requirements for the program.
- **Enabling Objective** – Identify labels and categories of hazardous material.
- **Enabling Objective** – Identify the information, which can be found on Safety Data Sheets.
- **Enabling Objective** – Identify publications, references, and lists associated with hazardous material and their location.
- **Enabling Objective** – Identify the safety precautions used in the stowage and handling of hazardous material.
- **Enabling Objective** – Identify the purpose and basic procedures of the HAZMAT Use/Waste Handling and Disposal program.

**HAZARDOUS MATERIAL AND TRAINING REQUIREMENTS**

As a Sailor, you will use hazardous materials aboard ship for a variety of equipment maintenance tasks. It is important to know how to identify hazardous material, including how they are labeled and stored and the training requirements of the Hazardous Materials Training Program.

The purpose of Hazardous Material Control and Management (HMC&M) standards is to address the storage, use, and disposal of all hazardous materials. The Navy Safety and Occupational Health (SOH) Program Manual for Forces Afloat (OPNAVINST 5100.19 Series) provides the detailed guidance that ship need to properly manage and control hazardous materials. Special precautions are required for the stowage, handling, and use of these materials aboard ship because they present significant hazards, such as fire, toxicity, dermatitis, asphyxiation, and burns.

Upon reporting aboard ship and annually thereafter, you will receive job-specific training on hazardous material by your WCS. This training includes:
- Recognizing types of hazardous material in your work areas and aboard ships.
- Recognizing used and excess HAZMAT and understanding how to dispose of HAZMAT.
- Reading and interpreting HAZMAT labels.
- Understanding information provided in Safety Data Sheets, or SDSs, and knowing where to find a copy of SDSs.

You will also become familiar with general information on hazardous material handling, storage, use, and disposal, along with the use of protective measures when handling HAZMAT. Training is the best way to refresh your skills and stay current on hazardous material regulations. Yearly HAZMAT training is important to refresh your knowledge on hazardous material regulations.

**LABELS AND CATEGORIES OF HAZARDOUS MATERIAL**

HAZMAT are grouped into categories and given labels in order to make them easy to identify. Categories help determine if the material is hazardous or if they have specific instructions governing their control. Labels help quickly identify the type of hazardous material and how it should be handled. Being able to identify labels and categories of hazardous material is the first step in safety while handling them.

HAZMAT is grouped into flammable and combustible liquids, compressed gases, toxic materials, corrosive materials, oxidizing materials, and aerosol containers. Some materials are not categorized as hazardous because they have specific instructions governing their control. These materials include: ammunition, weapons, explosives, propellants, pyrotechnics, chemical and biological warfare materials, explosive actuation devices, pharmaceutical supplies, medical waste, infectious materials, bulk fuels, and radioactive material.

Labels help Sailors differentiate between a cleaning solution and a dangerous corrosive. Precautionary labels are attached to each container of HAZMAT, but they are only helpful if you understand them. Hazardous material containers must clearly identify hazard pictograms, a signal word, hazard and precautionary statements, the product identifier, and supplier identification. If hazardous material is transferred from one container to another, the new container is labeled in the same manner as the old container.

The National Fire Protection Association (NFPA) diamond is used to visually represent flammability, health, reactivity, and special information about the hazard. Numbers from zero to four are placed in red, blue, and yellow diamonds to show the degree of hazard present.

**The blue diamond indicates health hazards.**

4–Deadly: Too dangerous for firefighters. Normal breathing apparatus and protective clothing do not provide adequate protection.
3–Extreme Danger: Indicates that the material is extremely dangerous. Enter this area with extreme care.
2–Hazardous: Enter area freely with a self-contained breathing apparatus.
1–Slightly Hazardous: Enter area freely with a self-contained breathing apparatus.
0–Normal Material: Exposure to fire would offer no health hazard.

**The red diamond indicates flammability hazards.**

4–Below 73º F: Very flammable gases or volatile liquids. If possible, keep cooling water in containers. Withdrawal may be necessary.
3–Below 100º F: Must be moderately heated before ignition can occur. Water spray may be used to extinguish the fire.
2–Below 200º F: Must be preheated before ignition can occur. Water spray may be used to extinguish the fire.
1–Above 200º F: Will not burn. Will not burn.
0–Will Not Burn: Will not burn.

**The yellow diamond indicates reactivity or stability hazards.**

4–May Detonate: Likely to explode when heated; Too dangerous for firefighters to approach the fire.
3–Shock and Heat May Detonate: May detonate when heated and under confinement. Too dangerous to approach, but hose handlers can be set up from behind an explosion resistant location.
2–Violent Chemical Change: Will undergo a violent chemical change with elevated temperatures and pressures. Use solid stream water from a distance to cool the material.
1–Unstable if Heated: Normally stable but may become unstable in combination with other materials or at elevated temperatures and pressures. Use normal precautions when approaching.

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1–Unstable if Heated: Normally stable but may become unstable in combination with other materials or at elevated temperatures and pressures. Use normal precautions when approaching.
0–Stable: Does not produce any reactivity hazard.

Situational awareness is the key factor in avoiding mishaps. It is important to know what and who is around you. Hazardous material warning signs let you know that you are in the presence of a hazard. These warning signs are used to warn you of a material’s primary hazard rather than specific effects. Warning signs are classified into one of nine hazard classes:

- Explosives.
- Flammable gases.
- Flammable and combustible liquids.
- Flammable solids.
- Oxidizers.
- Poisonous materials.
- Radioactive materials.
- Corrosive materials.
- Miscellaneous hazardous materials.

SAFETY DATA SHEETS INFORMATION

The Hazard Communication Standard (HCS) requires chemical manufacturers, distributors, or importers to provide Safety Data Sheets (MSDSs) to communicate the hazards of hazardous chemical products. MSDSs are technical bulletins that provide information about the properties of each chemical, physical, health and environmental health hazards, protective measures, and safety precautions for handling, storing, and transporting the chemical. It is important to be able to identify the information found on MSDSs in order to follow proper handling and safety precautions.

MSDSs are required to be presented in a consistent, user-friendly, 16-section format. This helps those who handle hazardous materials easily find the information they need, once they are familiar with the format. A copy of the MSDS for each material is stored in the HAZMAT locker. You have the right to review a copy of the MSDS for any chemical material in your work area.

- **Section 1:** Identification includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.
- **Section 2:** Hazard(s) identification includes all hazards regarding the chemical; required label elements.
- **Section 3:** Composition/information on ingredients includes information on chemical ingredients; trade secret claims.
- **Section 4:** First-aid measures includes important symptoms/effects, acute, delayed; required treatment.
- **Section 5:** Fire-fighting measures lists suitable extinguishing techniques, equipment; chemical hazards from fire.
- **Section 6:** Accidental release measures list emergency procedures; protective equipment; proper methods of containment and cleanup.
- **Section 7:** Handling and storage lists precautions for safe handling and storage, including incompatibilities.
- **Section 8:** Exposure controls/personal protection lists OSHA’s Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE).
- **Section 9:** Physical and chemical properties lists the chemical’s characteristics.
- **Section 10:** Stability and reactivity lists chemical stability and possibility of hazardous reactions.
- **Section 11:** Toxicological information includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.
- **Section 12:** Ecological information.
- **Section 13:** Disposal considerations.
- **Section 14:** Transport information.
- **Section 15:** Regulatory information.
- **Section 16:** Other information includes the date of preparation or last revision.

PUBLICATIONS, REFERENCES, AND LISTS ASSOCIATED WITH HAZARDOUS MATERIAL AND THEIR LOCATION

The location of hazardous material related documents, such as the Hazardous Material Information System, MSDSs, Shipboard Hazardous Materials List, list of authorized hazardous material storage locations, the ship’s HAZMAT inventory, and the Hazardous Material User’s Guide are discussed in local instructions. However, a copy of the MSDS for each hazardous material should be kept in each HAZMAT locker where it is stored.

Being able to identify publications, references, and lists associated with hazardous material and their locations is important so that proper handling and safety precautions are always at your fingertips. The Shipboard Hazardous Materials List, or SHML, is a record of hazardous materials authorized aboard U.S. Navy surface ships. It provides surface ships with the ability to determine hazardous material authorized onboard and preclude the stocking of dangerous material for which the ship has no use. For ease of use, the SHML is provided quarterly on CD-ROM.

The SHML can be searched using the federal supply code, national item identification number, nomenclature, or part number. Each list item is marked with a hazardous material use category in the Allowed on Board data field. The Naval Supply Systems Command working with the technical systems commands assigns the following use categories based on a technical, safety, and health assessment of the product:

- “A” indicates the material is approved for use aboard the ship.
- “P” indicates the material is prohibited from use on the ship.
- “O” indicates the material is obsolete.
- “N” indicates the material has not been determined. This hazardous material is under review for authorization for use aflloat.
- “R” indicates the material is not allowed on surface ships except with certain restrictions.

HAZARDOUS MATERIAL STOWAGE AND HANDLING SAFETY PRECAUTIONS

Materials normally thought to be safe may be hazardous under certain conditions, so they must be stored in a manner that ensures that incompatible chemicals are separated, in order to avoid accident or injury. Therefore, it is important to identify the safety precautions used in the stowage and handling of hazardous material. Never store an excess supply of hazardous materials in your work area; they must be stored in a hazardous materials locker or storeroom. Surplus materials must be returned to the appropriate storage area or Hazardous Material Minimization Center, a shore facility, when not in use. All HAZMAT containers are checked for tightness of closure, corrosion, leakage, improper or inadequate labeling, and expired shelf-life.

Always ensure that hazardous materials stowage locations other than cabinets and lockers are equipped with supply and exhaust ventilation. The proliferation of readily-combustible materials, exotic chemicals, fuels and metals and toxic gas producing materials aboard ships cause extreme
personnel and ship survivability hazards during battle. Additionally, many materials create splinter and shrapnel hazards under extreme shock conditions associated with major battle damage. The combined effect may seriously jeopardize the survivability of the ship. In-use flammable liquid cabinets, within or near the workspace, are used to stow a seven-day quantity of flammable liquids used on a daily basis. Do not use cabinets to store more than 30 gallons of flammable liquid per space. Follow these safety precautions when working with flammable liquids:

- Liquids such as coolants, hydraulic fluids, lubricants, and aerosols must be stowed in flammable liquid storerooms, ready service storerooms, or issue rooms.
- Only enough hazardous material essential for immediate need during a work shift shall be issued.
- Large quantities of flammable and combustible liquids with a flashpoint of less than 200°F must be stored in flammable liquid storerooms, ready service storerooms, or issue rooms.
- Flammable liquids with a flash point of less than 200°F should never be stored in machinery spaces.

Lockers and cabinets, used for in-use flammable and combustible liquids, should have permanently mounted labels that read, “Flammable/combustible liquids during strip ship condition. Relocate the contents of this cabinet to a flammable liquids storeroom, issue room, or ready service storeroom.”

Strip ship condition refers to the Strip Ship Bill which establishes policy and procedures for the identification and labeling, evaluation, and eventual removal of hazardous material from ships in preparation for battle. This bill assigns responsibilities and duties under the authority of the CO in removal of hazardous material as well as review of items before installation or receipt on board.

When handling hazardous material, you must wear the protective clothing required for that material, which may include aprons, gloves, goggles, and/or respirators; ensure that you are properly trained on the hazards associated with the material you are handling; avoid prolonged skin or eye contact; and avoid breathing vapors or dust from hazardous materials.

- **Hydraulic Fluids and Synthetic Lubricants:** When using, handling, and storing hydraulic fluids and synthetic lubricants aboard ship, heed the precautions found on the MSDS for that material. The MSDS is extremely useful in identifying safety precautions, personal protective equipment (PPE), spill response, and immediate first aid recommendations prior to working with HAZMAT.

- **Paints:** There is no smoking in the vicinity of a Sailor working with paint. If you are the one working with paint, ensure the following:
  - Post NO SMOKING signs.
  - Wear supplied air respirators when spray painting in confined spaces.
  - Provide exhaust ventilation in enclosed areas.
  - De-energize electrical equipment in compartments being painted.
  - Return all paints and thinners to the paint lockers upon completion of the job, at the end of the workday, or when taking a lengthy break.

- **Synthetic Lube Oil:** When working with synthetic lube oil, safety goggles, a splash suit or coveralls, and rubber gloves must be worn.

- **HyPOCHLORITE:** Do not mix calcium hypochlorite with anything but water. Do not allow calcium hypochlorite to come into contact with paints, oils, greases, or organic materials and avoid contact with skin or eyes. Do not reuse containers for any purpose.

- **SOLVENTS:** When using solvents, provide adequate ventilation or wear respirators; wear protective clothing; and avoid contact with eyes or skin.

- **CAUSTIC SODA:** When using caustic soda, wear goggles and chemical resistant rubber gloves and mix in distilled water only.

- **MERCURIC NITRATE:** When using mercuric nitrate, wear goggles and chemical resistant plastic or rubber gloves; absorb any spill with rags or absorbent transfer rags, or absorbent to a sealable plastic bag marked CONTAINS MERCURY WASTE, and hold for shore disposal.

- **REFRIGERANTS:** When using refrigerants, never drop cylinders; never attempt to mix gases in a cylinder; and store cylinders in a cool, dry place and in an upright position. Never fill refrigerant cylinders above 85% capacity and never allow a cylinder to be subjected to temperatures above 130°F. When refrigerant comes into contact with excessive temperatures, it breaks down into toxic gases.

- **STOCK REAGENTS:** When using stock reagents, wear goggles, chemical resistant plastic or rubber gloves, and an apron.

- **LIQUID PETROLEUM GASES:** Liquid petroleum gases are flammable when mixed with air in certain proportions from 2% to 9.5%. Never allow fuels such as acetylene, hydrogen, oils or grease to be close to oxygen producing and storage devices. A leak from these items in close proximity to each other may result in a serious fire and/or explosion.

### PURPOSE AND BASIC PROCEDURES OF THE HAZMAT USE/WASTE HANDLING AND DISPOSAL PROGRAM

Proper hazardous material use, waste handling, and disposal are critical in keeping the ship and crew safe by preventing needless accidents; therefore, it is important to identify the purpose and basic procedures of the HAZMAT Use/Waste Handling and Disposal program. While aboard ship, you will encounter used or excess hazardous materials and must to be aware of how to collect and dispose of them. It is important to follow proper protocol when handling and storing used hazardous material containers. The following safeguards must be followed when handling used HAZMAT:

- Containers must be securely sealed using the installed or provided closure device to ensure the container does not leak during transportation.
- Containers must be properly labeled to indicate content.
- Containers must be stowed in appropriate locations.
- Used HAZMAT that is collected shall be segregated.
- Used HAZMAT shall either be placed in the original material’s container or in an impervious container specified in the OPNAVINST 5100.19 series.
- All used HAZMAT in a container should be of only one stock number.

HAZMAT, for which there is no further use on board the ship, is considered used or excess. Hazardous waste is any discarded, or intended to be discarded, material, liquid, solid, or gas, which meets the definition of hazardous material and/or is designated as hazardous waste by the Environmental Protection Agency or State Authority. Full, properly sealed containers of usable hazardous material, in excess of the work center’s needs, are turned in to the Supply Officer. The Supply Officer, or Hazardous Material Minimization Center supervisor, determine if this material may be used elsewhere in the ship or if it exceeds the ship’s needs. If the material exceeds the ship’s needs, it is transferred to the supporting Fleet and Industrial Supply Center with a properly completed DD Form 1348-1 for each National Stock Number of material being transferred.

Ships are required to transfer used or excess HAZMAT or hazardous waste in properly sealed containers to a Navy shore activity to determine its further use. Asbestos and lead require special guidance for handling and control. They are addressed specifically in OPNAVINST 5100.19
The safety precautions for handling used or excess hazardous materials are the same as for handling usable materials. Use the SDS as your source for safety precautions.

**VARIOUS PERSONNEL AND PERSONAL RESPONSIBILITIES ASSOCIATED WITH HAZARDOUS MATERIAL**

Many people are involved in the different responsibilities of handling, care, and storage of hazardous materials. It is important to identify various personnel and personal responsibilities in order to efficiently and safely work with hazardous materials.

- **The Safety Officer:** in conjunction with the Master-at-Arms force, is responsible for spot checking to ensure the day-to-day compliance with HAZMAT safety. Such spot checks include checking for improper stowage and checking for proper use of hazardous materials and management of used/excess HAZMAT. The Safety Officer must also ensure that the Hazardous Material Control and Management Program is evaluated annually for compliance and effectiveness.

- **Hazardous Materials Coordinators:** must ensure that management of shipboard HAZMAT follows procedures and precautions outlined in the OPNAVINST 5100.19 series. They are responsible for:
  - Training supervisors annually in the proper marking, handling, stowage, usage, spill response, and disposal procedures relative to HAZMAT and in the use of Material Safety Data Sheets (MSDSs).
  - Determining the locations and quantities of all HAZMAT kept aboard ship.
  - Retaining the Hazardous Material Information System (HMIS), this contains MSDS information and SDSs for locally purchased material or for materials not covered in the HMIS.
  - Ensuring that hard copy MSDSs are available to personnel or their supervisor upon request.
  - Ensuring a physical inventory of all HAZMAT aboard the ship is conducted annually.

This inventory is compared to the Shipboard's Hazardous Materials List (SHML). Any differences between the inventory and the SHML shall be resolved either by transferring the material as used or excess HAZMAT or submitting a change to the SHML to reflect the requirement for the material.

- **The Division Officer:** ensures that approved personal protective clothing and equipment are available for HAZMAT operations or incidents and those personnel are trained in their proper use and maintenance. They ensure that prior to using and handling any HAZMAT, those personnel have been trained on the hazards associated with that material, are aware of MSDS information and its location, and have an MSDS available for each hazardous material used. Division Officers also ensure that all personnel are indoctrinated upon reporting aboard, and annually thereafter, in the handling, usage, reutilization, and storage and disposal of HAZMAT and in responding to HAZMAT spills. They maintain records of stock levels, locations, and usage of HAZMAT stored within division spaces, as well as obtaining the Commanding Officer's authorization for all open purchased items by the division.

- **Work Center Supervisors:** train work center personnel in the use of MSDSs. They ensure that prior to using any HAZMAT; those personnel under their supervision have been trained on the hazards associated with that material and are equipped with the proper protective equipment. They also ensure that the Damage Control Petty Officer (DCPO) has conducted PMS on flammable liquids storage lockers. If HAZMAT is stored by the work center, the supervisor inspects HAZMAT storage locations monthly for flammable liquids and quarterly for other HAZMAT.

- **Individual crew members:** are responsible for returning HAZMAT to appropriate stowage or to the Hazardous Material Minimization Center (HAZMINCEN) upon completion of use or at the end of the workday, whichever is earlier. Crew members must always follow the instructions for proper use of HAZMAT and report any spills to the Officer of the Deck, Division Officer, and Damage Control Central.

All hands are responsible to ensure that HAZMAT transferred into new containers is properly marked. It is also everyone's responsibility to ensure the collection and segregation of any residue resulting from HAZMAT transfer, and to ensure all HAZMAT is properly stowed or that any improperly stowed HAZMAT is returned to the HAZMINCEN. Many people aboard ship handle hazardous materials and are therefore involved in the safety responsibilities of those materials.
In the Navy, you need to be prepared to perform basic first aid on your fellow shipmates. Having a basic idea of how to treat the injured, can help save the life of a fellow Sailor until medical care arrives. Treating the injured requires identification of how to provide the competent care that makes the difference between life and death, temporary or permanent injury, and rapid recovery or long-term disability.

**Terminal Objective** - Identify Basic First Aid concepts and procedures.

- **Enabling Objective** - Identify the objectives, priorities, procedures, and general rules involving first aid.
- **Enabling Objective** - Identify the symptoms and treatment for heat exposure injuries.
- **Enabling Objective** - Identify the symptoms and treatment for bum injuries.
- **Enabling Objective** - Identify the first aid procedures for treatment of injuries to personnel.
- **Enabling Objective** - Identify the first aid procedures for treatment of fractures.
- **Enabling Objective** - Identify the four methods used to control bleeding.
- **Enabling Objective** - Identify the first aid procedures for treatment of toxic inhalation poisoning.
- **Enabling Objective** - Identify the proper methods and techniques for transporting injured personnel.

**OBJECTIVES, PRIORITIES, PROCEDURES, AND GENERAL RULES OF FIRST AID**

First aid is the emergency care given to a sick or injured person until competent medical care is available. The purposes of first aid are to save life, prevent further injury, and to minimize or prevent infection. While administering first aid, the three primary objectives are to maintain an open airway, maintain breathing, and to maintain circulation. During this process, you also control bleeding and reduce or prevent shock.

A victim is kept lying down with their head level with the body until the type and seriousness of the injury or illness is determined. If the victim shows difficulty breathing, bleeding around the mouth, and/or is semi-conscious, position the victim on their back. Place their head lower than their feet, and then turn the victim lying on their side. This reduces the victim’s chances from choking on blood, vomit, or water.

Place the victim in a sitting or semi-sitting position if the victim has a chest injury or breathing difficulties such as shortness of breath. For shock, place the victim on their back with their head slightly lower than their feet. Reassure the victim and keep them comfortable and warm enough to maintain their body temperature. The victim can endure more pain and discomfort if they are confident of your ability. Carry the victim with their feet forward during transport. This allows the rear stretcher bearer to monitor the victim for respiratory obstruction or stoppage of breathing.

Do not move the victim unless it is necessary. The victim may have unseen injuries and you could cause additional problems if the victim is moved unnecessarily. You may need to cut or rip the clothing along the seams to facilitate determination of the extent of injuries. Do not touch any wounds or burns with your fingers or unsterile objects. Always place a barrier between you and blood or body fluids using gloves or clean cloth. The only exception to this rule is when it becomes necessary to stop bleeding, and a sterile dressing is not available. If the person is unconscious, do not administer any food, water, or medications by mouth.

Shock is the failure of the heart and blood vessels, to maintain enough oxygen-rich blood flowing, to the vital organs of the body. Shock does not cause a loss of blood, but a marked loss of blood pressure is a characteristic. One common symptom of shock includes vacant, or lackluster, eyes with dilated pupils. The victim may also be experiencing shallow or irregular breathing, pale, cold, and moist skin, and/or a weak or absent pulse. Properly treating shock depends on you remaining calm and upon keeping the victim calm and comfortable. Lay the victim down with their feet and legs positioned higher than their head and keep them covered with a coat or blanket.

**SYMPTOMS AND TREATMENT FOR HEAT EXPOSURE INJURIES**

Heat exposure injuries are a threat in any hot environment, especially in desert or tropical areas and in the boiler rooms of ships, but most cases are preventable. Excessive heat affects the body in a variety of ways. When a person exercises in a hot environment, heat builds up inside the body. To get rid of this heat, the body sweats. If the body loses large amounts of water and salt from sweating, heat cramps and heat exhaustion may develop. If the body overheats, the body’s heat regulation mechanism malfunctions and shuts down. The result is heat stroke.

The three stages of heat exposure, in severity from least to worst are: heat cramps, heat cramps, and heat stroke.

Excessive sweating may cause painful cramps in the abdomen and leg and arm muscles. Heat cramps are muscular pains and spasms resulting from the loss or depletion of water, electrolytes, and salt from the body. Heat cramps can also result from drinking ice water or other cold drinks too quickly or drinking large quantities of liquids after exercise. Heat cramps are often an early sign of approaching heat exhaustion. The most common symptoms of heat cramps are muscle pain and spasms.

Treatment includes moving the victim to a cool or air conditioned area, giving them one-half glass of cool water every 15 minutes if they can drink, and gently stretching or massaging the muscle to relieve the spasm. Request medical assistance if the victim has other injuries, or does not respond to these procedures. As an engineer, most of your workday may be spent in the engineering plant where normal operating temperatures in the space often average over 85 degrees Fahrenheit.

Heat exhaustion is the most common condition caused by working in a hot space. It is caused by the excessive loss of water and salt. This is a good enough reason to drink plenty of fluids, especially water. Heat exhaustion produces a serious disruption of blood flow to the victim’s vital organs, including the brain, heart, and lungs. The disruption of blood flow causes the victim to experience dizziness, weakness, headache, loss of appetite, and nausea. The skin appears ashen (or pale) and has a cold, moist, and clammy feeling, as well as a normal or below normal body temperature. The victim’s breathing may be shallow, with a weak and rapid pulse, and the pupils may be dilated. Treat heat exhaustion just like shock. Move the victim to a cool area. Apply a cool, wet cloth to help the body cool down. Remove the victim’s clothing but Do Not allow the victim to become chilled. If the victim is conscious and can drink, give him or her one half glassful of cool water every 15 minutes. If the victim vomits, stop giving water. Do NOT give salt tablets. Request medical assistance for heat exhaustion victims as soon as possible.

While heat exhaustion can make you seriously ill, heat stroke can kill you. In fact, heat stroke has a 20% mortality rate. Heat stroke victims suffer from the breakdown of the sweating mechanism and are unable to get rid of excess body heat. Since you can’t cool off, your body’s temperature rises. If the body temperature becomes too high, permanent damage occurs to the brain, kidneys, and liver. The symptoms of heat stroke include hot and dry skin. The victim’s breathing may be deep and rapid at first but later becomes shallow and almost absent. The victim’s pupils may constrict to pin points as well. To treat a victim of heat stroke, you need to reduce the heat immediately. Promote cooling with
whatever practical means possible. Move victim to the coolest available place, as well as removing as much clothing as possible. The victim should be lying on their back with head and shoulders slightly elevated.

**SYMPTOMS AND TREATMENT FOR BURN INJURIES**

Burns and scalds are essentially the same type of injury and can be very serious, even life threatening. Dry heat causes burns while moist heat causes scalds. Burns classifications are either first, second, or third degree, according to their depth in the body’s tissue. Being able to identify the symptoms and treatment for burn injuries is beneficial to know how to treat it.

- **First degree** burns are characterized by redness and tingling in the affected area. Mild sunburn is the most common type of first degree burn.
- **Second degree** burns are characterized by blisters and mottling in the affected area. The affected areas may also “weep” (bodily fluids slowly oozing out). Two examples of this type of burn can be severe sunburn or a rope burn as it slips from your hands.
- **Third degree** burns are full thickness injuries that penetrate into the muscle, connected tissues, and even down to the bone. Pain may be absent from the actual burn site, if all the area nerve endings are destroyed. Tissue color will range from white, due to scaling, or black due to charring.

When evaluating the seriousness of the burn, the extent of the burn area is more important than the depth of the burn. Also, the location of the burn is of great importance. Serious burns on the head, hands, feet, and genitals require hospitalization. A burn to the face requires you to guard the victim’s airway. When treating a burn, administer first aid ONLY to the minimum. Ensure you protect the area of the burn by covering it with clean sheets, or dry sterile dressing (dressings). Do not remove clothing which adheres to the wound; you may accidentally remove some layers of skin from the burn site. You should take care whenever you use cleaning solutions. When the acids, alkalis, and other chemicals come in contact with the skin, they may cause injuries commonly referred to as chemical burns. These burns occur not by heat, but by the direct chemical destruction of the body tissues.

To treat a chemical burn, quickly flush the affected area with large amounts of water. If possible, identify what type of chemical caused the burns to the victim. Acid burns to the eye must be flushed with large amounts of water, or sterile saline solution for 5 to 10 minutes. Flush alkali burns for at least 20 minutes. Your ship will have eyewash stations and/or emergency showers installed in areas where exposure to chemicals may occur.

Electrical burns occur from the body’s exposure to an electrical shock. Environmental conditions can cause changes in the body (such as sweat, moisture, etc.), which affect the body’s resistance to electrical shock. As body moisture increases, the body’s resistance to electrical current flow decreases. This makes you a better conductor of electricity. When electrical current shocks your body, the burns created may be far more serious than a preliminary examination indicates. The entrance and exit wounds may be small, but the electrical current may have burned a large area just below the surface.

To treat for electrical shock, first remove the victim from the power source. Then encourage the flow of blood to the brain by keeping the victim lying down with feet and legs positioned higher than the head. Keep the victim warm by using a dry covering, even on a hot day. An electrical burn’s treatment is the same as a thermal burn. You need to administer first aid ONLY to the minimum necessary to aid the victim. In other words, don’t treat for a condition that does not exist. Protect the area of the burn by covering it with clean sheets, or a dry sterile dressing. Remember, do NOT remove clothing which adheres to the wound.

**FIRST AID PROCEDURES FOR TREATMENT OF INJURIES TO PERSONNEL**

Knowing the proper first aid procedures for treating the victim, or victims of chest, head and abdominal injuries, is important for their full recovery. If you are the first on the scene, remain calm and do what you know how to do. Consider all chest injuries serious, because they can cause breathing difficulty (dyspnea) and severe bleeding. Examine all victims complaining of breathing difficulty without signs of an airway obstruction for either an open or closed chest injury.

The most serious chest wound requiring immediate first aid, is a sucking chest wound (open pneumothorax). This is a penetrating injury that makes a hole in the chest cavity, causing the lung to collapse, which prevents normal breathing. This condition is a medical emergency that will result in death if not treated quickly. The signs and symptoms of a sucking chest wound include difficulty breathing, sharp chest pain, bluish skin color, and anxiety.

Immediately seal the wound with your hand, or any airtight material available. An ID card works effectively. The material must be large enough so that it is not sucked into the wound when the victim breathes. If the victim’s condition deteriorates, remove the seal immediately. Firmly tape the material in place with adhesive tape leaving one corner unsecured to prevent a pressure buildup. The purpose of the dressing is to keep air from going in through the wound. If unconscious, lay the victim on their affected side. If conscious, place the victim in a semi-sitting position to help them breathe easier. Treat the victim for shock. Do not let the victim see their injuries, because it could be pretty traumatic for them and deepen the shock conditions. Do NOT give the victim anything to eat or drink. If the victim complains of thirst, wet their lips with a wet towel. Request medical assistance immediately, because this type of injury will require additional treatment by medical personnel.

There are special precautions for providing first aid to a person who has suffered a head injury. Treat head wounds with particular care, since there is always the possibility of brain damage. The general treatment for head wounds is the same as that for other flesh wounds. Some additional precautions are:

- Never give any medications, even if the victim is complaining of a headache.
- Keep victim lying flat, with the head level with the body.
- Do not raise the feet if the face is flush.
- If the victim is having trouble breathing, raise the head slightly.

If the wound is at the back of the head, turn the victim on their side. Watch the victim closely for vomiting. Make sure that you have positioned the head to avoid aspiration of vomitus, or saliva into the lungs. Do not use direct pressure to control hemorrhage if the skull is depressed or obviously fractured. You may cause additional injuries including brain damage.

Abdominal injuries can easily become a medical emergency due to the potential damage to the vital organs. Most injuries to the abdomen require surgery to repair the internal damage. There are three types of abdominal wounds: closed, open, and open with protruding intestines. Abdominal injuries that are closed are difficult to diagnose because most of them do not appear externally. A severe blow or crushing injury, where the skin remains intact, is a cause of closed abdominal injuries. Bleeding into the abdomen usually causes death. A complication known as peritonitis, usually the result of a rupture in the intestines, is not immediate, but develops later and can be fatal.
With a closed injury, there is intense pain, nausea, vomiting, and spasm of the abdominal muscles. The victim may also experience, tenderness, distention, muscle rigidity, bruising and shock. Usually, the victim will lie with their legs pulled up, going into a fetal position to protect the abdomen.

Gundots, stabblings, and other penetrating wounds where the skin is broken cause open abdominal injuries. You should always suspect that damage has occurred to the internal organs, even if the signs and symptoms are not immediately present. Extensive lacerations may allow some of the internal organs to stick out, a condition known as eversionation.

The signs of an open abdominal injury are similar to the closed abdominal injury, to include intense pain, nausea, vomiting, and spasm of the abdominal muscles, tenderness, distention, muscle rigidity, and shock. In addition, there will probably be lacerations, puncture wounds, and vomiting of blood. If the victim is experiencing back pain, it could be a sign that there is kidney damage as well. Like the closed abdominal wound, the victim will lie with their legs pulled up, going into a fetal position to protect the abdomen.

The treatment for an open abdominal injury is the same as the closed abdominal injury:

-Step 1: Ensure that you do not give anything by mouth.
-Step 2: Carefully remove enough clothing to get a clear idea of the extent of the injuries.
-Step 3: Place the victim in the most comfortable position.
-Step 4: Treat the victim for shock.
-Step 5: Immediately request medical assistance.
-Step 6: Establish and maintain the airway, breathing, and circulation (ABCs).

When the intestines are protruding from an abdominal wound, there are additional specific steps to prevent further injury or infection to the victim. In addition to the six steps used for open wounds, control bleeding and apply a dry sterile dressing or compress, moistened with sterile water. Do not use a material that clings, such as paper towels, cotton, or toilet paper. If sterile water is not available, use clean drinking water.

FIRST AID PROCEDURES FOR TREATMENT OF FRACTURES

When rendering first aid, you must be alert for signs of broken bones (fractures), dislocations, sprains, strains, and bruises (contusions). Before learning first aid for injuries to the bones, joints, and muscles, you need a general understanding on the proper use of splints. Take a look at splints and how they can benefit the victim when used properly. Injuries to the joints and muscles often occur together, and it is difficult to tell whether the injury is to a joint, muscle, or tendon. This also makes it difficult to tell joint or muscle injuries from fractures.

The primary process of first aid for fractures consists of immobilizing the injured part. This prevents the ends of the broken bones from moving, and causing further damage to the nerves, blood vessels, or internal organs. Use splints to immobilize injured joints or muscles and to prevent the enlargement of severe wounds. In an emergency, almost any firm object or material can serve as a splint. Some useful splinting materials include, umbrellas, canes, rifles, sticks, oars, wire mesh, boards, cardboard, pillows, and folded newspapers. You can also immobilize a fractured leg by securing it to the uninjured leg. Splints should be lightweight, padded, strong, rigid, and long enough to immobilize the joint above and below the suspected fracture. Use articles of clothing, bandages, blankets, or any soft material as padding.

Fasten splints in place with bandages, adhesive tape, clothing, or any suitable material. Splints should be tight, but never tight enough to stop the circulation of blood. When applying splints to the arms or legs, leave the fingers or toes exposed to help you see whether the splint is too tight. If the tips of the fingers or toes turn blue or cold, loosen the splint. Also, shortly after the initial trauma, injuries tend to swell. Splints or bandages applied correctly now may later become too tight.

There are two basic types of fractures, closed and open. Either type of fracture can cause severe pain and or shock. Fractures can also deform the injured part, or cause an unnatural position body part. If you are unsure of a deformity, compare the injured part with the uninjured part. The victim may sense pain, discoloration, and swelling at the fracture site, and there may be instability, if the bone is broken clear through.

If the victim can move the injured part, they may feel a grating sensation (crepitus) as the ends of the bones rub against each other. If a bone is cracked, rather than broken, the victim may be able to move the injured part without too much difficulty. It can be difficult to tell if an injury is a fracture, dislocation, sprain, or strain.

A closed fracture, also known as a simple fracture, does not produce an open wound in the skin. Since the bone does not stick out, you might see a wound, but fail to see the broken bone. Closed fractures can become open fractures by rough or careless handling of the victim. Therefore, always use extreme care when treating a suspected fracture.

In an open (compound), fracture the sharp end of broken bones pushing through the skin causes open wounds. An open fracture is easy to see, because the end of the bone sticks out through the skin. Open fractures are usually more serious than closed fractures. They involve extensive tissue damage and are likely to become infected.

If you suspect a fracture, perform the following steps:

Step 1: Remember the ABCs (airway, breathing, circulation) and treat for shock.
Step 2: Control the bleeding with direct pressure, indirect pressure, or tourniquet only as a last resort.
Step 3: Remove all jewelry from the injury site, unless the victim objects. Gently cut clothing away so that you don't move the injured part and cause further damage.
Step 4: Cover all wounds with sterile dressings, including any open fractures.
Step 5: Apply the splint while maintaining traction (a gentle pulling force) until the splint is secure. Wrap from the bottom to the top of the splint, firmly but not too tight.
Step 6: Check the distal pulse, which is the pulse farthest away from the heart on the injured limb, to ensure that circulation is still present. If the pulse is absent, loosen the splint until the circulation returns.
Step 7: Once you stabilize the victim, request medical assistance.

All suspected fractures require professional medical treatment. Therefore, do not attempt to straighten broken bones, push the bone ends back into the skin, or move the victim until after splinting the injury. Also, be sure to avoid excessive pressure on the wound. A fracture of the spine may cause crushing, cutting, or other damage to the spinal cord so severe that death or paralysis may result. If the fracture does no serious damage to the spinal cord, there is a good chance of a complete recovery if the victim receives proper care. The primary symptoms of a fractured
spine are pain, shock, and paralysis. The pain is likely acute at the point of the fracture and may radiate to other parts of the body. Shock is usually severe, but (as in all injuries) the symptoms may be delayed. Quickly assess a potential spinal injury by asking the victim if they can move their extremities. If the victim cannot move their legs, feet, or toes, the fracture is probably in the back. If the fingers will not move, the neck is probably broken.

Treat any person, whose injuries include acute pain in the back or the neck, as though there is a fractured spine, even if there are no other symptoms. Emergency treatment for all spinal fractures, whether of the neck or of the back, has two primary purposes.  

- **First**, minimize the shock by keeping the victim comfortably warm. Do not attempt to keep the victim in the position ordinarily used for the treatment of shock, as it might cause further damage to the spinal cord. Just keep the victim lying flat, do not attempt to lower the head.

- **Second**, prevent further injury to the spinal cord. To avoid further damage, do not move the victim unless it is absolutely essential. If movement is necessary, move the victim in a way that causes the least possible damage. Do not bend or twist the victim’s body, do not move the head forward, backward, or sideways, and do not, under any circumstances, allow the victim to sit up.

To move a victim with a spinal injury, follow some general rules. Do not attempt to lift the victim unless you have adequate assistance. Remember, any bending or twisting of the body is almost sure to cause serious damage to the spinal cord. If the spine is broken at the neck, transport the victim lying on their back, face up. Place pillows or sandbags beside the head so that the head cannot turn to either side. Do not put pillows or padding under the neck or head. Also, if you suspect a spinal fracture but do not know the location of the break, treat the victim as though the neck is broken. If both the neck and the back are broken, keep the victim on their back.

Two acceptable methods for placing the victim on a spine board, also known as a long spinal board, are the straddle-slide method and the log-roll method. If there are at least four (preferably six for the log-roll) people present to help lift the victim, they can accomplish the job without too much movement of the victim’s body. Never attempt to lift the victim with less than four people.

- **Straddle-slide method:**
  - Requires four people.
  - One person lifts and supports the head.
  - Two persons each lift at the shoulders and hips, respectively.
  - One person slides the spine board under the victim.

- **Log-roll method:**
  - Requires four to six people.
    - Roll the victim as a single unit towards the rescuers.
    - Position the spine board.
    - Roll the victim back onto the spine board.
    - Securing the victim in place.

**METHODS USED TO CONTROL BLEEDING**

Bleeding is the escape of blood from capillaries, veins, and arteries. It can occur inside the body, outside the body, or both. The adult body contains approximately five to six quarts of blood (10 to 12 pints). The body can normally lose one pint of blood, the usual amount given by donors, without harmful effects. Your body normally replenishes this amount of blood in 24 hours. Since it is critical to control or stop all bleeding, it is important be able to identify the methods to control bleeding. A loss of two pints may cause shock. A loss of five or more pints usually results in death. During certain situations it will be difficult to decide whether the bleeding is arterial or venous. The most important thing to remember is to control bleeding as soon as possible.

There are three types of blood vessels in the body: capillaries, veins, and arteries. Capillaries are very small blood vessels that carry blood to all parts of the body. Bleeding from capillary vessels is normally slow and blood "oozes" from the (wound) cut. Veins are blood vessels that carry blood to the heart. Venous bleeding is a dark red or maroon color, and flows in a steady stream. Arteries are large blood vessels that carry blood away from the heart. Arterial bleeding is bright red, and the blood "spurts" from the wound. This type of bleeding is life threatening and difficult to control.

While administering first aid to a victim who is bleeding, you must remain calm. Most bleeding is less severe than it appears, and tissue and bone protect most major arteries. Although bleeding can be fatal, you usually have enough time to think and act calmly. The four methods used to control bleeding are:

- Direct Pressure
- Elevation
- Pressure Points
- Tourniquets

Direct pressure is the first and most effective method used to control bleeding. In many cases, applying pressure directly to the wound controls the bleeding. Place a sterile dressing or clean cloth on the wound. Then tie it tight, or adhere tape directly over the wound, only tight enough to control bleeding. If bleeding continues uncontrolled, apply another dressing over the first, and apply direct pressure with your hand or fingers over the wound. If the victim is conscious, they may also apply direct pressure. Under no circumstances is a dressing removed once it has been applied.

Accomplish elevation by lifting or raising the injured extremity (arm or leg) above the level of the heart. Use elevation and direct pressure together to slow or the stop bleeding. Do not elevate an extremity if you suspect a broken bone (fracture) or until it has been properly splinted and you are certain that elevation will not cause further injury. Use a stable object to maintain elevation. Placing an extremity on an unstable object may cause further injury.

Use pressure points or indirect pressure in cases where direct pressure and elevation are not controlling bleeding. Pressure points are areas of the body where pressing the artery against an underlying bone can slow the blood flow. Use caution when applying pressure points or indirect pressure because it can cause damage to extremities due to inadequate blood flow. Since this method can cause cardiac arrest, do not apply pressure to the neck (carotid) pressure points.
Use indirect pressure in addition to direct pressure and elevation when possible. Position the victim on his or her back. Kneel on the side opposite the wounded area; place the fingers, thumb, or heel of your hand directly on the pressure point, and apply pressure. If the bleeding does not slow, it may be necessary to press directly over the artery with the flat surface of your fingertips, and apply additional pressure on the fingertips, with the heel of your other hand.

Use a tourniquet on the extremities ONLY AS A LAST RESORT to control severe bleeding. Before you use a tourniquet, you must thoroughly understand its dangers and limitations. Tourniquets can cause tissue damage and the loss of extremities when used by untrained individuals. Tourniquets are rarely required and use it only when an arm or leg is partially or completely severed and bleeding is uncontrollable. The standard tourniquet is normally a piece of cloth folded until it is three or more inches wide, and six or seven layers thick. A tourniquet can be a strap, belt, neckerchief, towel, or other similar item. A folded triangular bandage makes a great tourniquet.

Always apply a tourniquet above the wound and towards the trunk as close to the wound as practical. To apply the tourniquet:
1. Place a pad (or roll) over the artery.
2. Wrap the tourniquet around the extremity twice, and tie a half-knot on the upper surface.
3. Place a short stick, or similar object, on the half-knot and tie a square knot.
4. Carefully twist the stick to tighten it until the bleeding is controlled.
5. Secure the stick in place.
6. Never cover a tourniquet, keep an eye on the area to ensure the bleeding has stopped.
7. Using lipstick or markers, make a “T” on the victim's forehead with the time of application.

Once applied, never loosen or remove a tourniquet. Loosening a tourniquet may dislodge formed clots and result in blood loss causing shock and death. Also, do not touch any open wounds with your fingers unless it is absolutely necessary. Wash your hands with soap and warm water immediately after providing care, even if you wore gloves, or used another barrier.

**FIRST AID PROCEDURES FOR TREATMENT OF TOXIC POISONING**

Treatment for inhalation poisoning begins with:
1. Removing the victim from the toxic atmosphere immediately.
2. Start basic life support by opening the airway, checking for breathing and circulation.
3. Remove or decontaminate the clothing if chemical warfare agents or volatile fuels were the cause.
4. Keep the victim quiet, treat for shock, and transport the victim to a medical treatment facility for further treatment.

Suspect poisoning in all cases of sudden, severe, and unexpected illness. Once poisoning is established, the general rule is to quickly remove as much of the toxic substance from the victim as possible. The method of removing the poison varies, depending upon how the poison enters the body. If inhalation is the cause, then get the victim to an area with plenty of uncontaminated oxygen. Some poisons can get on the skin and are easily absorbed. The treatment in this situation is primarily cleansing the skin to reduce or eliminate absorption into the body. If poisoning is by injection, then the best cure is receiving the recommended antidotal medications.

**PROPER METHODS AND TECHNIQUES FOR TRANSPORTING INJURED PERSONNEL**

A victim’s condition and the immediacy of danger dictate the appropriate method to use when moving a victim to safety. When possible give all necessary first aid before moving the victim. However, at times, it is necessary to move the victim immediately without regard to the severity of the injuries; therefore, it is important to identify the proper methods and techniques for transporting injured personnel. Aboard ship, there are several different types of stretchers for transporting injured personnel. Becoming familiar with all types of stretchers and their location will enable you to safely move your injured shipmates.

All personnel on the ship must be familiar with the location of first aid boxes, battle dressing stations, poison antidote lockers, and stretchers throughout the ship. The location of medical equipment is ship specific and identified in your Ship’s Information Book (SIB). Make a mental note of these items when you are walking around your ship.

Whenever possible, render first aid before transporting the victim. Do not carry the victim to the stretcher, take the stretcher to the victim and fasten them in so that they do not slip, slide, or fall off. Use the proper stretcher with enough blankets, clothing, or other material to pad the stretcher and protect the victim from exposure. Have enough people to carry the stretcher so that you do not drop the victim. Position the victim on their back, and move them feet first, except when going up ladders or trunks.

Always give a complete account of the situation, before transferring care of the victim to medical personnel. The information should include:
- Identity of the victim
- Cause and type of injury
- First aid procedures provided

Use the Neil Robertson stretcher to remove a victim from engineering spaces, holds, vertical trunks, and other compartments where hatches or ladders are too small to use other stretchers. It is made of a semi-rigid canvas with wooden slats sewn to the length of the stretcher. When firmly wrapped around the victim in a mummy fashion, it provides sufficient support to lift the victim vertically. A 12-foot length of handling line is on the O-ring at each end to prevent the victim from swaying against the bulkheads while being lifted out of the space.

To safely transport injured personnel in a Neil Robertson stretcher, perform the following steps in sequential order.
1. Arrange the stretcher flat on the ground and completely unfolded. Remove the hood.
2. Pick up the victim with at least three people. A fourth person should be available to slide the stretcher under the victim.
3. Ensure the victim’s shoulders line up over the stretcher and place the victim on the stretcher.
4. Secure the hood to the stretcher.
5. Place the chest flaps over the victim’s chest and under their arms.
6. Fold the leg flaps in place over the victim’s legs.
7. Secure the leg straps.
8. Secure the outer chest straps over the victim’s chest and under their arms.
9. Secure the victim’s arms to the side by placing the middle chest strap over their upper arms and chest.
The Stokes stretcher consists of a wire basket supported by iron rods and will hold the victim securely even if the stretcher is tipped or turned over. Use this stretcher for transferring injured persons to and from boats, direct ship-to-ship transfer or rescuing injured survivors from the water, (when used with flotation devices). On board ship, you may find 15-foot handling lines attached to each end of the stretcher to aid in moving the victim out of a space vertically.

Pad the stretcher with three blankets. Two of them placed lengthwise so that one is under each of the victim’s legs, and the third folded in half and placed in the upper part of the stretcher to protect the head and shoulders of the victim.

To safely move a victim in a Stokes stretcher, perform the following steps:
1. Lower the victim gently into the stretcher and make them as comfortable as possible.
2. Fasten the feet to the end of the stretcher so that the victim will not slide down.
3. Cover the victim with another blanket, to keep them warm.
4. Fasten the victim to the stretcher by means of straps that go over the chest, hips, and knees. The straps go over the blanket or other covering, thus holding it and the victim in place.

One of the oldest and still useful stretchers is the Army litter. This is a collapsible stretcher made of canvas and supported by wooden or aluminum poles. It is very useful for transporting battle casualties. The litter legs keep the patient off the ground. However, it is sometimes difficult to fasten the victim onto the Army litter, and for this reason, its use is somewhat limited aboard ship where sometimes we need to go up and or down ladders.

The construction of the Miller Board is an outer plastic shell with an injected core of polyurethane foam. It is impervious to chemicals and the elements. You can use the full body board in virtually every confined space for rescue and or vertical extrication. Turning of a victim can be vertically and laterally with no movement, and the board’s narrow design allows passage through hatches and crowded passageways. This board fits within a Stokes (basket) stretcher and floats with a 250-pound person. The Miller Board will eventually replace the Neil Robertson Stretcher.

Use standard stretchers whenever possible to transport a seriously injured person. If none are available, such as when the victims outnumber the stretchers, it may be necessary for you to improvise. You can use shutters, doors, boards, blankets, and even ladders as stretchers. Take great care that all substitute stretchers are well padded and fasten the victim securely in place. Unfortunately, many improvised stretchers do not give sufficient support in cases where there are fractures or extensive wounds of the body. Therefore, use substitutions only when the victim is able to endure some sagging, bending, or twisting without serious consequences. If a stretcher is not available or the environment prohibits its use, the fireman’s carry is one of the easiest ways to carry an unconscious victim. However, you should not attempt to use the fireman’s carry if the victim has an injured arm, leg, ribs, neck, or back.

To perform the fireman’s carry, use the following steps:
1. Place the victim face down. Face the victim, and kneel on one knee at the victim’s head. Pass your hands under the armpits; then slide your hands down the sides and grasp them across the back.
2. Raise the victim to his knees. Take a better hold across the victim’s back.
3. Raise the victim to a standing position and place your right leg between the victim’s legs. Grasp the right wrist in your left hand and swing the arm around the back of your neck and down your left shoulder.
4. Stoop quickly and pull the victim across your shoulders and, at the same time, put your right arm between the victim’s legs.
5. Grasp the victim's right wrist with your right hand and straighten up.

The steps to lower the victim are less complex. Bend over until the victim’s feet touch the deck. Then, ease the victim to the deck carefully, and finally, lay the victim’s head on the deck softly.
The Naval Ships' Technical Manuals (NSTM) and manufacturer technical manuals are important to you and the Navy because they establish standard procedures for operation, maintenance, and supervision of systems on your ship. Understanding the manual sections enables you to quickly locate the information needed to perform a particular procedure. Knowing the specific procedures for making changes ensures that the manual's technical accuracy is maintained. Since you perform the steps in the manuals, you will be the first to recognize updates and mistakes. If you find an error in a technical manual, it is your job to report it and initiate the change. So, you need to know the approved technical manual changes plus the location and purpose of all the ship's technical manuals.

**Terminal Objective** - Identify location, purpose, and change characteristics of technical manuals.

**Enabling Objective** - Identify the approved technical manual change characteristics (types of change and how changes are documented).

- Enabling Objective - Identify the location and purpose of the other technical manuals, such as SIB, PPM, Class Advisory Notebook, and Joint Fleet Maintenance Manual (JFMM).

**MANUAL CHANGE CHARACTERISTICS**

If an error is found, it is your job to report it and initiate the change. Technical manuals specific to equipment and systems are published by direction of Commander, Naval Sea Systems Command. The manufacturers of the equipment/system usually write the associated technical manual. When the manual conflicts with the NSTM, the manufacturers' manuals take precedence over the NSTM until higher authorities resolve the issue. Technical manuals contain specific information for equipment or a system. The sections in a technical manual include: the List of Illustrations, Tables, and Chapter headings.

The only authorized methods to update or change a technical manual are accomplished with the Advance Change Notice (ACN), Formal Change, and Formal Revision documents:

- **An Advanced Change Notice (ACN)** is added to each applicable chapter of the technical manual when there is insufficient time to prepare and publish the permanent, or formal, revision. ACNs are distributed to the technical manual holders that are on record as having a need for the information. The changed information on a replacement page is identified with a vertical change bar on the outer margin, adjacent to the changed text.

- **A Formal Change** consists of one or more replacement pages for an existing chapter or volume. It is intended for insertion into the appropriate document. The changed information on a replacement page is identified with a vertical change bar on the outer margin, adjacent to the changed text.

- **A formal revision** affects an entire chapter or volume, incorporates any outstanding ACNs, and is listed on the Revision Record page that follows the changed page. This example of a Revision Record shows the list of revised paragraphs – highlighted in blue. On this Revision Record example, you can see that the chapter has been completely revised.

The List of Effective Pages lists the pages in the technical manual that have been changed. Each change in the manual is identified by the page number on which it occurs, displayed below the column heading Page Number, and an associated change number, displayed below the column heading Change Number. The Record of Changes document is used to track changes. The date, description, and name of the person who entered the change are recorded. The modified pages are removed and destroyed.

The NSTM is available in both CD-ROM and paper versions. Onboard your ship, the NSTM Guide is located in the ship’s Technical Library. The guide describes the responsibilities, maintenance, and utilization of NSTM publications. It also describes the technical manual structure and provides guidance for accessing specific information within the NSTM. Each NSTM set includes a document, or electronic file, that provides instruction and guidance on how to use it.

The NSTM is configured into chapters, and each chapter into volumes. There are approximately 100 chapters, numbered in a non-consecutive sequence between 001 and 999. Each chapter covers a different topic and may include more than one volume. When a conflict exists between an NSTM and any other document, the document related to specific equipment or a system, such as a manufacturer's technical manual, will take precedence until the issue is resolved. Such conflicts are forwarded to NAVSEA, using the TMDER. A blank TMDER is found on the back page of each NSTM chapter. The NSTM contains preventive and corrective maintenance information of a general nature. It is NOT intended to take precedence over PMS procedures.

**OTHER TECHNICAL MANUALS**

There are other Technical Manuals that you will use as references during the performance of your job.

- **Ship's Information Book (SIB)** the purpose is to provide technical information for the ship’s force, building, planning and overhaul yards, for fleet and afloat commands, and other naval activities. The scope of technical information includes a general description of the ship's design characteristics and the major shipboard arrangements and systems. Onboard, the SIB for each ship is located in the ship’s Technical Library. NAVSEA receives a copy of each SIB. They print and distribute it to the appropriate locations. Each ship's SIB is prepared by its ship builder. The ship’s crew uses the SIB to familiarize themselves with the characteristics of the ship. Eight volumes are typically included in the SIB, covering the following areas: Hull and Mechanical, Propulsion Plant, Auxiliary Machinery, Piping, Ventilation, Heating, and Air-Conditioning Systems, Power and Lighting Systems, Electronic Systems, Interior Communications, Weapons Control Systems, and Ballasting Systems.

- **The Propulsion Plant Manual (PPM)** describes the component parts of the propulsion plant for each specific ship. On board, the PPM for each ship is located in the ship’s Technical Library.

- **The Class Advisory Notebook** is located in the Technical Library. The Class Advisory Notebook contains all the class advisories for the ship. Class advisories disseminate authoritative information concerning equipment operations and technical/logistic issues for the ship’s class.

- **The Joint Fleet Maintenance Manual** is located in the Technical Library and provides repair standards such as Quality Maintenance Procedures.

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It is important that you protect yourself by being mindful of the heat. One of the main things you will need to avoid is heat stress. Heat stress is any combination of air temperature, thermal radiation, humidity, air flow, and workload which may stress the body as it attempts to regulate body temperature. Heat stress became important to the Navy, to be in compliance with the Occupational Safety and Health Act (OSHA) of 1970, the Office of the Chief of Naval Operations (OPNAV) formally established the Heat Stress Program in November of 1973. The Heat Stress Program is evaluated periodically.

**Terminal Objective** - Demonstrate an understanding of the Heat Stress Program fundamentals.
- Enabling Objective - Identify the causes and effects of heat stress.
- Enabling Objective - Identify the purpose and responsibilities of the Shipboard Heat Stress Control Program.

**CAUSES AND EFFECTS OF HEAT STRESS**

To avoid heat stress illnesses, Sailors need to become aware of the causes of heat stress, the symptoms, and illnesses associated with heat stress, as well as the precautions needed to prevent heat-related illnesses. Degraded material conditions, inefficient plant operations, steam, water, or boiler casing leaks, high bilge water, missing or deteriorated lagging and insulation, and inefficient or improper insulation can all create a hot environment.

Inefficient or improper ventilation can cause heat stress conditions. Dirty vent screens or filters, inoperative fan motors and controllers, misdirected ventilation ducting, missing or mutilated ducting, and even poor ventilation design all inhibit ventilation. Of course, in addition to environmental factors, physical factors can cause heat stress conditions as well. When these conditions lead to a heat stress environment, both equipment and personnel can be affected. Since we know of factors that can cause heat stress, we must take corrective action when they exist. A primary solution to correct heat stress hazards is to make the space cooler through proper maintenance and material corrections. To do so, steam, water, and boiler air casing leaks, missing or deteriorated lagging and insulation, ventilation deficiencies, and system degradation should be identified, recorded, and corrected. Also, bilges should be kept dry to reduce humidity.

Sweating is the body's method of maintaining a heat balance in the environment and cooling off. Under normal conditions, sweating keeps the body's temperature within the normal range of 97° to 99° Fahrenheit. However, when heat stress conditions are present, the body must work even harder to stay cool. When sweat evaporates from your body, you are removing excess heat. But in a hot or humid environment, it becomes more difficult for your sweat to evaporate, thus trapping the heat in. Moisture from your sweat glands will condense on your skin forming beads of sweat instead of evaporating, which will actually cause more stress to your body, as it cannot cool off.

**SYMPTOMS AND ILLNESSES**

Symptoms of heat stress include fatigue, rashes, cramps (particularly in the extremities and abdomen), profuse sweating, tingling in extremities, clammy skin, rapid heartbeats, severe headache, nausea, and vomiting. These symptoms are associated with the different types of heat stress illnesses, which include dehydration, heat rash, heat cramps, heat exhaustion, and heat stroke.

- **Dehydration** results from the lack of proper fluid intake. The symptoms of dehydration can include increased thirst, rapid heartbeat, dizziness and weakness.
- **Heat cramps** are painful, brief muscle cramps that can occur during or after prolonged work in a hot environment. Tired muscles may spasm involuntarily. Heat cramps are usually caused by a salt deficiency.
- **A heat stroke** is a potentially fatal medical emergency. Heat stroke is a total breakdown of the body’s heat balance. Symptoms of heat stroke include hot, dry skin and constricted pupils. During a heat stroke, breathing becomes deep and rapid, and then becomes shallow and almost absent and pupils constrict. Heat stroke is the most serious form of heat injury. If you are showing symptoms of heat stroke, notify your supervisor and go to medical.
- **A heat rash** looks like tiny, prickly, bumps surrounded by irritated skin and is usually found on parts of the body that are covered by clothes. A heat rash can develop when your sweat ducts are blocked by restrictive clothing in a hot, humid environment. Heat rashes interfere with sleep and impair your body’s ability to cool down.
- **Heat exhaustion** occurs when a body's heat balance mechanism is overworked but functioning. Symptoms of heat exhaustion include pale skin, skin that feels cold, moist, and clammy, a low temperature, weak and rapid pulse, shallow breathing, and dilated pupils.

Suffering from heat stress can result in poor physical and mental performance. One short-term effect of heat stress is the loss of performance efficiency. A long-term effect of heat stress is the progressive loss of performance capability. Fortunately, there are precautions you can take to help prevent heat stress.

- **Clothes**: When working in an environment with heat stress conditions, clothing should be worn loosely at the neck cuffs or sleeves, and at the bottom of the trousers. Also, your clothing should not be starched.
- **Acclimation**: In most individuals, appropriate repeated exposure to heat stress causes a series of physiologic adaptations called acclimatization. This is where the body becomes more efficient in coping with heat stress. An acclimatized individual can tolerate a greater heat stress before harmful level of heat strain occurs. Personnel acquire heat acclimatization only gradually, being fully achieved over a 3-to-4-week of sustained physical activity.
- **Diet**: A great way to prevent heat stress is to have your body fully nourished, so be sure to always eat three adequate, well-balanced meals daily. A normal diet provides more than the required amounts of salt; the use of salt tablets is an outdated and unhealthy concept that is not recommended. Also, drink plenty of water to help prevent dehydration. There are plenty of scuttlebutts on the ship for you to drink from.

The Heat Stress Program establishes Navy policy and procedures for the control of personnel exposure to heat stress. It provides a listing of recurring heat stress-related deficiencies, establishes procedures for requesting assistance in resolving conditions associated with heat stress, and describes heat stress standards and repair actions. It sets the standards for evaluating and monitoring heat stress conditions, establishing safe work schedules in heat stress environments, identifying and correcting causes of heat stress conditions, investigating and reporting personnel heat injuries, and training. The goal is to operate a propulsion plant at its maximum capabilities for as long as possible with minimum stress on personnel and equipment. The CO, Safety Officer, Engineer Officer, Supply Officer, Department Heads, Division Officers, Medical Department Representative (MDR), and All Hands are all involved with the Heat Stress Program.

**The Commanding Officer** establishes and enforces an effective Heat Stress Program, which includes training and reporting instances of personnel injury resulting from heat stress.

**The Safety Officer** monitors the Heat Stress Program for compliance and effectiveness.
The Engineer Officer assigns, ensures training of, and qualifies Engineering Department personnel to perform heat stress monitoring in engineering spaces.

The Supply Officer identifies heat stress related deficiencies and requests the Engineering Department's assistance to repair them.

Department Heads and Division Officers ensure that assigned personnel are trained and maintain training records. They limit personnel heat exposures to periods allowed (except as extended by the CO). They also ensure that instances of personnel injury from excessive heat stress are promptly reported to the MDR.

The MDR performs heat stress monitoring of non-engineering spaces as requested or as required. The MDR also reviews heat stress monitoring sheets daily, when required, and submits them at the eight o'clock reports. When a heat stress injury occurs, the MDR prepares the report. The MDR also provides training to divisions on heat stress health hazards, symptoms, and first aid procedures upon request.

All Hands must obtain prompt medical attention for personnel who exhibit heat stress symptoms and follow recommended work practices and procedures for controlling heat stress hazards.

**Devices and Terminology**

The QUESTemp®48N is an instrument that combines the effects of the globe thermometer, relative humidity sensor, and dry bulb thermometer and produces the Wet Bulb Globe Thermometer (WBGT) Index. The WBGT Index is a calculated number that is used to determine how long one can work in a heat stress environment, known as their stay time. Other terms you need to know include dry bulb, wet bulb, psychrometer, radiant heat, globe thermometer, and Physiological Heat Exposure Limit (PHEL).

- **Radiant Heat:** Radiant heat is the transfer of thermal energy by wave motion from one object to another.

- **PHEL Chart:** The PHEL is the permissible exposure time limit determined using the WBGT Index and the rate of work performed by the individual.

- **Bulbs (Dry, Wet):** When using a dry bulb, air temperature is measured with an ordinary thermometer shielded from radiant heat sources. When using a wet bulb, air temperature is measure with an ordinary thermometer except a wet wick is fitted over the bulb and air flow is passed over the wick. The wet bulb measures the dew point of the air. The dew point is the temperature corresponding to 100% relative humidity.

- **Globe Thermometer:** A globe thermometer is a copper sphere painted flat black which contains a dry bulb thermometer. It measures the impact radiant heat has on the temperature.

- **Psychrometer:** The motorized psychrometer is an environmental monitoring device that reads dry bulb, wet bulb, and globe thermometer temperatures. It is used when manually calculating the WBGT index.

The dry bulb thermometer is permanently hung at key watch/work stations. The dry bulb is positioned so that adjacent or local heat sources do not influence the bulb. For potential heat stress hazard areas, the dry bulb must be temporarily installed to monitor conditions during heavy work. Dry bulb temperatures are recorded at least once per watch or work period. The measurements are taken at the beginning of the period or prior to the start of work. They are recorded on the appropriate log sheet in the Heat Stress Log, which the EOW reviews. If the difference between the hanging dry bulb thermometer temperature and the dry bulb temperature measures by the WBGT is great than or equal to 5° F, then the dry bulb is not representative of the temperature at the station and must be remounted.

Heat stress monitors are the basic instrument for assessing how long personnel can work in a heat stress environment. The QUESTemp®48N consists of the Globe thermometer, Relative humidity sensor, dry bulb thermometer, and the battery pack. This portable, rechargeable meter uses the relative humidity sensor to calculate the waterless wet bulb from a combination of dry bulb temperature, humidity, and wind speed measurements. The waterless wet bulb is used to calculate an estimated WBGT index, which is used to determine stay times, the time a Sailor is allowed to be in a heat stress environment. The QUESTemp®48N is used to obtain an index.

**PHEL Chart**

The WBGT index provided by the QUESTemp®48N or manually calculated is used when determining stay times and we do that by referencing the PHEL chart. The chart has six PHEL curves based on different levels of work, from light, PHEL Curve I, to heavy work, PHEL Curve VI. To determine stay times, you use the appropriate curve and follow it until it intersects the WBGT index. When a heat stress injury occurs or when performing non-routine operations, personnel must be evaluated on one curve higher than normal. The point where the PHEL chart and the WBGT index intersect will tell you the appropriate stay time. Only during operational emergencies can the CO extend stay times. The Engineer Officer shall ensure exposure limits for engineering personnel are being properly determined in these instances.

The PHEL Chart is referenced when using the Heat Stress Survey Sheet to record the temperature and to determine stay times. Material deficiencies that may be contributing to adverse heat stress conditions are also included. The time, the dry bulb hanging, dry bulb, web bulb, globe thermometer, and WBGT index are listed on the Heat Stress Survey Sheet. Using the PHEL Chart, maximum stay times for routine, non-routine, engineering casualty controls drills (if planned), and heavy work are also recorded. When the results of a heat stress survey indicate that a watch-stander or other personnel will be subjected to a maximum permissible exposure duration of less than their watch or work period, the survey results must be routed to the CO promptly.

Fuel combustion gases (stack gas) and fuel vapors can have severe adverse physiological effects on personnel in a heat stress environment. Prolonged exposure to relatively low concentrations can impact the ability of personnel to work safely. If someone can smell the odor of “stack gas” or fuel vapors, then a harmful concentration may exist. In these instances, personnel should be checked for watering eyes, breathing difficulty, tingling or numbness of the tip of the tongue, tip of the nose, finger tips and/or toes. If two or more of these symptoms associated with exposure to stack gases and fuel vapors are exhibited, then exposure must be limited accordingly. To determine the new stay time, calculate safe stay times for existing heat stress conditions, and divide that number by 3. For example, six hours of stay time would be reduced to two hours.

Heat Stress surveys must be conducted: When the dry bulb temperature is greater than or equal to 100 Fahrenheit and the watch length is four hours or less. When the dry bulb temperature is greater than or equal to 90 Fahrenheit and the watch length is greater than four hours. When the dry bulb temperature is greater than or equal to 85 Fahrenheit and the work level is PHEL Curve IV through VI. As required for follow-on surveys.

Personnel leaving, or who have been directed to leave, a heat stress environment because they have reached or exceeded their stay time, shall remain in a cool, dry area to recover. The recovery time is twice the stay time, or four hours, whichever is less. Upon the event of a suspected heat injury, an immediate supervisor is contacted. The subject in question is then sent to sick bay. When, in judgment of a trained MDR, a heat injury has occurred, a Heat Injury Report shall be filed by the MDR. All Heat Injury Reports are filed using NAVMED Form 6500/1. The Heat Injury Report must be submitted to the Commander of Naval Medical Command following heat related injuries. The Commanding Officer will conduct a JAG MAN investigation for any heat stress injury resulting in unconsciousness. A complete file of all surveys and reports will be
maintained on board in the custody of the medical representative for one year (the Engineering Log Room should also maintain a copy for engineering inspections).

**ADDITIONAL TRAINING**

Heat stress training is conducted upon reporting and annually thereafter for appropriate personnel; those who maintain heat stress related equipment and those who perform heat stress monitoring. Additionally, the Engineer Officer shall include heat stress training as part of the overall Engineering Department training program.

Personnel are trained using the Watch-station 303, Heat Stress Monitor, of the Safety Programs Afloat PQS. The additional heat stress training consists of heat stress health hazards, symptoms of excessive heat stress exposure, heat stress first aid procedures, and causes of heat stress. Appropriate heat stress tapes are shown to All Hands and supervisory personnel as part of this training. Two Navy educational films are available; “Play it Cool,” which is required for All Hands training, and “Use and Care of the Heat Stress Meter,” which is required for monitoring personnel training.
ENGINEERING DEPARTMENT ORGANIZATION

All Navy ships are organized into different departments with varied functions that contribute to its success. Each department is guided by a department head that is responsible for department organization, battle readiness, and assignment of personnel to their stations and duties. It’s your job to learn the hierarchy and responsibility of the engineering department personnel.

Terminal Objective - Identify the members and regulation for the Engineering Department Chain of Command.

- Enabling Objective - Identify the responsibilities and regulations of the members in the Engineering Department Chain of Command (COC).

ENGINEERING DEPARTMENT ORGANIZATION

From the Engineering Officer down to the most junior Fireman, every single Sailor is an integral part of the Engineering Department. You will learn about the key personnel in the department, and what each person’s responsibilities and duties are. Two helpful references for understanding department organization and regulations are the Standard Organization and Regulations Manual (SORM) and the Engineering Department Organization and Regulations Manual (EDORM). Both manuals are typically located in the Engineering Log Room.

The Standard Organization and Regulation Manual (SORM) define the ship’s administrative organization. The SORM organizes the Engineering Department for the operation, maintenance, and repair of the ship’s propulsion plant, auxiliary machinery, and piping systems.

The Engineering Department Organization and Regulations Manual (EDORM) is a comprehensive guide to the organization, responsibilities, and administrative requirements of the engineering department. It addresses the importance of the Engineering Officer’s overview in departmental operations, program management, and increasing watch-stander level of knowledge for programs and systems. It details engineering department personnel duties and responsibilities, as well as the watch organizations.

- **Engineering Officer**, also known as the Chief Engineer or CHENG, is the Engineering Department Head. The Engineering Officer reports to the Commanding Officer (CO) and to the Executive Officer (XO) for all administrative matters. The Chief Engineer’s specific duties include: providing direction to all repair lockers; designating appropriate casualty power configuration; serving as the Plant Control Officer and supervising the Engineering Officer of the Watch (EOOW) during Restricted Maneuvering operations. Restricted Maneuvering is set when getting underway, proceeding to anchorage, arriving pier-side, and at other times when extra care is required. The Engineering Officer is also responsible for the operation, maintenance and repair of all propulsion machinery, auxiliary machinery, damage control and other equipment. During firefighting and damage control functions the Engineering Officer serves as the Damage Control Officer (DCO) and is responsible for Engineering Department personnel. Finally, the CHENG reviews and signs all Engineering Department logs and records.

Under the Engineer Officer, there are officers and senior enlisted personnel assigned as principal assistants (Main Propulsion Assistant, Damage Control Assistant, Auxiliaries Officer, Electrical Officer, etc.). They are responsible for frequent inspections of their assigned spaces, informing the Engineer Officer of the material condition of systems and equipment. They are also responsible for reviewing all operating records and other predictive maintenance documents of assigned equipment. They also ensure proper operation and maintenance of systems and equipment; supervise the training and qualification of watch-standers and division personnel; assist the Damage Control Assistant with ensuring accuracy and periodic validation of space mechanical and electrical isolation lists.

- **Main Propulsion Assistant (MPA)** reports to the Engineering Officer. The MPA serves as the Plant Control Officer in the absence of the Engineering Officer and effectively operates all main engines, boilers and associated equipment. The Main Propulsion Assistant is also responsible for: proper care, stowage, and use of fuels; operation and maintenance of the main propulsion fuel oil systems; maintaining fuel records, daily fuel and water reports. The Main Propulsion Assistant supervises the preparation and care of the Engineering Log and Engineer’s Bell Book. The Main Propulsion Assistant may also serve as the Main Propulsion Division Officer.

- **Damage Control Assistant (DCA)** reports to the Engineering Officer and is responsible for establishing and maintaining an effective damage control organization and supervising repairs to the hull and machinery assigned. The DCA also serves as the Gas Free Engineer unless otherwise designated by the Commanding Officer. The DCA also trains the ship’s personnel Commanding Officer, and supervises ballasting and de-ballasting of the ship. The DCA also prepares and maintains the ship’s Damage Control closure log, reviews it daily to ensure the accuracy and adequacy of all entries, and may serve as the Repair, or “R” Division Officer.

- **Auxiliary Officer (AUXO)** reports to the Engineering Officer and is responsible for the ship’s small boats and auxiliary machinery and equipment, including anchor windlass, steering gears, galley equipment and laundry equipment. He also serves as the Auxiliary or “A” Division Officer.

- **Electrical Officer (EO)** reports to the Engineering Officer and is responsible for the shipboard electrical safety program, ensures electrical deficiencies are promptly corrected, and supervises the qualification of the tool issue custodians. The EO is also responsible for the Casualty Power Bill and associated shipboard casualty power training and may serve as the Electrical or “E” Division Officer.

Depending on the ship’s class, technical assistants such as the Engineering Officer of the Watch (EOOW), Engineering Duty Officer (EDO), Oil and Water King, Departmental Training Officers, Training Team Leaders, and Fire Marshals may be assigned accordingly.

- **Engineering Officer of the Watch (EOOW)** - (Officer, Chief Petty Officer, or Petty Officer on watch) – is responsible for the safe and proper operation of the ship’s engineering plant, and the engineering watch team (while underway). The EOOW ensures that all orders received from the Officer of the Deck (OOD), are promptly acknowledged and carried out. The EOOW also obtains permission from the OOD before conducting any major engineering plant evolutions. The EOOW promptly reports and corrects hazardous conditions in the engineering plant, and ensures that the Tag-Out log is properly maintained. The EOOW directs engineering equipment start-up and securing, coordinates with the engineering Officer and the DCA to maintain the ship’s list and trim, and ensures the Engineering Log, Engineer’s Bell Book/Automatic Bell Logger Record Sheet, and the prescribed operating records are properly kept. Finally, the EOOW ensures all required fuel and lubricating oil samples are taken and properly evaluated and notifies the Engineer Officer of any unsatisfactory samples.

- **Training Team Leader** – the leaders of the Training Teams are responsible for ensuring that teams are effective and meeting training objectives, and that personnel assigned are qualified in the area(s) they are assigned to train. They also provide briefing and debriefing of training evolutions.

- **Engineering Duty Officer (EDO)** - is the Officer, Chief Petty Officer, or Petty Officer qualified and charged with the safe and proper operation of the ship’s entire engineering plant. The EDO represents the Engineering Officer when absent, and when in port, is charged with many of the same duties and responsibilities as the EOOW for departmental operations. The EDO is responsible for executing all standing orders, special operating orders, and night orders from the Engineer Officer. The EDO commences preparations to place the electrical plant and/or the main
propulsion plant in operation when ordered by the Engineer Officer, Command Duty Officer, or higher authority. The EDO also safeguards the watertight and physical integrity of all engineering spaces, and ensures that all machinery is operated safely and economically. Additionally, the EDO ensures that the proper material condition is set, supervises all department training conducted after working hours, and ensures that all logs are properly maintained including the Engineering Log, the Tag-Out Log, and all equipment logs.

**Departmental Training Officer** - is assigned as a collateral duty of another Engineering Department Officer or senior enlisted. The Departmental Training Officer is a central point of contact in regards to training, and manages departmental records/software and associated training materials.

**Oil and Water King** - is a senior Petty Officer (E6-E9) normally with a machinery rating, (Machinist’s Mate (MM), Gas Turbine System Technician Mechanical (GSM), or Engineman (EN)). This senior Petty Officer supervises all personnel involved in the handling, testing, and treating of water, fuel (F-76/F-44), or lube oil. The Oil and Water King coordinates all refueling and fuel transfer evolutions throughout the ship. The Oil and Water King also maintains: proper boiler/feed water chemistry and required logs and records; supervises the preparation of the daily fuel and water reports; records the boiler feed water test results; and maintains the proper list and trim as directed by the EOW/EDO and DCA.

**Engineering Training Team (ETT)** - main duty is to train and evaluate the ability of watch-standers to respond to casualties and take the necessary corrective action. The ETT also establish realistic qualification goals, ensure all baseline documents are available, drill cards are realistic in every respect, drill plan is well coordinated, and drills are realistically critiqued to better enhance the development of the watch-stander. They also verify that all reports and evaluations of drill are properly documented and forwarded through the chain of command.

**Damage Control Training Team (DCTT)** - is to train and evaluate repair party personnel and main space personnel on their ability to respond to damage control casualties and take necessary corrective actions.

**Fire Marshal** - assists the Engineer Officer and the Damage Control Assistant. The Fire Marshal’s duties also include daily inspections of the ship, preparing, routing, and following-up including correcting reports of identified fire hazards, and conducting training for ship’s fire teams, import emergency teams, and divisional Damage Control Petty Officers.
As a new engineer, it will be important for you to understand engineering orders. You will be able to clearly identify engineering orders as established by the Engineering Department Organization Manual (EDORM).

**Terminal Objective** - Demonstrate an understanding of Engineering Orders for engineering departmental daily operation.
- **Enabling Objective** - Identify Engineering Orders for engineering departmental daily operation.

**ENGINEERING ORDERS FOR ENGINEERING DEPARTMENTAL DAILY OPERATION**

Let’s begin with the foundation or framework of Engineering Orders, called Standing Orders. Then we will continue learning until you understand each set of Engineering Orders.

**Standing Orders** from the Engineer Officer are always in place unless superseded by Special Operating Orders or Night Orders. Standing Orders reinforce daily policies, practices, and procedures and provide guidance where policies are not clearly stated. Standing Orders help to clear-up any confusion and ensure that you know exactly what to do in each situation. They are the orders that you will come to rely on most often and may cover a variety of areas. It is your responsibility to know and understand your Standing Orders and refer to them for your daily operating procedures. The EDORM requires that certain topics be covered as part of your Standing Orders and provides suggestions for additional topics.

**Special Operating Orders** can be thought of as temporary Standing Orders. They are issued by the Engineer Officer and approved by the Commanding Officer. If procedural changes, extreme conditions, or operational limitations arise, the Engineer Officer may need to deviate from normal procedures. In this case, the Special Operating Orders modify the already existing Standing Orders. Special Operating Orders can also be used in conjunction with caution tags to warn of potential danger in special circumstances. To do this, the Engineer Officer will document the change in the form of a Special Operating Order and get approval from the Commanding Officer. Once this order takes effect it supersedes your existing Standing Orders.

**Night Orders** book contains routine or special instructions for planned evening or night watches. These orders are important to you because during times when your Engineer Officer is not in the main engine room, you will need instructions for routine and special night evolutions planned. The Engineer Officer uses the Night Orders book to issue orders to the Engineering Officer of the Watch (EOOW) underway or the Engineering Duty Officer (EDO) in-port daily. This means that for every evening or night watch Night Orders will be issued. All watch-standers must read, understand, and initial them before beginning their watch. Signing the Night Orders book ensures that you are aware of your duties and instructions provided by the Engineer Officer and lets your EOOW or EDO know that you have read and understand your orders.

**Light-Off Orders** are issued by the Engineer Officer after approval by the Commanding Officer and are used to supplement the Engineering Operating Procedures (EOP). These orders specify what plant changes will take place, what equipment will be used, the timeline of each major event, all watch-standers involved, and watch-stander responsibility for each step. The Master Light-Off Checklist (MLOC) and the Planned Maintenance System (PMS) are often used in conjunction with Light-Off Orders. These cross-references will provide additional guidance for each step.
Standing watches will become an important part of your routine when you report to your ship. On a typical ship, personnel keep watch on the bridge and over the running machinery. Engineers ensure that the running machinery continues to operate within tolerances. A secondary function of watch-standing is the ability to respond to emergencies. In this lesson, you will review the engineering responsibilities for the different types of watches and introduce the members of the engineering in-port or underway watch organization and their areas of responsibility. You must be able to identify the responsibilities of in-port and underway watches, and identify the engineering plant underway watch organization.

**Terminal Objective** - Demonstrate an understanding of the in-port/underway watch organization and relief procedures.
- **Enabling Objective** - Identify the responsibilities of in-port and underway watches.
- **Enabling Objective** - Identify the engineering plant in-port and underway watch organizations.

The following references were used in preparation of this study material:
- COMNAV SURFORINST 3540.3 Series EDORM – Engineering Department Organization and Regulations Manual

Always reference selected resources according to Navy publication standards for the security and safety of you and your command/unit.

**RESPONSIBILITIES OF INPORT AND UNDERWAY WATCHES**

Watch-standing requires operational experience, some level of knowledge about system interrelationships, some maintenance and repair expertise, and a clear understanding of watch requirements. Watch-standers serve as the caretakers of the plant as well as the first line of defense against a catastrophe. You will become a watch-stander when you report to your ship. You must be able to perform all of the watch-station tasks listed in the PQS book assigned to you, before you can become qualified to stand watch.

**Cold iron** – The term is used to describe the operating condition of a ship when it isn’t operating any of its generators, propulsion boilers, or main engines, or is in an auxiliary steaming condition. In cold iron, a qualified Engineering Officer of the Watch (EOOW) is not required for gas turbine or diesel propulsion ships as long as a qualified Engineering Duty Officer (EDO) is on station. For steam propulsion ships, a qualified EOOW is also not required during conditions of cold iron as long as a qualified EDO is on station. However, an EOOW is required before lighting any propulsion boiler for conditions of auxiliary steaming.

All engineering watch-standers are required to obey promptly all orders issued by the EDO or EOOW. They are also required to carry out Night Orders, Special Operating Orders, and Engineer Officer’s Standing Orders, in that order. Other documents in the hierarchy include, in order of precedence, Technical Documentation including Class Advisories and Permanent Technical Documentation, Engineering Operational Sequencing System (EOSS), Planned Maintenance System (PMS), and Technical Manuals.

Watch schedules are called “watch bills.” At sea, watches normally follow a predictable rotation. The number of qualified watch-standers determines the interval between watches. Unless heat stress conditions dictate otherwise, four-hour periods are the norm. Thus, a four-man watch rotation means one four-hour watch is followed by twelve hours not on watch although a normal workday may just be beginning. An exception is two men, or “port and starboard” watch-standing, which is usually conducted as six hours on and six hours off. So, the sooner you qualify the better!

The following procedures apply for all watch reliefs. A watch-stander is considered properly relieved when the following requirements are fulfilled. Oncoming watch-standers shall make a tour of the designated spaces to observe the status of all machinery. Conduct a “talk-through” of the watch station status with the watch-stander on watch noting, at a minimum, the following things: any significant items noted during review of logs for the period since last on watch where feasible, understand any abnormal equipment conditions. Watch relief will not be permitted when plant conditions are changing significantly or when other unusual conditions exist.

Subordinate watch-standers shall request permission from the immediate senior watch-stander to be relieved. When satisfied with the knowledge of plant and watch-station conditions, each watch-stander performs a formal relief by stating, “I relieve you” and reports the watch relief to the immediate supervisor. The off-going watch-stander acknowledges the watch relief by stating “I stand relieved” and makes an appropriate entry in the watch station logs, noting the time of relief and the name of the relieving watch-stander.

**ENGINEERING PLANT INPORT AND UNDERWAY WATCH ORGANIZATION**

A ship’s watch organization is dependent on whether the ship is in-port or underway and also the type of engineering plant present. You will learn the In-port and Underway Steam, Gas Turbine, and Diesel Engineering Plant watch organizations, as dictated by the EDORM.

In-port the Engineering Duty Officer (EDO) represents the Engineer Officer when absent. The EDO has many of the same duties and responsibilities in-port as the EOOW performs underway. In-port concerns, such as managing the duty section, maintenance, refueling, and heightened concern for the environment require the leadership, management, and dedication of an experienced, mature engineer. The EDO is the officer, Chief Petty Officer or Petty Officer qualified and charged with the ship’s entire engineering plant. The EDO is responsible for the safe and proper operation of the engineering plant and for the performance of duties prescribed in the Engineering Department Organization and Regulations Manual (EDORM) and other competent authority. Some assigned duties of the EDO include safeguarding the watertight integrity and physical security of all engineering spaces, ensuring all machinery is operated safely and economically, ensuring a proper material condition is set, supervising all department training conducted after working hours, maintaining the Tag-out log, and ensuring all equipment logs are kept properly. Once you have qualified for your assigned watch-station, you will stand that watch and continue to qualify for other watch-stations.

- **Cold Iron Watch** ensures the proper and safe operation of machinery, take readings on equipment, remain alert for unusual conditions such as flooding, fire, or sabotage, and to follow the orders of the EDO.
- **Auxiliary Steam Watches** are assigned when the ship is pier side, but not receiving “hotel services” such as steam and electricity. Auxiliary Steam Watches include Central Control Station or Main Control Supervisor, Equipment Monitor or Messenger, and Sounding and Security.
- **Damage Control Central (DCC) Watch** is responsible for monitoring the ship’s fire, flooding and material security and ensuring ship compliance with the effective material condition set by the EDO or Command Duty Officer (CDO).
- **Sounding and Security Watch** is responsible for detection and prevention of fire, fire hazards, flooding, theft, sabotage, and compromise of classified information or other irregularities affecting the physical security of the ship.
We will explore the responsibilities of each of the key personnel in your chain of command for each type of propulsion system. You never know when you’ll be called on to fill in for other personnel during an emergency.

**STEAM PROPULSION**
- **Engineering Office of the Watch (EOOW)** is the officer, Chief Petty Officer, or Petty Officer on watch in charge of the ship’s entire engineering plant. The EOOW is responsible for the safe and proper operation of the engineering plant, and for the performance of duties prescribed in the Engineering Department Organization and Regulation Manual (EDORM) and other competent authority.
- **Engine-room Supervisor (MMOW)** is in charge of the engine-room watch team. He or she is responsible for the main engines, reduction gears, shafting and bearings, ships service generators if they are located in the engine-room, and all associated auxiliary equipment.
- **Fire-room Supervisor (BTOW)** is responsible for the proper operation of the boilers and associated equipment, and other duties as assigned by the space supervisor or EOOW.
- **Electrical Supervisor** is assigned watch at the main ship’s service switchboard or location designated for control of the electrical distribution system.
- **Damage Control Central** watch is responsible for monitoring the ship’s fire, flooding and material security and ensuring ship compliance with the effective material condition set by the EOOW or Officer of the Deck (OOD).
- **Assistant Oil/Water King** watch is responsible for oil and water testing and treatment. The assistant reports to the EOOW for operational matters and the Oil/Water King for administrative matters.
- **Engine-room Watch Team** includes personnel qualified to operate propulsion turbines, ships service turbine generators (SSTG), distilling plants, and auxiliary equipment.
- **Fire-room Watch Team** under the Fire-room Supervisor includes personnel qualified to operate the boiler, boiler control consoles, and auxiliary equipment.
- **Electrical Switchboard Operator** is the electrician assigned watch on one of the main or emergency electrical switchboards.
- **Sounding and Security** watch is an assigned roving security patrol.

**GAS TURBINE PROPULSION**
- **Engine-room Supervisor** or Operator is in charge of the equipment in the engine-room. He or she is also in charge of the equipment monitor watch.
- **EOOW** is the officer, Chief Petty Officer or Petty Officer on watch in charge of the ship’s entire engineering plant.
- **Auxiliary Machinery Supervisor** or Operator is in charge of the watch and responsible for operating the machinery in the auxiliary machinery room(s) (AMR).
- **Propulsion and Auxiliary Control Console Operator (PACCO)** is responsible for operating and maintaining surveillance over the propulsion system and the auxiliary machinery systems, following orders from the EOOW or OOD.
- **Electric Plant Control Console (EPCC)** operator is responsible for operating and maintaining surveillance over the electrical distribution system.
- **Damage Control Console Operator** is responsible for monitoring the ship’s fire, flooding and material security and ensuring ship compliance with the effective material condition set by the EOOW or OOD.
- **Assistant Oil/Water King** watch is responsible for oil and water testing and treatment.
- **Engine-room Watch Team** includes personnel qualified to operate propulsion turbines, ships service turbine generators (SSTG), distilling plants, and auxiliary equipment.
- **Electrical Switchboard Operator** is the electrician assigned watch on one of the main or emergency electrical switchboards.
- **Sounding and Security** watch is an assigned roving security patrol.

**DIESEL PROPULSION**
- **EOOW** is the officer, Chief Petty Officer or Petty Officer on watch in charge of the ship’s entire engineering plant.
- **Engine-room Supervisor (ENOW)** is responsible for operating the main engines and associated auxiliaries, as directed by the EOOW.
- **Damage Control Console Operator** is responsible for monitoring the ship’s fire, flooding and material security and ensuring ship compliance with the effective material condition set by the EOOW or OOD.
- **Engine-room Watch Team** has personnel qualified to operate diesel engines, distilling plants, and auxiliary equipment.
- **Sounding and Security Watch** is an assigned roving security patrol.
In this lesson you will learn how to use several different records and logs, including the Engineering Log and the Bell Book. These logs and records document important events onboard ship. Some logs are considered legal records and are required by law. Your goal is to identify the purpose of the engineering department’s legal records, operating logs, and reports.

Terminal Objective - Demonstrate an understanding of the purpose and process of maintaining logs and records.

- Enabling Objective - Identify the purpose of the engineering department’s legal records, operating logs and reports.
- Enabling Objective - Identify how to fill out a watch station record when provided with a log, sequence of events and a simulated gauge panel.

ENGINEERING DEPARTMENT LOGS AND RECORDS
Logs and records are a part of everyday life aboard ship. Throughout history, Sailors have kept logs to track the events of their voyages. In the past, these logs have assisted navigation, and in current times, they aid in maintaining and improving equipment, and keeping life aboard ship safe environment. Logs and records are maintained to document important events and to record other required information. Logs can warn the operator of an impending problem or can help in troubleshooting an existing problem. They can also provide information needed to make reports to higher authorities.

The Engineering Log is a record of engineering system status and operational events on surface ships, and is one of the two legal records maintained by the Engineering Department. It is a complete daily record that covers important events and data pertaining to the Engineering Department and the operation of the ship’s engineering systems. The Engineering Log shows a variety of information. It records which equipment is in operation, casualties to equipment or personnel, and any general information that affects the engineering plant. Quantities of fuel, water, and lube oil on hand are also entered in the log. Finally, regular entries are made to record miles traveled and the ship’s draft. There are several characteristics that you need to remember about the Engineering Log.

- First, the Engineering Log is a LEGAL document. You need to ensure its accuracy and safekeeping. This log is kept onboard ship for three years in case you need to check previous years' entries for any reason.
- Second, when entering information into the log you should use a continuation sheet to allow as many entries for the day as necessary.
- Third, the Engineering Log may NOT contain erasures. When a correction is necessary, a SINGLE line is drawn through the original entry so that the original entry remains legible. The correct entry is then entered clearly and legibly. The correction is then INITIALED at the margin.
- Fourth, ONLY the person required to sign the log may make corrections, additions, or changes. No other person shall make entries or corrections in the log.

The Bell Book, or Bell Log, is a record of all bells, signals, and other orders received by the throttle man regarding movement of the ship's propellers. It is one of the two legal records maintained by the Engineering Department. The Bell Book is a LEGAL document and is kept onboard ship for three years. It is maintained by the station in control of the shaft, where entries are made as soon as an order is received. If a ship has more than one shaft, a separate log is kept for each shaft. On gas turbine ships, the Bell Log automatically monitors the propulsion status, rpm, and pitch each hour, and as changes occurred. It provides an automatic printout of this information. Should the automatic log system fail, the Bell Log must be manually maintained. In addition, on gas turbine ships the data log automatically generates printouts of Propulsion Status parameters, Auxiliary System parameters, and electrical plant parameters.

There are many more logs and reports that you will encounter.

- The Fuel and Water Report lists current quantities and locations of liquids onboard, such as fuels, lubricating oil, and fresh water.
- The Fueling Memorandum must be approved by the Engineer Officer whenever fuel, diesel oil, or lubricating oil is received or transferred.
- The Navy Energy Usage Reporting System or NEURS is a monthly report on inventory, re-supply, sale, and consumption of petroleum products aboard Navy ships.
- The Bearing Record is a locally prepared, permanent log that records the thrust clearances of the turbines and reduction gears, as well as the journal-bearing clearances of the turbines and main propulsion shafting. Additionally, the bride or micrometer depth gauge readings and comments on the thrust bearings are maintained in the log. Finally, measurements or conditions that deviated from original or normal readings, or any departures from standard procedures, must be recorded in the Bearing Record.
- The Damage Control (DC) Closure Log is maintained in Damage Control Central. It shows the existing material condition of readiness. It also records which settings have been broken, such as when fittings are open that should have been closed or when fittings are closed that should have been open.
- The Boiler Water Chemistry/Feed-water Chemistry Logs are records maintained by the oil and water king that contain the data used to maintain proper water conditions in a steam propulsion plant.
- The Trouble Call Record is a daily record of trouble calls; this record includes the time received, nature of problem, who is assigned to correct the problem, and time completed. These records provide information about unusual maintenance problems and ensure that service calls are handled properly.

WATCHSTATION LOGS AND RECORDS
Data recorded on operating logs/records ensure frequent observation of the machinery by the watch-standers and provide the basis for performance analysis. Such records are examined daily by the Division Officer and the Engineer Officer, as appropriate. The Operating Log contains records for each major piece of machinery in the engineering plant. Operating Logs are maintained onboard for six months.

The log has the minimum and maximum readings for each piece of equipment that define normal operation. These readings will give a quick reference point for detecting abnormal operation. Unexpected changes in readings must be investigated even if the reading is within the minimum and maximum readings allowed. Readings indicating abnormal operations (that is, outside the minimum and maximum allowed as noted in red in the log) must be circled in red and reported to the watch supervisor, and an annotation made in the remarks section. Both the circle and the annotation should be made with red ink. The Operating Log is a daily log that runs from midnight to midnight. Readings are normally taken every hour the equipment is in operation, and they should be taken as close to the hour as possible. When a correction is required, a single line is drawn through the original entry such that it remains legible. The correct entry must be made neatly and then initialed. Only the Watch-stander required to sign the log is permitted to make corrections, no erasures are allowed. Make sure you follow proper procedure for any corrections that are made to the log.
Readings are normally taken every hour; however, exceptions do occur. If hourly readings are missed for any reason, a set of readings must be taken as soon as practical. In the Remarks section, record when the readings were taken and the reason for the delay. Readings should be taken on all operating equipment and on non-operating equipment where you can obtain meaningful data. When readings are not taken, the reason should be noted in the space where the reading should have been. When a whole station is secured or if the equipment is secured for several hours, a single word “secured” should be used. All spaces must be filled either with readings or notations. When equipment is started, an individual set of readings should be recorded in the previous hour’s column and a note added to indicate when the unit was started and the readings taken.
As a watch-stander in the Navy, you have to maintain a vigilant watch at all times. The threats to ship security not only come from external forces, but possibly from internal threats by Sailors that may deliberately cause damage to the ship or the crew. The technical complexity of modern warships makes them vulnerable to a wide variety of deliberately inflicted damage. A ship with mangled reduction gears cannot move under its power, and is as much a loss to any pending operation as if it had been destroyed. As a member of the division, you will be responsible for divisional spaces, including their security. This lesson identifies the purpose of the Physical Security Program and requirements for security devices within the engineering department, physical security as it relates to watch-standing and making reports within engineering; lastly, you’ll learn to identify the effects of emergency situations on physical security.

Terminal Objective - Demonstrate an understanding of the physical security program and watch standing fundamentals.

Enabling Objective - Demonstrate the purpose of the Physical Security Program and requirements for security devices within the Engineering Department.

Enabling Objective - Identify physical security as it relates to watch standing and making reports within engineering.

Enabling Objective - Identify the effects of emergencies on physical security.

**PHYSICAL SECURITY PROGRAM REQUIREMENTS**

The Engineer Officer is specifically charged with drafting and enforcing a complete security plan for the engineering department. This instruction may be one of the Engineer Officer’s Standing Orders or an enclosure to the ship’s Physical Security Plan, or both. At a minimum, the engineering physical security measures should address the following: purpose and terms, key control, space locking requirements, equipment locking requirements, reduction gear physical security, and finally, breach of security procedures, which will be covered in this lesson. Whether in the continental United States or overseas, all navy ships must meet common security requirements to ensure their own protection in the face of external terrorist threats or internal sabotage efforts.

The purpose of the Physical Security Program is to safeguard the ship and ship’s company from fire, flooding, sabotage, compromise, espionage, terrorism, and other criminal or subversive activities. Shipboard security is an essential part of a ship’s overall mission. Ultimate responsibility for physical security lies with the Commanding Officer. Each ship is required to prepare a comprehensive Physical Security Plan; one that sets down the security requirements of each department for each threat condition.

- **A lock** is a device requiring an external key, combination, or other opening device; entry or manipulation is positively prevented.
- **A locking device** is a positive stop designed to prevent inadvertent manipulation.
- **A control key** is a specially constructed key, which allows complete disassembly of a security lock. This key is used to conduct Planned Maintenance (PMS) on the lock itself and is maintained in the custody of the key issue control custodian. The Engineer Officer maintains custody of the control key for the main reduction gear security locks.
- **An operator key** is a standard key used by watch-standers and maintenance personnel to open locks and operate or conduct maintenance on the protected system.

The main propulsion spaces are engineering spaces containing the main reduction gears, the main propulsion engines, supporting systems and propulsion shafting. The major auxiliary spaces are shipboard spaces containing auxiliary equipment vital for support of main propulsion spaces or vital to individual primary ship mission areas.

Key control, in its most efficient form, enforces Physical Security aboard our ship. One key locker contains all the keys to the main propulsion spaces, the major auxiliary spaces, the major equipment, the locks of vital system valves and the locks of sounding tubes. The key issue control custodian, the Engineering Duty Officer and the Engineer Officer have the only keys to the key locker. The custodian issues keys as necessary to the watch-standers and the keys become pass-down items that succeeding watch-standers assume accountability for. The Engineer Officer maintains custody of the operator keys to the main reduction gear security locks, and the control keys used to disassemble them.

The main propulsion and major auxiliary spaces, both in-port and underway, must be kept locked or continuously manned. All the accesses to the locked spaces must be checked at least hourly, and the spaces themselves entered and checked. Emergency escape trunks and scuttles must never be locked from the inside. Anyone inside must be able to get out quickly, without needing a key. Hatches and scuttles equipped with permanently installed, double-acting hand-wheels may be fitted with a hinged, lockable box that covers the top hand-wheel without impeding the operation of the hand-wheel from the inside by an escaping crewmember. Hatches and scuttles fitted with removable hand-wheels may be stripped of their top hand-wheels, and the attachment point covered by a smaller, hinged, lockable box or welded hasp.

Reduction gear physical security is the Engineer Officer’s absolute responsibility. He must approve removal of any inspection plate, fitting, or cover which permits access to the reduction gear casing, and must ensure that all of the following specific security precautions are adhered to. He must establish a controlled access area; be present for the removal of any inspection plate, fitting, or cover that permits access to the gear casing. Assign a responsible E-5 or above to guard the openings constantly, or install temporary closures, and make a final inspection prior to closing the access. The Engineer Officer must make this inspection.

Requirements onboard ships for specific equipment-locking devices or seals are specified in the EDORM. All CHT vent valves will be locked open if closing them would cause tank pressurization. Stripping pump discharge valves to the fuel transfer system will be locked closed with a locking device or lock. Stripping pump suction valves from the fuel service pump suction headers will be locked closed with a locking device or lock. AFFF system valves may need to be tamper sealed in the open or shut position. All Ballast and de-ballast valves, the operation of which would allow interconnection of oil or oily waste with the sea, or allow the sea to flood operating spaces, will be locked shut. Lock all boiler safety valves with a padlock (and with lead wire seals, as applicable) to prevent any unauthorized changing of settings. Boiler safety valves adjusting nut caps will be locked to prevent inadvertent adjustment. All feed-water tank-sounding tubes will be locked shut.

Any lube oil valve which by its operation could starve, limit, interrupt or in any way impede lubrication to any main engine, reduction gear, generator, turbine driven equipment and line shaft bearings, will be locked in the required position for normal operation. This includes lube oil drains, rundown, and hose connection valves. Lube oil supply valves have to be locked or have a locking device installed in addition to end caps or plugs. Lube oil sight flow indicators will be lead wire-sealed. All lubricating oil pump suction and discharge cutout valves will have locking devices to permit locking in the open position as per applicable EOP or diagram, including priming valves. The intent is to eliminate inadvertent securing of any valve that would cause oil starvation to vital machinery.
Potable water sounding tubes provide all potable water tank-sounding tubes with valves or caps and padlocks. All potable water tank-sounding tubes will be locked shut. Main Reduction Gear (MRG), ship service and emergency diesel access/inspection covers will be locked with medium security locks and sight flow indicators will be lead wire-sealed. Spring bearing or line shaft bearing inspection covers, whether hinged, pinned, or bolted, will be secured by high security-type locks. Line shaft bearing access cover bolts will be lock-wired.

**WATCHSTANDING AND ENGINEERING REPORTS**

Any lock can be defeated, given enough time. The locks required by the physical security program will be ineffective without the additional protection of alert, conscientious, and knowledgeable watch-standers, supervisors, and engineering department officers. The Sounding and Security watch maintains a continuous patrol above and below decks following a prescribed check-off sheet. Sailors will check the security of the engineering spaces, be constantly alert for sabotage, theft, fire, flooding, checking damage control fittings for compliance with the current material condition, and taking tank soundings to ensure no changes in liquid loading are occurring.

The Watch-stander must have the skills to detect unusual noises, vibrations, odors, or events that may indicate abnormal conditions. Broken or missing security locks and wire seals may indicate theft or sabotage. Missing nuts and bolts may indicate sabotage as well. Unusual noise and vibration or gauge readings may indicate faulty equipment operation. The Watch-stander must be ready in emergencies to act quickly and independently. As a Watch-stander, if you do not know whether the condition is abnormal ask the immediate watch supervisor. The Cold Iron Watch will ensure that the spaces are in satisfactory condition—for example, ensuring there are no tools, rags, or other gear adrift and the bilges are reasonably free of water.

Inspect all the equipment in accordance with the EOSS before starting. Include notations for locked and unlocked spaces in the sounding and security log. Ensure that all supervisors check watch-standing procedures, both in-port and underway. Supervisors are responsible for the conduct of these watches and should initial logs hourly, randomly inspect spaces to ensure that they are locked or properly manned. Report Sounding and Security inspection results hourly to the appropriate authority as designated by ship’s instruction. The Cold Iron and Equipment monitor watch is responsible for checking the security of the main and auxiliary spaces, being constantly alert for sabotage, theft, fire, flooding, or any other abnormal conditions in the plant. Report Cold Iron inspection results hourly to the appropriate authority as designated by ship’s instruction.

The ship is in a cold iron status when it stops operating its propulsion plant(s) and is receiving services from shore or other ships. The Cold Iron Watch-stander is the person assigned to the main engineering spaces while the space is in a cold iron status. As a Cold Iron Watch-stander, you will make frequent inspections of the assigned area. The purpose of the cold iron watch is to detect and prevent flooding, fire, theft, sabotage, unauthorized personnel, and other abnormal conditions.

The physical security program is comprised of the following chain of command:

- **The Command Duty Officer (CDO)** represents the Commanding Officer in their absence, is responsible for physical security of the ship, and takes direct control of security forces in the event of a security alert.
- **The Officer Of the Deck (OOD)** In-port, represents the Commanding Officer, and reports to the CDO. They control access to the ship and receive hourly reports from the sounding and security watch. The OOD will be armed at the Commanding Officer’s discretion. The Petty Officer of the Watch (POOW) assists the OOD in ensuring quarterdeck security. They are usually armed in foreign ports and when the Commanding Officer directs.
- **The Departmental Duty Officers** are responsible both to the CDO and to their department heads for the security of their departmental spaces and equipment. The Engineering Duty Officer (EDO) is further responsible for the status of the engineering plant while in port.
- **The Sounding and Security Watch (S/S)** are continuously roving seamen, firemen or petty officers who check for space security, take fuel, water and void soundings, and look for signs of unusual activity. During their rounds, their findings are logged hourly. The OOD must call away a Security Alert if they are late in reporting.
- **The Ship’s Self Defense Force** (SSDF) and Physical Security Officer are also integral parts of the of the physical security program.

**EFFECTS OF EMERGENCY SITUATIONS**

Breach-of-security procedures are identified as part of the engineering department physical security measures. Any breach must immediately be reported to the Engineer Officer or, in his absence, the Engineering Duty Officer. Any further operations involving that equipment or that space should be delayed until a thorough investigation can be completed. Only the Engineer Officer, Command Duty Officer or Commanding Officer can approve the resumption of normal operations.

All types of security violations are serious and cannot be tolerated in our Navy. It’s your responsibility to report all physical security violations to the Officer Of the Deck or Command Duty Officer. In cases involving fire or flooding, be sure to state the following information: what type of casualty have you witnessed, the location of the casualty, the compartment noun name, your name, your rate/rank, and telephone number. You should refer to local instructions for reporting procedures for acts of terrorism which include the possibility of bombs, intruders, or possible tampering or compromise of main reduction gear covers.

Possible ignition sources must be monitored and controlled from hot equipment, welding sparks, and smoking lamp violations. Accumulation of fuels and oils in drip pans and other areas must be promptly removed. When hot work is conducted in the watch area, the cold iron watch ensures that a fire watch is stationed. The fire watch stands by with an extinguisher. The cold iron watch is to stop the hot work if the fire watch is not on station.

The Cold Iron Watch-stander makes their inspection round by touring the spaces, and detecting and identifying any unusual or hazardous condition that may occur during the watch. When conducting inspection rounds of a cold iron space follow established guidelines for detecting and identifying unusual or hazardous conditions. Standing a good watch is the best way to gain the respect and confidence of your supervisors and shipmates. Some ways to ensure a successful watch is to relieve the watch on time or a little early to have a good turnover, and know the condition of the machinery and the things that need to be done prior to assuming the watch. Also, tour the space before relieving the watch. Do not relieve the watch first and then try to figure out the condition of the plant later. When being relieved, ensure that the relieving Watch-stander completely understands the situation of the plant, and ensure that the watch-station is clean and there is no gear adrift.
As an engineer you need to know how to properly operate a ship’s propulsion plant. Following the proper procedures onboard Navy ships, ensures an increase in equipment service life and minimizes casualties. Your goal is to become familiar with the purpose, location, and terminology of the Engineering Operational Sequencing System or EOSS. You will learn about the parts of the EOSS. Understanding the EOSS will enable you to properly perform your job as an engineer.

Terminal Objective - Demonstrate an understanding of the purpose, location, and parts of EOSS.
- Enabling Objective - Identify the purpose, location, and terminology of the Engineering Operational Sequencing System.
- Enabling Objective - Identify the parts of the Engineering Operational Sequencing System.

EOSS PURPOSE, LOCATION, AND TERMINOLOGY
As an engineer, you will use the standardized procedures found in the Engineering Operational Sequencing System (EOSS) to perform scheduled plant evolutions. EOSS provides safe, technically accurate, and standardized operational and casualty control procedures tailored to the individual ship’s configuration. Use of EOSS is mandatory, increases equipment service life and minimizes casualty occurrence by ensuring that each system or component is properly aligned, operated and secured. EOSS also ensures that shipboard training for machinery operation is standardized.

A shipboard EOSS package consists of one complete laminated set of Engineering Operational Procedures (EOP) and Engineering Operational Casualty Control (EOCC) procedures to be used as the on-station books in the Engineering Spaces. There is also a CD-ROM to be kept in the log room. The Log Room copy is an information copy, contains an electronic copy of EOSS for use in the Engineering Log Room. The CD-ROM allows the user to view and/or print EOSS documents for a particular ship.

The EOSS uses certain terms throughout each of its parts. You should become familiar with each term and its meaning so that you will accurately understand the instructions you are being given with each procedure. Let’s look at some of the terms you will need to understand when using EOSS. You can find additional terminology in the EOSS User Guide.

- Align – The opening or shutting of valves in a piping system or the positioning of switches or controls in an electrical system to permit the required flow of fluids or current.
- Controllable – Used to describe an abnormal condition or casualty situation when the Controlling Actions taken have contained the casualty or stopped the cascading effect and possibly returned the plant to normal operation.
- Crack-Open – The act of opening a valve a small amount to permit fluid flow at a minimum rate as compared to normal flow.
- Cross-Connect – The act of opening valves in a system with more than one segment, each capable of independent operation, so that the segments can operate as one system.
- De-energize – The act of opening an electrical circuit breaker or switch at a power supply.
- Energize – The act of closing an electrical circuit breaker or switch at a power supply.
- Notify – Used to indicate vital information that must be passed to other watch-standers.
- Order – Indicates an action or series of actions which must be directed and controlled. When an Order is given, there will be a Report that the action or series of actions has been completed.
- Report – Used to indicate that the actions or series of actions have been completed as ordered.
- Shift – Action(s) required to ex-change components or change a system’s mode of operation.
- When Ordered – Used to indicate an action or series of actions which must not be performed until ordered by the EOOW or Space Supervisor.
- When Reported – Used to indicate an action or series of actions which must not be performed until Report of previously ordered action or series of actions is received.
- When Required – Used to indicate an action or series of actions which may or may not be required to be performed.

In various EOSS procedures you may find Notes, Cautions, and Warnings. Warnings alert you to an action or series of actions, which if not strictly adhered to, may result in injury. Warnings will always precede notes, cautions, and the action or series of actions to which they apply. Cautions alert you to an action or series of actions, which if not strictly adhered to, may result in equipment damage. Cautions always precede notes and the action or series actions to which they apply. Notes alert you of essential information, project final results, or highlight a particular condition. Notes normally precede the action or series of actions to which they apply.

EOSS PARTS
As an engineer you need to know the procedures to align, operate, and secure a system. The Engineering Operational Sequencing System (EOSS) on your ship will provide you with these procedures. The EOSS is tailored to individual pieces of equipment or systems and is issued to the watch-station to which it applies. You must follow the steps as stated in the EOSS procedures at the watch-station for each piece of equipment. As you repeatedly use the EOSS procedures to operate a propulsion plant, your level of proficiency and performance on the job will increase.

During the operation of the ship’s systems, you may need to shift the ship’s propulsion plant between the various steady state operating conditions, respond to a casualty situation, or restore a system from a casualty situation. To properly respond to these conditions you must adhere to the approved EOSS procedures that are installed on your ship. If any change or deviation from the EOSS is necessary, the change must be authorized by the Commanding Officer (CO) with either a signature at the bottom of each procedure or a cover letter explaining the authorized change.

The EOSS User’s Guide, found in book one of the EOSS package, and explains the other two main parts of the EOSS. This guide also provides suggestions for training the ship’s personnel to properly use the EOSS procedures. The other two main parts of the EOSS are the Engineering Operational Procedures (EOP), and Engineering Operational Casualty Control (EOCC).

EOP
The EOP consists of technically correct written procedures, status charts, and diagrams required for the normal transition between steady state operating conditions. The EOP is configured according to the individual ship’s engineering plant configuration and degree of plant control (for example, fully automated, partially automated, and non-automated) to provide the maximum level of control and minimum level of supervision.
**The EOCC** consists of technically correct, logically sequenced procedures for responding to and controlling commonly occurring casualties. When properly followed, these procedures result in the placing of the propulsion plant in a safe, stable condition while the cause is being determined. After the cause has been discovered and the problem corrected, provision is made for casualty restoration.

The EOP is further divided into several parts:

- **Component procedures (CP)** contain logically sequenced actions and required reports to prepare, align, start, and operate, shift, secure, or stop a specific component as ordered by the Space Supervisor. CP gives specific steps for aligning components for ready operation. It is important that you follow the steps as they are written. This ensures that the component is properly aligned and is ready for operation.

- **System Procedures (SP)** contains logically sequenced procedures and required reports to align or secure a system. They also contain sequenced procedures to start or stop components within a system, as necessary, to complete an evolution as ordered by the Space Supervisor, EOOW, or OOD. Each system procedure directs the user to a specific diagram to be used in support of the System Procedure being accomplished.

- **Master Plant Procedures (MP)** are a set of corresponding Operational Procedures that contain all the required actions necessary to accomplish a specific plant status change. These procedures contain logically sequenced actions and required communications between the Engineering Officer of the Watch Engineering Officer of the Watch (EOOW), Officer of the Deck (OOD), and Space Supervisors.

- **Operational Procedure (OP)**, each OP for the EOOW contains logically sequenced actions and required communications for directing, controlling, and coordinating the actions of Space Supervisors to accomplish a plant status change. Each OP for the Space Supervisor contains logically sequenced actions and required communications between the Space Supervisor, the EOOW and all watch station personnel under the supervisor’s control in support of plant status changes. Each OP will specify the Component Procedure (CP) or System Procedure (SP), by use of acronyms, required by watch-standers to perform the action as ordered by the Space Supervisor.

- **Status charts (SC)** contain information about the plant status. In these charts, you will find information on components such as pumps, engines, or equipment on line. The use of status charts ensures that the exact plant status is readily available. By using the information in the status charts, the supervisor can determine the effect a specific action will have on the plant.

- **System Diagrams (SD)** is provided for systems within the propulsion plant. These diagrams will show all valves in a specific system. The numbers assigned to each valve are the numbers designated by Planning Yard documents or “E” numbers assigned by the EOSS developer for those valves not designated in those documents. You can see the numbers assigned to each valve on this diagram. If you need to ensure a valve is locked, a system diagram will help you find the valve’s location.

- **Tank Tables (TT)** provides the proper valve alignment for each combination of tanks, components, fuel stations, and systems that are used when accomplishing an evolution. Each Tank Status Diagram contains the Fuel Oil Service, Storage, Contaminated, and Reserve/Emergency feed-water tank location. The capacity of each tank is shown and space is provided to record the actual amount in feet and inches.

- **The Master Pre-light Off Check List (MLOC)** is the recommended minimum actions that must be completed prior to plant start-up. Some plant start-up actions are aligning systems, running pumps, or starting heaters. The last page of the pre-light off checklist provides a space for the Engineer Officer to list specific actions that are to be completed prior to start up/light-off. All MLOC discrepancies must be reported to the Engineer Officer. The Commanding Officer is the only one who may waive MLOC discrepancies.

**EOCC**

You must know how to operate equipment and also know what to do to prevent equipment casualties. For example, if you hear an unusual noise in the main reduction gear, you must know how to respond to this casualty situation. If this noise is left unchecked, loss of the ship’s maneuverability could occur. The part of EOSS called, the Engineering Operational Casualty Control (EOCC), gives you this information. The EOCC consists of technically correct, logically sequenced procedures for responding to and controlling commonly occurring casualties. When properly followed, these procedures result in the placing of the propulsion plant in a safe, stable condition while the cause is being determined. After the cause has been discovered and the problem corrected, provision is made for casualty restoration.

**Master Causality Response Procedure (MCRP)** provides an overview of the casualty response for each specific casualty. All watch-standers must review the Master Causality Response Procedures regularly to get a complete picture of the overall casualty response, which allows you to see your role in that response. Within each MCRP there are several sections, these sections contain symptoms or indications, possible causes, effects, and basic actions. The MCRP will then list the actions all watch-standers are to take. The four basic watch area actions described in the EOCC are controlling actions, immediate actions, supplementary actions, and restore casualty actions.

**Casualty Response Procedures (CRP)** actions are logically sequenced for each watch area to respond to a specific casualty. The minimum required communications to maintain positive control is included. The individual watch areas use the CRPs. Watch area CRPs do not contain Symptoms or Indications, Possible Causes, and Possible Effects. Each watch area CRP will contain the Controlling Actions, Immediate Actions, Supplementary Actions, and the Restore Casualty Actions for that particular watch area. Personnel have a complete set of MCRPs available which are intended to be used as a study guide. Once Immediate and Controlling Actions have been accomplished from memory, then the watch-stander will review the Immediate and Controlling Actions in the EOCC to ensure all steps were followed. Once the Immediate and Controlling Actions have been reviewed, the watch-stander will proceed to Supplementary Actions and eventually restore from casualty steps.

- **Controlling Actions** are watch-stander actions that you take to prevent or minimize damage during a casualty. This part of EOCC must be memorized.

- **Immediate Actions** are watch-station actions that you take to stop the spread of a casualty and to minimize plant losses. This part of EOCC must be memorized.

- **Supplementary Actions** are watch-station actions that you take to bring the plant to a safe and stable operating condition. Once you take the actions necessary to bring the plant to a safe and stable operating condition, report the cause of the casualty and estimated time of repair to the Engineer Officer (EO).

- **Restore Casualty Actions** consist of proper EOPs used either for restoring the plant for operation or for the continuance of securing the affected equipment. If you correct the cause of the casualty, the restore casualty actions will tell you how to restore the plant to an operational condition.
The Navy’s ability to accomplish its mission requires daily land, sea and air operations. The Navy operates ships and shore facilities in a committed and compatible manner with the environment. It treats national defense and environmental protection as compatible goals and safeguards its endeavors to prevent pollution and to protect the environment.

**Terminal Objective** - Identify the risks and corrective actions for protecting the environment.

- **Enabling Objective** - Identify the common causes of shipboard pollutants and steps taken to protect the environment.

### COMMON CAUSES OF SHIPBOARD POLLUTANTS AND STEPS TO PROTECT THE ENVIRONMENT

The mission to prevent pollution and protect the environment is not one to be taken lightly. To ensure the Navy can effectively perform this mission, all hands must be aware of the environmental laws and regulations established to prevent destruction of the environment in which it conducts operations. The Navy is committed to ensuring that all personnel develop and exhibit an environmental protection ethic. This lesson covers the common causes of shipboard pollutants and steps you need to take to protect the environment. Everyone can make immense contributions to the preservation of the environment by taking steps to avoid polluting it.

The purpose of the Navy’s Environmental Readiness Program is to establish an environmental controls policy that ensures the ability of United States Navy forces to effectively operate worldwide in an environmentally responsible manner, both ashore and afloat. The Environmental Readiness Program Manual provides guidance, policy, and responsibility for strict adherence to all applicable environmental regulatory standards, including control of oil and oily waste, discharges of solid waste, sewage, and hazardous substances, and noise and air pollution.

The Clean Water Act prohibits the discharge of oil in a harmful quantity into all waters off the US coast. US EPA regulations state that a discharge of oil in a harmful quantity is one that violates applicable water quality standards or causes sheen on the water. The oil content within a discharge that is sufficient to cause sheen varies with the type of oil, sea state, lighting and viewing angle. In general, 15-20 parts per million (PPM) of oil is sufficient to cause a sheen. To ensure compliance with the federal, state, and local environmental policies, there are shipboard operational and management requirements for bilge water and oily waste, shipboard oil pollution abatement, and waste/used oil.

Ships shall minimize the oil contamination of bilge water. Properly functioning mechanical seals in oil and water pumps and the proper segregation of oily and non-oily wastewater greatly reduces the generation of oily waste. Use of bilge cleaners or chemical agents that promote chemical emulsion (i.e., detergents and surfactants) for machinery space cleaning is not permitted. For bilge water and oily waste disposal in port, the Navy policy is to maximize separation, recycling, and reuse of oil and dispose of bilge water and oily wastes per supporting activity guidance using permanent shore reception facilities or an Oil Water Separator system (OWS).

The bilges are compartments near the bottom of the hull where water collects so that it may be pumped out. Spills and leaks are possible onboard ships, with most of these spills collecting in the ship’s bilges. Bilge water contaminated by pollutants is pumped into the ship’s oily waste tank to be processed by the Oily Water Separator. Because oil in the bilges may generate vapors that can ignite with a spark or open flame, you need to remove any oil from the bilges.

For shipboard Oil Pollution Abatement (OPA), the Navy established, as a major goal, the complete discontinuation of all discharges of oily wastes into streams, harbors, and oceans by Naval ships. This goal is set forth in OPNAVINST 5090.1 series, the Environmental Readiness Program Manual. Oil or oily wastes shall not be discharged into the sea or other waters from any Navy activity or ship.

Waste oil is oil whose characteristics have changed markedly since being refined, has become unsuitable for further shipboard use, and is not considered recyclable. Used oil is similar to waste oil in that its characteristics have changed; however, used oil may still be suitable for future use and is economically recyclable. Collection, labeling and storage of synthetic lube oils and hydraulic oils will be kept separate from other used/waste oils for shore reclamation. Ships shall retain containers (drums, cans, etc.) in which oil products were originally packaged and properly label them per reference for storing and transferring oil ashore.

Ships must have a Shipboard Spill Contingency Plan (SSCP) in place to respond to spills of Hazardous Materials (HM) and a Shipboard Oil Spill Contingency Plan (SOSCP) to respond to oil spills. Each plan contains procedures for reporting, containing, controlling, recovering, and disposing of spilled material, protective clothing, and spill clean-up materials; information sources for oil and HM; and names and telephone numbers of fleet, as well as shore-side Navy On-Scene Coordinator (NOSC).

### TYPES OF SHIPBOARD WASTE

All of us produce waste. The ship and her crew produce several types of waste during daily operations in port and underway. Hazardous substances or Hazardous Waste (HW) is any discerned, or intended to be discarded, material (liquid, solid, or gas) that meets the definition of hazardous material and is designated as a hazardous waste by the Environmental Protection Agency (EPA) or State Authority. Ships must transfer used or excess hazardous material or hazardous waste in properly sealed containers to a Navy shore activity to determine its further use. Asbestos and lead require special guidance for handling and control. They are addressed specifically in the OPNAVINST 5100.19 Series, Navy Safety and Occupational Health (SOH) Program Manual for Forces Afloat.

Oily waste is any solid or liquid substance that can produce a surface film or sheen when discharged into clean water. Most oily wastes are derived from petroleum products. Oil waste contains only a small amount of water but cannot be used by the ship. It’s separated from the water and sent to the oily waste tank. Any mixture that causes an oily sludge or emulsion to be deposited beneath the surface of water is oily waste. Oily waste usually comes from lubricating oil tank cleaning operations, leakage, and drainage from equipment and their systems, stripping from contaminated oil-settling tanks, or compensating water used in fuel tanks.

Shipboard sewage treatment systems are used to control the pollution of inland and coastal waters by controlling certain aspects of the Shipboard Sewage System. In accordance with Navy policy, sewage cannot be discharged within 3 miles of land. The ship’s collection, holding and transfer (CHT) tanks hold the sewage until discharge is allowed. There are some ships that incinerate sewage, while others use a biological process to break it down. Sailors operating the sewage systems are subject to serious hazards, including explosive gases, toxic vapors, and biological contaminants. Following the ship’s policy for proper and safe handling will minimize these hazards.

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Although not toxic to marine organisms, plastic waste causes death to marine life through entanglement and ingestion. Ships are required to process and retain all plastics aboard for transfer or shore disposal. It is permissible to replace disposable plastic items with non-plastic items where possible. The overall goal is to minimize the amount of plastic supplies consumed onboard.

**MERCURY AND MERCURY COMPOUNDS**

Mercury is common aboard ships as elemental mercury and as organic or inorganic mercury compounds. This highly toxic metal poses a serious health hazard to exposed personnel and likewise is toxic to fresh and salt water marine organisms. Therefore, the handling and release of mercury and mercury compounds must be controlled to minimize personnel and environmental exposure. Mercury presents an extreme health hazard and is stowed and handled with great caution. When exposed to air, mercury releases vapors in toxic concentrations. Inhalation, ingestion, or absorption through the skin can damage the central nervous system. Repeated exposure to low concentrations causes chronic poisoning and cumulative damage.

Mercury should be stowed in accordance with NAVSEAINST 5100.3 series: Control of Mercury, Mercury Compounds and Components Containing Mercury, or Mercury Compounds. Stowage should be in plastic bottles or plastic-lined glass bottles with tight stoppers or caps. Use the original containers whenever possible. Inspect the containers regularly for leaks. Keep the stowage spaces cool, dry, and well ventilated. When handling mercury or mercury compounds, observe general precautions for hazardous material and special stowage precautions. Handle mercury only in specified areas that are kept free from excessive heat (heated mercury releases toxic fumes). When handling mercury or its compounds, wear a neoprene splash suit, an apron or coveralls, neoprene gloves, and rubber-soled shoes or rubber boots. No food, drinks, or smoking is allowed in areas where mercury is handled.

If there is a mercury spill of two ounces or less, perform the following procedure:

1. Wear protective clothing at all times.
2. Apply local ventilation to the immediate areas of the spill.
3. Direct ventilation overboard, and keep the area as cool as possible.
4. Gather the mercury by sweeping or brushing, or by vacuuming with a special vacuum cleaner.
5. Use masking tape to pick up final traces of mercury globules.
6. Seal the collected material in plastic bags and retain for shore disposal.
7. Wash the spill area with a solution of HgX Mercury Decontaminate.

Mercury is an environmental pollutant and must not be discharge into any body of water or released into any ship’s waste disposal system. Disposal should be coordinated with the ship’s Hazardous Material Coordinator and shore facility and will be in accordance with NAVSEAINST 5100.3 series: Control of Mercury, Mercury Compounds and Components Containing Mercury, or Mercury Compounds.
General plant safety is vital to ship and personnel wellbeing. Safety enhances operational readiness by reducing the number of deaths, injury to personnel, and equipment damage due to accidents. All equipment operators and maintenance personnel must be familiar with the most common safety hazards. A good understanding of what to look for and how to react to hazards will ensure the safety of all aboard. It is important to identify the components of the Operational Risk Management or ORM concept, know how to identify the basic safety precautions related to the Engineering Department, and know the method for identifying hazards, assessing risks, and implementing controls to reduce the risk associated with any operation.

**Terminal Objective** - Demonstrate an understanding of Operational Risk Management and safety precautions related to the Engineering Department in accordance with OPNAVINST 5100.19 and Operational Risk Management (ORM), OPNAVINST 3500.39.

- Enabling Objective – Identify the basic components of the ORM concept.
- Enabling Objective – Identify the basic safety precautions specifically related to the Engineering Department.
- Enabling Objective – Identify the hazards related to the Engineering Department.

**ORM CONCEPT COMPONENTS**

As military personnel, we have a responsibility at every level to identify hazards, take measures to reduce associated risk, and accept risk only when the benefits of operation exceed the accepted risk. The goal is to make Operational Risk Management (ORM) part of our daily operations. This simple, logical process helps save lives, protect people and preserve assets, while we accomplish our missions efficiently and effectively. You will become familiar with the ORM process and how it fits in with plant safety precautions to be observed when a plant is in steaming or cold iron conditions. ORM does not aim to eliminate risk, but to manage risk so that your duties can be accomplished with the minimum amount of loss. The five-step ORM process is a standardized tool that helps you operate successfully in high-risk environments.

ORM is a decision making tool used by personnel at all levels to increase operational effectiveness by anticipating hazards and reducing the potential for loss, thereby increasing the probability of a successful task. This increases your ability to make informed decisions by providing the best baseline of knowledge and experience available. It also minimizes risks to acceptable levels, proportionate with task accomplishment. It is a process for identifying and controlling hazards. It follows a five-step sequence that is applied on one of the three levels depending on the situation and is guided by four principles. It is important to understand ORM terms clearly and communicate risk effectively in order to use the ORM process.

**Hazard** - A condition with the potential to cause illness, injury, death, property damage, or duty degradation.

**Cause** - Something that produces an effect, result, or consequence, or is the person, event, or condition responsible for an action or result.

**Risk** - A possible loss expressed in terms of severity and probability. Leaders can make better decisions once a hazard is converted to a risk.

**Risk Assessment** - The process of detecting hazards and assessing associated risks.

**Severity** - An expected consequence of an event in terms of degree of injury, illness, property damage, or other task-imPairing factors.

The five-step ORM process is one area of ORM as a whole. Applying the ORM process reduces mishaps, lowers injury and property damage costs, provides for more effective use of resources, improves training realism, and improves the readiness of all aboard. There are five steps to the ORM process: Identify Hazards, Assess Hazards, Make Risk Decisions, Implement Controls, and Supervise. These steps provide you a better understanding of what needs to take place when confronted with a potential hazard.

- **Identifying hazards** is the first step in isolating a possible accident. Along with this first step, you must conduct an operational analysis, list all the major steps of the operation, perform a preliminary hazard analysis that list hazards and possible causes, list the hazards associated with each step, and list the possible causes of the hazards.

- **Assessing hazards** determine the degree of risk for each hazard in terms of severity and probability. A matrix is recommended but not required, it provides a consistent framework for evaluation, shows the relative perceived risk between hazards, and prioritizes which hazards to control first. After the Risk Assessment is complete, a Risk Assessment Code (RAC) is assigned based on the probability and severity of threat. This code is represented by a number: 1 Critical, 2 Serious, 3 Moderate, 4 Minor, and 5 Negligible.

- **Make risk decisions** by developing risk control options. Start with the most serious risk first and select controls that will reduce the risk. With selected controls in place, decide if the benefit of the operation outweighs the risk. If the risk outweighs the benefit or if assistance is required to implement controls, communicate with your supervisor in the chain of command.

- **Implementing Controls** is used to eliminate hazards or reduce the degree of risk. Some types of controls are administrative controls, engineering controls, and the use of personal protective equipment (PPE). Administrative controls are designed to limit your exposure to a hazard. This is done through specific administrative actions, such as providing suitable warnings, markings, placards, signs, and notices. This control includes establishing written policies, programs instructions, and Standard Operating Procedures (SOP). Another important part of this control is the training of personnel to recognize hazards and take appropriate precautionary measures. Engineering controls use engineering methods to reduce risks by design, material selection, or substitution when technically or economically feasible. The control of PPE provides a barrier between personnel and a hazard. Use PPE when other controls do not reduce the hazard to an acceptable level.

- **Supervise follow-up** evaluations of the controls to ensure they remain in place and have the desired effect. Monitor changes that may require further ORM, and take corrective action when necessary.

The Operational Risk Management (ORM) process exists on three levels. The Commanding Officer selects which level based upon the mission, situation, time available, proficiency level of personnel, and assets available. While it is preferable to perform a deliberate or in-depth risk management process for all evolutions, the time and resources to do so are not always available.

- **The deliberate level** is best described as being at the point of commencing or during execution of a mission or task. At this level there is little or no time to make a plan. An on-the-run mental or verbal assessment of the new or changed/changing situation is the best you can do. Time is limited in this situation, so the application of the 5-step process has proven impractical and ineffective. This is the level at which personnel operate on a daily basis both on- and off-duty.

- **The time critical level** refers to situations when time is not a limiting factor, and the right answer is required for a successful mission or task. Research and analysis of available data, use of diagrams and analysis tools, formal testing or long term tracking of associated hazards are some of the tools used at this level.

As with most processes, prior planning is essential to how well the job or duty is performed. Whether you are assigning, managing, or performing a task, ensure all risks associated are kept to a minimum. There are four principles of the ORM process.
**BASIC SAFETY PRECAUTIONS**

The Department of the Navy places a high value on the safety of its sailors. It is the basic safety policy that no task is so important that a sailor must violate a safety rule or take a risk resulting in injury or illness in order to get the job done. It is your responsibility to follow the basic safety precautions specifically related to the Engineering department and the training you receive. The general safety standards in this section are applicable to all shipboard operations and spaces. These standards have been adopted from requirements from the Naval Sea Systems Command (NAVSEA), the Occupational Safety and Health Administration (OSHA), USCG, Safety of Life at Sea (SOLAS), American National Standards Institute (ANSI), and previous OPNAV directives.

You experience more danger before 0900, than most people experience all day. Safety training may seem to be a worn out topic, however it is your job to stay informed about the safeguards instituted. The Navy spends countless hours to help protect you from injury. Many of your daily duties have you on and around hazardous equipment. Follow all safety precautions and be aware of surroundings. Complying with the following safety standards may save your life.

Know all exits you use in working and living spaces, and the emergency shutdown procedures for all equipment you use. Know the location of all life jackets, lifeboat/life raft stations and Emergency Escape Breathing Devices or EEBDs; all fire stations and other firefighting equipment from your living and working spaces. Know where all life rafts, water-markers, and flares are located for man overboard emergencies. Always ensure all movable objects in your spaces are secured for sea, and exits are not blocked with equipment or boxes. Roll up sleeves when operating rotating industrial machinery. Ensure ventilation ducts or diffusers are not altered and are free of blockages. Ensure low overheads and obstructions above inclined ladders (72") and passageways (75") are padded, and hazardous areas around machinery and elevators are color coded. Walk cautiously when nearing a “blind” corner.

Never run in passageways or up or down ladders, straddle or step over lifelines, wire, and chains under tension, and never dismantle or remove any lifeline system without permission of the commanding officer and without providing temporary lifelines; never lock escape scuttles so they cannot be opened from the inside. Never operate machinery with defective safety devices or machine guards without the specific permission of the commanding officer, and never tamper with any damage control fittings or equipment.

Keep familiar with the whereabouts of crewmembers in your spaces, especially in tanks, voids, or other restricted movement areas. Keep decks free of obstacles and materials causing slippery conditions, and post warning signs when needed. Ensure non-skid is installed around machinery work areas, at the top and bottom of ladders, on both sides of doors and arches with high coaming used for continuous traffic, and both sides of crew messing space doors. Only authorized personnel shall use equipment. Wear sunglasses topside, and not as protective equipment for temporary protection; never lock escape scuttles so they cannot be opened from the inside. Never operate machinery with defective safety devices or machine guards without the specific permission of the commanding officer, and never tamper with any damage control fittings or equipment.

Ensure the equipment is de-energized and properly tagged out of service before attempting to perform repairs or maintenance. If you do not see a red tag on it, check with your supervisor. Ensure all shaft guards, coupling guards, deck plates, handrails, flange shields, and other protective devices are properly installed. Do not bypass any safety devices, alarms, or sensors.

Machinery and piping in the engineering spaces produce large amounts of heat. The temperature in machinery spaces may sometimes reach over one hundred degrees. The surfaces of machinery and piping may also be extremely hot, especially piping, which is easily identified by its aluminum paint. Most machinery has moving/rotating parts, which may expose personnel to possible injury. Wear proper protective clothing when required. Never place any part of your body into moving machinery. Never attempt to ride machinery that is not designed for transport. Supervisors ensure that personnel who incur any type of injury or who are exposed to any occupational hazard receive prompt medical attention. Promptly reinstall shaft guards, coupling guards, deck plates, handrails, flange shields, and other protective devices removed as interference immediately after completion of maintenance on machinery, piping, valves, or other system components. Do not use low pressure (LP) air to unplug flammable fluid piping systems unless a specific directive or approved procedure requires its use.

To prevent injury to personnel and damage to equipment, the tag-out program is mandatory for all shipboard equipment, components, and systems. The tag-out procedure consists of a series of tags or adhesive labels that are applied to instruments, gauges, valves, or meters to indicate that they are inoperative, restricted use, or out of calibration. A tag is not to be removed without the permission of the authorizing officer, and only after being cleared following command-approved procedures. Tag-outs must never be ignored or bypassed. Ensure the equipment is de-energized and properly tagged out of service before attempting to perform repairs or maintenance. If you do not see a red tag on the instrument, gauge, valve or meter, check with your supervisor. If any system or portion of a system has more than one type of tag or sticker, the Danger (red) tag shall take precedence over all other tags or stickers. Make sure you stay up to date and read the proper instruction before tagging out an item.
While working with workshop/work-center equipment ensure areas around machines are kept clear of obstructions. DO NOT use compressed air to clean metal chips from machines. Ensure all personnel are clear before starting any industrial tools or equipment. Notify others by shouting out that you are going to start the equipment. Always keep machine guards in place. Safety barriers are used to prevent personnel from falling or getting into an unsafe area. If you see any type of barrier, that means keep out. Removal of any safety rails or lifelines requires the authorization of the Commanding Officer. Never hang or secure any weight or line to any lifeline. Lifelines are not designed for leaning against.

Steam-tight covers on incandescent lights must be used to minimize the hazards of fire caused by contact of flammable fuels with exposed lamps. Deck plates, gratings, and handrails are secured in place to prevent missile hazards, and to afford personnel support in heavy seas. Missile hazards occur onboard ship when material and equipment are not secured. Vertical ladders onboard ships pose an unusual safety hazard due to their steep incline and the movement of the ship. Never dismantle or remove any inclined or vertical ladders without the permission of your supervisor.

If you have to remove vertical ladders, secure with temporary safety lines and post warning signs. When transiting a ladder while carrying any load, make sure that you keep one hand on the safety rails. It is going to take a while to get used to going up and down these ladders.

When working on a pressure system component, ensure the pressure is fully relieved by opening any drain valves. Always use the tag-out procedures. Use two-valve protection when working on high pressure systems of 1,000 PSI or more. At least 75% of systems aboard ships use some type of liquid or gas which is used under extreme pressure. Caution must be used when working with these fluids so you will not hurt yourself or anyone else. Do not use compressed air to clean personnel or clothing, or to perform general space clean up in lieu of vacuuming or sweeping. Compressed air may be used to clean machinery parts that have been properly disassembled provided the supplied air pressure does not exceed 30 PSI and a proper safety shield tip is used. A face shield and goggles must be worn while using compressed air to clean machinery parts. When operating a compressed air system DO NOT attempt to stop or repair an air leak while the leaking portion is still under pressure. Do not use combustible cleaning solvents to clean compressor parts. Avoid rapid operation of manual valves. Heat compression caused by a sudden flow into an empty line or vessel can cause an explosion if oil is present.

While you are working with electrical or electronic equipment, be sure to stay alert to the presence of dangerous voltages, and avoid striking such equipment with tools of any kind. Should such damage inadvertently occur, report it immediately to the ship's electrical officer. Always remove your rings, watches, keys, rings, and other items that may become entangled or caught on projections, or may be a shock hazard when working with electrical or electronic equipment. Obey all the warning signs and read equipment working labels before using them. Always de-energize and tag out installed electrical equipment before making repairs. Only operate electrically powered portable tools or equipment if they bear a ship’s identification mark or tag indicating that they were inspected and electrically safe for use on board Naval ships. In case of electrical fires, carbon dioxide (CO2) is the preferred extinguishing agent.

While operating portable electric tools; keep the power tools clean, lubricated, and in good repair. Ensure tools without a positive accessory holding are equipped with an operable dead-man switch. If not, get it checked out by the ship’s electrical officer. Ensure metal-cased portable tools have three-pronged plugs, and use them with rubber gloves. Ensure personal electrical equipment has been checked by the electrical/electronic shop and has a current inspection label attached. When it comes to electricity, take no chances.

While working with pneumatic tools, personnel must be trained and authorized to operate the tools. They must wear and use necessary personal protective equipment (PPE), and must not use excessive air pressure. While working on the ship, you are exposed to many hazards that could injure you. By using your personal protection properly, you reduce your chance of injury. Proper PPE must be worn during any evolution requiring their use. Take a look at what is required and what to do in case of an incident. Clothing, such as an exposure suit, fire retardant utilities (with long sleeve shirts) or coveralls must be worn in all engineering spaces at all times. Steel toe safety shoes must be worn in all engineering spaces at all times.

The Navy Occupational Safety and Health or NAVOSH enhances operational readiness and mission accomplishments. It establishes safety and health programs designed to reduce occupational injuries, illnesses or deaths, and material loss or damage. The organization is primarily concerned with safety, which is the elimination or control of hazards that can result in immediate injury or death. NAVOSH is also concerned with occupational health, which is the identification and elimination of adverse health effects caused by the exposure to chemical, physical, and biological agents. Flash gear must be worn when fighting fires or during a radiological attack. Use thermal gloves when welding or when working around hot equipment such as steam lines. Hard hats assist in preventing serious head injuries, and are normally used for replenishment duties. The safety harness or DYNA-brake prevents falling. It must be worn to break a fall in an area aloft or over the side where adequate porting and handholds are not present. Life jackets, kapoks, fanny packs, and auto-inflatable vests provide buoyancy in the water. They must be worn while at battle stations, when working over the side, on deck in rough weather, or while working in small boats underway or secured onboard.

The purpose of the Sight Conservation program is to prevent eye-related injuries, establish guidelines for eye protection, and enforce command rules and regulations regarding eye protection. Crewmembers must wear appropriate eye protection when performing eye-hazardous operations such as cutting, welding, drilling, grinding, milling, chipping, sand blasting, and pouring or handling corrosive fluids. Your ship will have eyewash stations and/or emergency showers installed in all areas where crewmembers may be exposed to corrosive materials. Eyewash stations will be marked with a green sign and white lettering. Emergency showers will be marked with a similar sign, indicating a shower.

Many repairs and maintenance operations generate air contaminants that are dangerous if inhaled. Some spaces may not contain enough oxygen to support life. Proper respiratory protection devices are worn when working in poorly ventilated spaces. Always wear respiratory protection if you are near or working around any hazardous material that emits noxious gases, such as paint or solvent. There are two basic types of respiratory protection. An air-purifying respirator removes air contaminants by filtering or absorbing them as the air passes through the cartridge. This type of respirator will not support life in an oxygen-deficient atmosphere. An atmosphere-supplying respirator is used when the contaminant’s concentration is too high to use air-purifying respirators or when there is not enough oxygen present in the compartment to support life.

Rubber aprons protect the body from burns caused by corrosive chemical compounds. Welding aprons protect your body from burns caused by welding. Rubber mats must be installed in front and in back of propulsion control cubicles, power and lighting switchboards, and electronic equipment to insulate personnel from electrical ground, and to minimize shock hazards.

Good housekeeping habits are important to ensure not only safety, but also professionalism within your group. The Navy keeps a very tight ship. Things you do more often than not are keeping the bilges clean and oil free. Oil in bilges may generate vapors that can be ignited by a spark or open flame. Keep the flange shielding properly installed. Keep the strainer shielding in good condition. Do not store paint or flammable liquids
in engine-rooms/fire-rooms. Ensure all moveable objects in your space are secured or lashed down. Replace oil-soaked lagging. Keep machinery wiped off. Keep rags properly stored. Occupational safety and health training on safety precautions and potential hazards applicable to a certain evolution should be frequently conducted for all personnel involved in the evolution. These safety standards are reviewed prior to scheduled evolutions (such as CONREP, VERTREP, aircraft operations, towing,anchoring, or engineering drills) or at scheduled divisional training periods. The standards may also be reviewed during the 2-5 minute stand-up safety briefings required during quarters or muster. Your daily duties will have you in and around hazards. Be aware and look for things out of the ordinary. If you have any doubt, check with your supervisor.

HAZARDS RELATED TO ENGINEERING
Hazards are all around the Engineering Department. The principle way to identify hazards is through workplace inspections. Hazards turn into mishaps when sailors become complacent or get caught up in the moment and forget the proper safety precautions associated with a certain hazard. All personnel should report any unsafe or unhealthy working conditions, mishaps or near mishaps to their immediate supervisor as soon as possible. An unsafe condition can cause death, injury, occupational illness, or damage to or loss of equipment or property.

Mishaps can happen anytime and anywhere. A mishap is any unplanned or unexpected event causing personnel injury, occupational illness, death, or material loss or damage. A near mishap is an act or event in which injury or damage was avoided merely by chance. If you are not satisfied with the action being taken, you may submit a written report of the unsafe condition on a Safety Hazard Report. The reporting person may stay anonymous and a final response should be completed within 10 days. If the originator remains dissatisfied after discussing the matter with the Safety Officer, he/she has the right to appeal to the Commanding Officer.

Shipboard fires can produce enough heat to melt the steel deck and bulkheads. Only cotton type uniforms or fire retardant coveralls may be worn while inside machinery spaces. Certified Navy Twill (CNT) uniforms and Corfam shoes may only be used for ceremonial purposes. CNT uniforms are much more likely to catch fire than the regular cotton uniform. Corfam shoes are also unauthorized for wearing in engineering spaces; they have been known to melt when worn on hot decks.

Oil fires may be caused by an ignition of oil vapor when oil is sprayed under pressure or allowed to accumulate as the result of leakage or spillage. Fuel may accumulate in boiler air casings from partially plugged atomizers. Supervisors must carefully select, train, and supervise those who perform fuel system maintenance. Making sure fuel system maintenance is timely, thorough, and error-free is the most important thing that can be done to prevent fuel fires. During heavy weather, maintain lifelines and ensure they are in good repair. Properly secure all moveable objects, and tie down anything that is not bolted to the deck. Personnel on deck must wear safety harnesses, life jackets, and safety helmets. Sky-larking is strictly prohibited onboard ship. Personnel may be burned from contact with hot surfaces, or injured by striking hard objects or by falling. Equipment and instruments could also be damaged. Horseplay is dangerous aboard ship.

There are many types of hazards aboard ship. Be aware, no matter the task, any aspect of your job can become a hazard. Understand what your job entails, and prepare ahead of time. If at any time you detect a hazard, it is your responsibility to report the hazard to your supervisor, and then ensure that it is corrected. Mechanical hazards involve all personnel in operation or maintenance of any mechanical equipment. They must be thoroughly familiar with the applicable safety precautions listed in OPNAVINST 5100.19 series and the manufacturer’s technical manuals. When encountering chemical hazards, follow the appropriate safety precautions that are found on that chemical’s Material Safety Data Sheet (MSDS). Proper use and stowage will reduce the chance of fires, burns, or illness due to inhalation. When working around thermal hazards such as steam and exhaust systems, care must be taken to prevent burns. These systems should be lagged to reduce burn hazards and retard heat radiation. There are certain hazards inherent to the operation and maintenance of the engineering plant. Basic safety precautions help minimize, if not entirely eliminate, the dangers posed by these hazards. Main hazards considered are health, fire, reactivity, and specific hazards.

When working on or close to electrical circuits, the first thing is to regard all electrical circuits as potential shock hazards. Next, you must exercise extreme caution when using water near electrical equipment, and heed all posted warning signs. Electrical hazards are always present onboard ship due to high humidity, metal structures, high voltage electricity, and perspiration. Even very small levels of current may be hazardous or fatal. An ordinary lighting circuit may have as much as 10 to 12 amps of current. Be aware that one amp could possibly kill you. Use electrical tools and lights only if inspected and approved. Check the tool before operation and ensure there are no defects. All personal portable electrical equipment must be electrically safety checked prior to use. Personally owned or non-Navy-standard equipment is prohibited from being introduced and used onboard ship. Some examples are fans, extension cords, high-intensity lamps, plugged-in reading lamps, electric blankets, heating pads, electric power tools, heat/sun lamps, hot plates and griddles, microwave ovens, electric heaters, portable refrigerators, portable air conditioners, and immersion-type water heaters.

Radiation could be the most deadly of all hazards. Exposure increases the risk of radiation burns, sickness and developing cancer at years later. There is no doubt potentially hazardous sources of radiation exist aboard Navy ships. Radiation is the energy transmitted through space in the form of electromagnetic waves or nuclear particles. There are two types of radiation:
- Ionizing: Sources of ionizing radiation are radioactive material and X-ray generating equipment.
- Non-ionizing: Sources of non-ionizing radiation are lasers, radars, and communication equipment (ship antennas).

Radar and communications equipment (transmitters) may emit hazardous levels of radio frequency/microwave radiation. Radio Frequency Radiation (RFR) warning signs are posted at all access points to areas where the RFR levels may exceed safe exposure.

The damage caused by missile hazards and flammable materials includes possible injury to personnel, and damage to equipment, or fire. Before beginning any job, do a pre-inspection of your area, the equipment you are going to work on, and things around you that may be potentially dangerous. During replenishment at sea, ensure that all personnel know their duties, and are aware of their responsibilities. It is very easy to get knocked overboard if you are not paying attention. Personnel must wear the proper clothes – all personnel on the fueling station must wear life jackets. Neatly flake all lines on deck to prevent tripping hazards. Do not overload rigs and winches.

Before working aloft, always receive permission from the Officer of the Deck (OOD). The OOD will pass a verbal warning over the 1MC prior to commencing work and every 15 minutes thereafter. ALWAYS use your safety harnesses.

No routine hazards, except for ordinance, are as dangerous as the presence of potentially lethal atmospheres in ships’ spaces. Before you enter a tank, void, or space not normally manned ALWAYS notify the Department Head or Division Officer. A Gas-Free Engineer must certify that the danger of poisoning, suffocation, or ignition of flammable gases has been eliminated inside the space. Protective equipment, including an attached safety line and ventilation, must be used every time you enter a tank, void, or space not normally manned. Ensure a safety observer is
Asbestos is a fireproof material that possesses high tensile strength, good heat and electrical insulating capabilities, and moderate-to-good chemical resistance. Most ships commissioned before 1976 are equipped with some asbestos thermal insulation. Asbestos material causes more health ailments in the industrial world than probably any other type of material. An Asbestos Control Program provides policies and procedures for identification and control of asbestos in the work place, adherence to prescribed practices for disposal, and work practices. Inhalation of asbestos fibers can cause at least two distinct disease states. The first, asbestosis is a progressively worsening disease of the lung and is a classic disabling or even fatal occupational disease. The second is cancer of the lung, such as malignant mesothelioma, and cancer of the gastrointestinal tract. Mesothelioma is a rare malignant tumor of the membrane that lines the chest and abdominal cavity. It is rarely found except in those exposed to asbestos. The risk of developing lung cancer increases dramatically when you inhale asbestos fibers and smoke tobacco products. Most symptoms of asbestos-related diseases do not show up until 10–45 years after exposure. The only prevention is by eliminating exposure to asbestos fibers.

Lagging from older ships contained asbestos internally and is not possible to identify based solely on a visual inspection. Further inspection would have been required. Therefore, handle thermal insulation as if it contains asbestos, especially on ships built before 1976, unless laboratory analysis shows the insulation material to be asbestos-free. Ships having asbestos identification capability, such as tenders, can provide this laboratory service to positively identify suspected asbestos-containing materials. Only identification by polarizing light microscopy is acceptable.

If you have any doubt as to whether a material contains asbestos, contact your immediate supervisor. Because of its characteristics, asbestos is used in many locations such as thermal and acoustical insulation, lagging for high-temperature machinery, boilers and piping, gasket materials, certain deck tiles, brake and clutch linings, and floor and roofing materials.

Personnel engaged in handling asbestos-containing materials during at-sea repair operations or in situations where the concentration of airborne asbestos is likely to exceed the Permissible Exposure Limit (PEL) must wear the following provided protective clothing.

- Coveralls should be full-body, one-piece disposable design (preferably constructed of Tyvek material or a comparable substitute). Use of a Tyvek coverall with an attached hood is highly desirable.
- Hoods (head coverings) must extend beyond the collar of the overall, completely protecting the neck area. The hood must be constructed of Tyvek material or a comparable substitute.
- Rubber gloves that are of medium weight and have thin cotton underneath to absorb perspiration.
- Safety glasses, vented goggles or other appropriate protective equipment are used whenever the possibility of eye irritation exists.
- Cutting any type of asbestos material by hand punching, shaping, or hand-operated mechanical punching, when in quantity, must be done in designated work areas posted as asbestos work areas. Neither respiratory protection nor protective equipment are required, provided that during the operation you frequently use a High Efficiency Particulate Air (HEPA) equipped vacuum unit approved for asbestos work to prevent visible dust and small particles of gasket residue. Keep your area clean once you complete the task ensures the safety and health of your fellow shipmates. Scrap asbestos gasket material are disposed of as waste and stored in designated containers. Hopefully, you do not have to remove material as hazardous as asbestos. Whenever possible, a shore facility or Intermediate Maintenance Activity utilizing personnel who are part of an ongoing Asbestos Medical Surveillance Program will remove existing asbestos insulation. When repairs must be made at sea, they are made at distances of three miles or greater from U.S. shores. The Commanding Officer must authorizes the asbestos removal and designate a Commissioned Officer or Petty Officer trained in asbestos removal procedures to directly supervise the work and ensure compliance with safety requirements.

Improper disposal of asbestos can be very harmful. Taking the proper procedures is extremely important. In preparation for disposal, personnel must adequately wet asbestos waste, when appropriate, prior to double bagging in heavy-duty plastic bags (six mil thickness) or other suitable impermeable containers. Provide all bags or containers with standard asbestos warning labels. Distinctively color-coded asbestos waste containers (such as bags) are colored red to assure easy recognition. Exercise care in order to prevent bags and other containers from rupturing as you transport them to a shore activity for disposal.

Ships commissioned or that have had insulation replaced after 1974 started using non-asbestos thermal insulation. Thermal insulation replacing asbestos consists of man-made vitreous (glass) fibers (MMVF) and is derived from rock, clay, slag, and glass. However, MMVF used aboard ships may still have some chemical and hazardous characteristics similar to asbestos minerals, and may have a similar health hazard potential.

Painting is something you do frequently aboard ship. While working with paint, do not smoke in the vicinity and post NO SMOKING signs. Always wear supplied air respirators when spray painting, and ensure some type of exhaust ventilation is used if in confined spaces to prevent lung damage. De-energize any electrical equipment in compartments or work spaces being painted. Return all paints and thinners to the paint lockers; upon completion of the job, end of the workday or when taking a lengthy break.

Another type of hazardous material is mercury. The element MERCURY (Hg) is a metal that is liquid at room temperature. Mercury is a bit like lead, but it is a liquid. However, the problem is its cumulative poisonous nature. In its pure metal form it is relatively inert, so not so deadly, but in compounds such as mercuric chloride it can be deadly. This substance can cause nerve damage. It represents potential personnel hazard if you ingest it, if it is absorbed through the skin, or inhaled.
As with asbestos, the newer ships should be free of lead. However, there are still things you may come into contact with that may contain this element. Lead (Pb) is a soft, malleable, and corrosion resistant material. Lead's high density makes it useful as a shield against X-ray and gamma radiation, and is often used in X-ray machines and nuclear reactors because of it. Lead is a health hazard and may adversely affect the peripheral and central nervous systems, red blood cells, kidneys, and the reproductive system. Be aware of the material you come in contact with and have it tested if needed. During the removal of lead paint, dust hazard is a special problem associated with the methods used to remove the paint. Sanding or grinding with electric or pneumatic tools generates more airborne exposure than the use of a chipping hammer followed by sanding. To minimize exposure potential, ensure that all hot work on lead surfaces is isolated from all other operations. Local exhaust ventilation is almost always required. Personnel engaged in the handling of lead or in a situation where the concentration of airborne particles is likely to exceed the permissible exposure limit must wear protective clothing. Always use proper respiratory protection as required. Warning signs are displayed at each location where airborne lead concentrations may exceed the permissible exposure limit.

While working with synthetic lube oils, a face shield, safety goggles, rubber apron, and rubber gloves are required. Refer to the applicable manual for the proper PPE.
One of your duties will be to perform maintenance on the different types of joints in the engineering plant. Packing and gasket materials seal joints in steam, water, gas, oil, and other lines. They also seal connections that slide or rotate under normal operating conditions. There are many types and forms of packing and gasket materials available. You will learn to identify packing and gasket materials, and the procedures for replacing packing and gaskets in fixed and moveable joints. As an engineer, this is important information for your daily routine.

**Terminal Objective** – Demonstrate an understanding of packing and gasket materials and the procedures for replacing them in joints.

- **Enabling Objective** – Identify packing and gasket materials.
- **Enabling Objective** – Identify the procedures for replacing packing and gaskets in fixed and moveable joints.

The packing and gasket material used to seal joints and couplings is commonly referred to as “software.” Packing is material used to provide a seal in a mechanical coupling where some form of movement between the surfaces to be sealed is intended or anticipated. Gaskets are materials used to create a seal between two stationary faces of a mechanical joint. The gasket functions to confine liquids or gasses (steam, water, fuel, air, lube oil, etc.) within an assembly and maintain this seal under various operating conditions.

Gaskets are commonly used to seal fixed joints such as flanges and pump casings. Flanges are installed in piping systems to ease removal and re-installation of piping and equipment. There are two basic types:
- **Flat-face flanges** are commonly used in low-pressure, low-temperature applications. They are usually made from non-ferrous materials and employ sheet type gaskets.
- **Raised-face flanges** are commonly used in high-pressure, high-temperature applications. They are usually made from ferrous materials and employ spiral-wound gaskets.

Sealing a moving joint, such as in a valve, is difficult because the seal must be tight enough to prevent leakage, yet loose enough to allow movement. Packing is the most common method of sealing a moving joint. Packing is a sealing method that uses bulk material (packing) that is reshaped by compression to effectively seal a moving joint. At one time, fixed joints could be satisfactorily sealed with gaskets of compressed asbestos sheet packing. Today, the 15 percent rubber content of the packing makes it unsatisfactory for modern, high-temperature, high-pressure equipment. Metallic or semi-metallic gaskets are in use in present day high-temperature and high-pressure installations.

- **O-ring** is the most popular type of gasket that you will see used in joints. An O-ring is a ring (seal) which has a round cross-section.
- **Quad-rings** may be installed with or without backup rings, depending upon the specific groove application and width. They work well in both static and dynamic applications for liquid and gas systems. Quad-rings are completely interchangeable with O-rings in sizes offered by the manufacturer.
- **Serrated-face metal gaskets** are made of steel, Monel or soft iron. They have raised serrations to make a better seal at the piping flange joints. Pressure tends to force the serrated faces tighter against the adjoining flange.
- **Spiral-wound metallic asbestos gaskets** are made of two parts. Inner Ring: The inner part consists of replaceable interlocking piles of preformed corrugated metal and asbestos strips, spiral-wound, called filler. Outer Ring: The outer part is a reusable solid metal outer or centering ring, called a retaining ring, which acts as a reinforcement to prevent blowouts. The gaskets can be compressed to the thickness of the centering ring.
- **Full-faced gaskets**, also called sheet gaskets, can be cut or punched out from sheets of material such as compressed asbestos, cork, or felt. They are cut to fit a specific application such as a flange.

The two most common types of packing are bulk materials and V-rings.

- **V-ring or chevron** type packing seals, are used primarily in high pressure, constant movement hydraulic applications requiring a dynamic seal between the cylinder gland and the operating rod. The most common application of V-rings is in steering gear hydraulic rams.

Bulk materials for packing can come in a variety of forms and materials, such as braided flax, high-pressure rod graphite-lubricated asbestos, and asbestos cloth and resilient rubber, or corrugated ribbon packing developed for use in high temperatures. You can also use rings made out of braided copper, pressed cotton fabric, wire inserted asbestos, or molded rings.

Packing is inserted into stuffing boxes. Stuffing boxes are annular chambers located around the rotating shaft. The packing material is held in place by gland nuts or other devices. The packing material is cut to length, rolled on the valve stem, and pushed into the stuffing box to form a solid, endless packing ring when compressed. If the stem and packing of a valve are in good condition, you can normally stop packing gland leaks by tightening up on the packing gland or nut. Over-tightening may cause the valve stem to score, bend, or seize.

**REPLACING PACKING AND GASKETS IN FIXED AND MOVEABLE JOINTS**

As part of planned and unscheduled maintenance, you will have to replace the packing and gaskets that seal fixed and moving joints. When renewing packing and gaskets, you need to pay attention to several safety precautions. Asbestos is a fibrous mineral that can be produced into a material that is fireproof, possesses high tensile strength, good heat and electrical insulating capabilities, and moderate to good chemical resistance. Because of these characteristics, asbestos has traditionally been used in piping, Garlock® type gaskets and some packing materials. Asbestos-containing materials (ACM) are health hazards and require special storage, handling and disposal. Friable ACM, which has the ability to become crushed and airborne, represents the most significant health hazard. Sheet gasket material used in high temperature applications is a typical example of friable ACM. Navy policy is to eliminate asbestos exposure hazards by substitution of ACM with asbestos-free materials, approved under the technical management of the Naval Sea Systems Command (NAVSEASYSCOM). However, NAVSEASYSCOM cannot definitively establish that a ship is free of ACM. Because of this, all ships implement and maintain an asbestos management plan.

When breaking open flanges, ensure that there is a two-valve protection to isolate any valve, there is no pressure in the line, and all valves you are using to isolate are firmly secured, wired closed, and tagged. Completely drain the line. Have two flange-securing bolts and nuts, 180 degrees opposite and across from each other, remain in place until the others are removed. These bolts are then slackened to allow breaking of the joint. Remove these after the line is clear. You also need to take appropriate safety precautions when opening flammable liquid lines. Ensure proper ventilation before the joints are broken in closed compartments. Thoroughly clean all sealing surfaces. Ensure the gasket is flush with the flange. Replace all damaged bolts, studs, and nuts in accordance with NSTM Chapter 075.
The Naval Sea Systems Command has prepared a packing and gasket chart to simplify the selection of packing and gasket materials commonly used. The packing and gasket chart shows the symbol numbers and the recommended applications of all types and kinds of packing and gasket materials. A four-digit symbol number identifies each type of packing and gasket.

Suppose you are required to repack and install a valve in a 300-psi saturated steam line. By referring to the packing and gasket chart, you will find several materials that are suitable for repacking the valve (symbol 1103 asbestos rod, braided, plain) (symbol 1104 asbestos rod, braided, wire insertion) (symbol 1430 Metallic, flexible).

Note that the first digit is 1 in each case, to indicate that the packing is suitable for a moving joint.

To install the valve, you will need suitable gaskets. In this case the first digit will be 2. By referring to the packing and gasket chart, you will find that you can use any of the highlighted gasket materials (Symbol 2150 asbestos, sheet, compressed) (Symbol 2151 asbestos, metallic, cloth sheet) (Symbol 2410 gasket, metallic asbestos spiral-wound).

The O-ring packaging contains a lot of important information:

- Size
- Reference letter
- Military specification
- National Stock Number
- Cure date
- Shelf life
- Expiration date
- Lubricant used

Dash numbers indicate the material out of which the O-ring is made.

Full-face gaskets can be cut from sheets of material such as compressed asbestos, cork, or felt. To cut a full-face gasket, follow the following step:

1. Lay the sheet on the flange.
2. Scribe in the bolt holes and flange circle lines with light blows of a ball peen hammer.
3. Using a gasket punch, 1/16 inch larger in diameter than the bolts, cut the bolt holes into the gasket material.
4. Step 4: After the holes have been punched, use shears or a sharp knife to cut the center and outside circles to form the ring.

Use Hardened-steel pointed or sharp-edge tools for removal of O-rings or backup rings. Scratches, abrasions, dents, and other deformities on critical sealing surfaces can result in seal failure, which may result in functional failure of the equipment. If new software is not available, used software may be reused after satisfactory inspection for damage. New O-rings must be inspected for defects such as blemishes, abrasions, cuts, or punctures, which are capable of preventing satisfactory O-ring performance. Faulty O-rings must be cut and discarded. Lack of lubrication may cause high friction, excessive abrasion, heat buildup, and rapid wear. Before installation, lubricate the O-ring with a light coat of system fluid or an approved lubricant. Installation of an O-ring must be made with care so the O-ring is properly placed in the groove and not damaged as the gland is closed. During some installations, such as on a piston, it will be necessary to stretch the O-ring. Avoid rolling or twisting the O-ring when maneuvering it in place. After the O-ring is placed in the cavity provided, gently roll the O-ring with the fingers to remove any twists.

Follow the guidance provided in applicable NAVSEA technical documents, such as in drawings, component technical manuals, and Naval Ships’ Technical Manuals (NSTM) for nuclear or non-nuclear applications. You can prevent an O-ring failure by ensuring its proper installation. Ensure grit or other foreign materials are not present. Lint free cloths are used for cleaning O-ring unions. Lubricate the O-ring with approved lubricant. Thread the union together by hand, and then torque the nut to the required torque.

Prior to installing new V-ring packing, saturate the packing with the type of fluid used in the component. Do not use combustible lubricants in air and oxygen systems. Surface defects are not acceptable. Clearances must not exceed maximum applicable drawing dimensions. When installing a packing set, never install the set as a single complete unit. Each packing ring and adapter must be installed individually. Ensure the hollow side or sealing lips of the packing faces the pressure. Ensure each part is properly seated before installing the next part. If split ring packing is being installed, open the joints sideways when placing the rings around the shaft. Do not pull the joints straight apart. When split ring packing is used as a replacement, joints must be staggered on each successive packing ring at least 90 degrees. Joints should never be placed one over the other.

There is a basic procedure you can apply for repacking valves:

1. Isolate the valve and danger tag it out of service.
2. Remove the packing gland.
3. Remove the old packing.
4. Inspect and clean the valve stem and gland.
5. Refer to documentation (technical manual, MRC, Work Center Manual 43P1) for the number of required rings.
6. Cut the packing and fit the ends flush. Soak the precut packing in pure (distilled) water.
7. Add new packing.
8. Reinstall the packing gland.
9. Clear danger tags and realign the system for operation.
10. Operate the valve to ensure correct tightness.
The Main Machinery Space is generally a hot place to work. We will explore the various types of insulation and the specific requirements for the insulation thickness by identifying the characteristics of lagging pads and flange shields. Also tell you about various types of protective coverings for valves, fittings, and flanges.

**Terminal Objective** - Demonstrate an understanding of the characteristics of lagging pads and flange shields.

- **Enabling Objective** - Identify the characteristics of lagging pads and flange shields.

### LAGGING AND FLANGE SHIELDS

Insulation is thermal insulation, which minimizes the transfer of heat to or from the surrounding atmosphere. Good thermal insulation materials have a low thermal conductivity. When installed over magazines, pyrotechnic lockers, or aluminum structures, fire insulation reduces the risk of serious fire damage. Fire insulation limits the heat transfer to underlying materials and the spread of fire to other compartments. When exposed to a standard fire, the insulation will keep the far side temperatures less than 450°F for a period of 30 minutes.

- **High Temperature Insulation Cement** is a mixture of dry, granular, flaky, fibrous, or powdery materials that, when mixed with water, develops into a plastic consistency. Also, when dried in place, it forms a coherent covering that provides substantial resistance to heat transmission.

- **Finishing Cement** is a mixture of fibrous or powdery materials that, when mixed with water, develops a plastic consistency and a relatively hard, protective surface. It is not an effective insulation material. It is intended to be used only to provide a smooth final surface. In those applications where cement is to act as an insulation material, high temperature cement will be used.

- **Blanket Insulation** is the relatively flat and flexible insulation in sheet form furnished in units of substantial area.

- **Block Insulation** is the rigid insulation preformed into rectangular units.

- **Board Insulation** is the semi-rigid insulation preformed into rectangular units having a degree of suppleness particularly related to their geometrical dimensions.

- **Radiation** is the method of heat transfer where a hot body gives off energy in the form of radiant heat that is emitted in all directions. Radiant heat travels like light, travels in straight lines at the speed of light.

- **Convection** is the process where heat is transferred from one point to another within a fluid, gas, or liquid, by circulating or mixing one portion of the fluid with another. These currents are produced by warm fluid being displaced by a heavier cold fluid. Convection reduces the effectiveness of air space insulation unless such space is very small.

- **Conduction** is the heat flow from one part of a body to another part of the same body, or from one body to another in physical contact.

- **Coating** is the liquid or semi-liquid applied to the lagging surface that dries or cures to form a protective finish. Coatings prevent the passage of fluids, liquids, or gases through the lagging and into the insulation.

Insulating material have low heat conductivity, are fire resistant, light weight, easily molded and applied, moisture repellent, and that they are non-corrosive, insoluble, and chemically inactive. The composition, structure, and characteristics of the insulation material must remain unchanged by the temperatures at which it is used. Once installed, it should not cluster, become lumpy, disintegrate, or build up in masses from vibration. It also has to be vermin-proof, but hygienically safe to handle. The type and thickness of thermal insulation installed on ship piping systems vary, according to the pipe's diameter and maximum operating temperature. Requirements are listed in the Naval Ships' Technical Manual (NSTM 505).

There are some common problems you might find with insulating materials, inspect all shipboard insulation for: Broken or loose insulation, securely fasten all broken or loose insulating or lagging materials. In some cases, you may need to reinstall the insulation. Heat Loss, to locate heat loss insulation areas where temperatures exceed limits, you may use an infrared thermometer or heat gun; after locating the hot spots, initiate the corrective action. Water Damage, when making emergency water damage repairs, strip the piping surface insulation. This prevents serious piping corrosion that could occur if the insulation is the type that retains large amounts of water. Replace the insulation and lagging if it is missing, damaged, or crushed. Verify that the thickness of the installed insulation is the thickness specified for the particular application. If insulation is found to be oil or water soaked, remove all the affected insulation, repair the source of the oil or water leak, and replace with clean, dry insulation. Repair, or replace, loose or improperly installed insulation. After replacing, re-inspect the insulation. Check for voids under removable covers. Fill the void space with layers of glass felt. These layers should match the thickness of the adjoining pipe covering. Check for missing or deteriorated insulation on adjacent pipes or surfaces. If this condition exists, inspect and repair affected area.

There are specific types of covers that you need to know about in order to perform your daily maintenance around the machinery spaces. Some of these covers are insulated and some are metal.

- **Lagging pad** is removable insulation and is usually installed in certain areas to lower the ambient temperature, lessen heat stress, and prevent injury. You use lagging pads on pipe flangings that must be disconnected for inspections or maintenance. You also use them on the bonnets of valves larger than 2 inches internal pipe size (IPS) that operate at 300 PSI and above or at 240 degrees Fahrenheit and above.

- **Flange safety shields** are usually made of aluminized cloth and are wrapped and wired around the flange. Flange safety shields will not stop leaks; however, they will prevent spraying when leaks occur.

Where the pipe insulation is terminated at flanges, you will allow for removal of flange bolts or bolt studs without removing sections of insulation on the adjoining piping. Removeable covers are fabricated so that they overlap the adjoining pipe insulation a minimum of 2 inches. Permanent covers are applied to those valves and fittings that are welded into the system and that do not normally require servicing. Metal lagging is installed to protect insulation from chafing or abrasion, or where the insulation may become oil soaked. It also protects areas where personnel may step on the piping. Metal lagging may be galvanized steel, aluminum, or stainless steel. Because of the hazards involved and the strict maintenance guidelines, asbestos lagging work must be conducted by the Intermediate Maintenance Activity (IMA) or contracted personnel. Additional guidance concerning safety and health policy issues and requirements on asbestos for Forces Afloat is contained in OPNAVINST 5100.19 (series). Health and safety precautions need to be rigidly followed when handling dust and fiber-producing materials such as asbestos, ceramic fibers, or fibrous glass. When performing work on older ships, you need to take extra care to ensure that no one comes into contact with products containing asbestos or ceramic fibers.
Day-to-day operations of equipment in the machinery spaces require the use of valves. You will be responsible for the operation and maintenance of these valves. That is why it is important for you to know the many different varieties of valves that you will encounter onboard ship and how they operate. You will identify the functions and component parts of basic manually and remotely operated valves. You will also identify valve hand wheel identification, color-coding, and valve labels. Finally, you will identify the functions and component parts of automatic valves.

Terminal Objective - Demonstrate an understanding of the functions, component parts, and valve hand wheel identification of basic valve types.
- Enabling Objective - Identify the functions and component parts of the basic valve types.
- Enabling Objective - Identify hand wheel identification, color-coding, and valve labels associated with basic valve types.
- Enabling Objective - Identify the functions and component parts of pressure-controlled and special valves.

FUNCTION AND COMPONENT PARTS OF BASIC VALVES

A ship requires a lot of valves to operate correctly. Many different types of fluids are carried throughout the ship, including potable water, seawater, fuel, oil, and other vital substances. This is why it is important for you to understand and be able to identify the types and component parts of basic valves. A valve is a device used to open, shut, or throttle the flow of fluids. As you may already know, throttling refers to operating a valve partially open to regulate the pressure or flow of the fluid. Valves control the flow of fluid throughout a ship, and are designed for specific applications that correspond to the characteristics of the fluid flowing through them.

Brass or bronze valves are never used in systems where temperatures exceed 550°F. Brass and bronze valves are used in seawater systems, where corrosion is a problem. Steel valves are used in temperatures above 550°F. Some systems utilize steel valves, not for their performance in relation to temperature, but because they are stronger when subjected to internal or external conditions of high pressure, vibration, or shock would be too severe for valves made of brass or bronze.

Although many different types of valves are used to control the flow of fluids, basic valves are generally grouped into two general classifications: manually operated valves and remotely operated valves.
- Manually operated valves are adjusted by hand.
- Remotely operated valves are controlled mechanically, hydraulically, pneumatically, or electrically.

Manually operated valves function to shut off, or in some cases, partially shut off (throttle) the flow of fluid. The movement of the valve stem controls the valve. There are six common manually operated valves: globe, gate, butterfly, ball, plug, and needle valves.

**The globe valve** is the most common valve in the engineering plant and can start, stop, and throttle the flow of fluids. The spherical shape of the globe valve’s body gives them their name. However, positive identification is made internally because other types of valves may have spherical bodies. Globe valve inlet and outlet openings are arranged in several ways to go with varying requirements of flow. The common types are straight flow, angle flow, and cross flow. The components of a valve are:
- **Hand-wheel** - Connects to the stem and manually rotates the stem in order to open or close the valve.
- **Stem** - Connects the hand-wheel and the disk.
- **Packing nut or packing gland stud and nut** - Pushes down on the packing gland in order to compress the packing in the stuffing box.
- **Packing gland** - Compresses packing in the stuffing box.
- **Packing** - A substance or material in a stuffing box to make a seal.
- **Stufing box** - A small chamber in which the packing is compressed around a stem to form a seal.
- **Bonnet** - As a rule of thumb, if the valve appears to have separate top and bottom sections, the top generally is the bonnet.
- **Union bonnet ring or bonnet flange** - Provides for a connection between the body and the bonnet.
- **Body** - Houses all the internal components.
- **Disk** - Attaches to the valve stem and mates with the seat to control flow.
- **Seat** - Attaches to the valve body at the bridge-wall, and mates with the disc to control flow.
- **Bridge-wall** - The reinforced section of the body that holds the seat.

**Gate valves** are used when straight-line flow of fluid and a minimum restriction is desired. The part of the valve that either allows or prohibits fluid flow through the valve acts somewhat like opening or closing of a gate. The gate valve, usually wedge-shaped, allows for the start or stop fluid flow. The gate fully draws up into the valve bonnet with a wide open valve. This leaves an opening for fluid to flow through the valve which is the same size as the pipe in which the valve is installed. This reduces the pressure drop or flow restriction through the valve. These valves are not suitable for throttling. The control of partial fluid flow is difficult with a gate valve, due to the valve design. The flow of fluid pushing against a partially open gate can cause extensive damage to the valve. In a rising stem gate valve, the gate is attached to the stem. The gate and stem rise and lower together as the valve is operated. In a non-rising stem gate valve, the stem threads into the gate. As the hand-wheel on the stem is rotated, the gate travels up or down the stem on the threads while the stem remains vertically stationary.

**Butterfly valve** may be used in a variety of systems aboard ship. These valves can be used effectively in freshwater, saltwater, fuel oil, lube oil, and chill water systems; it is lightweight and relatively small. Butterfly valves are quick acting, providing positive shut-off, and have throttling capability. To close or open a butterfly valve, turn the handle only one quarter turn to rotate the disk 90 degrees. Some larger butterfly valves may have a hand-wheel that operates through a gearing arrangement to operate the valve. This method is valued especially where space limitation prevents the use of a long handle. The notched throttle plate locks the valve in to a position via the locking trigger.

**Ball valves** are quick acting and start or stop the flow of fluid. These valves are not suitable for throttling because the valve cannot be locked in a partially open position. When the ball is rotated to place the hole in line with the pipe, the valve is open. When the ball is rotated so the hole is perpendicular to the openings of the valve body, the flow is stopped.

**Plug valves** are also called cock or stopcock valves. Their design is fairly simple. The valve is comprised of three main parts: body, cover, and plug. The plug is cylindrical, tapered, or generally a cone-shaped device that can be rotated within the seat to start or stop the flow of fluid. The valve is opened by rotation, with the plug itself being the only element that is capable of movement. This valve is not normally used to throttle.
**Needle valves** are used to make small or minute adjustments to fluid flow. The main parts of this valve are: stem, disk, and seat. Needle valves are often considered a form of the globe valve. The disk is tapered to a point like a needle. The shape of the needle or disk and the seat allow for only a small amount of fluid through the valve.

Remotely operated valves provide a means of operating these valves from distant stations. These valves may be operated mechanically, hydraulically, pneumatically, or electrically. A reach rod, a length of pipe or bar stock used as an extension on valve stems, or a series of reach rods and gears operates engine-room valves in instances where valves are difficult to reach. Other remote operating gear is installed as emergency equipment. Some cross-connect valves, main drainage system valves, and overboard valves are equipped with remote operating provisions. These valves can be operated normally or in an emergency, they may be operated from remote stations. Remote operating systems also include a valve position indicator to show whether the valve is open or closed.

**HAND-WHEEL IDENTIFICATION, COLOR-CODING, AND VALVE LABELS**

Piping system valve hand-wheels and operating levers are marked for training and casualty control purposes with a standardized color code. The valve hand-wheel color code identifies the system the valve is in. Color coding of the hand-wheel provides easy and quick identification during operation, training, and damage control conditions. All ships and shore based training facilities must conform to this color code, which helps you to recognize the hand-wheel identification, color codes, and valve labels onboard ship. Each system carries its own unique color code identifier. You need to memorize the colors and the systems they indicate:

- **Steam** – White
- **Potable water** – Dark Blue
- **Nitrogen** – Light Gray
- **HP air** – Dark Gray
- **LP air** – Tan
- **Sewage** – Gold
- **Salt water** – Dark Green
- **Chill water** – Striped Light Blue and Dark Green
- **Fire main** – Red
- **Foam discharge (AFFF)** – Striped Red and Green
- **Refrigerant** – Dark Purple
- **Feed-water condensate** – Light Blue
- **Hydraulic** - Orange
- **JP-5** - Purple
- **Lube oil** – Striped Yellow and Black
- **Fuel oil** - Yellow

Individual valves are identified by markings inscribed on the rims of the hand-wheels, by a circular label plate secured by the hand-wheel nut, or by label plates attached to the ship’s structure or to the adjacent piping. Since the valves for the piping systems are associated with propulsion plant systems, a three-part designation sequence identifies these valves: *The shaft or plant number, the system designation letters, and the individual valve number.*

**PRESSURE CONTROLLED AND SPECIAL VALVES**

Automatic valves are self-regulating and include check valves, pressure-regulating valves, and thermostatic valves. These valves can automatically stop fluid flow, reduce pressure, or control pressure, depending on the type of valve and the manner in which it is installed. Because of the complex shipboard systems that utilize these valves, it is important to understand the functions and component parts of these pressure-controlled and special valves.

Check valves allow fluid to flow in only one direction. They operate automatically in the system. A good way to think about a check valve is that is a one-way gate, allowing fluid to flow in the desired direction, but not backwards. This is important in the event of pressure loss, or other malfunction conditions. The major types of check valves are swing, lift, ball, and stop-check.

- **The swing-check** valve opposes reverse flow of fluid via a hinged disk. As the disk of the swing check valve rises, as the fluid flow below the disk pushes the disk off the seat. And flow is allowed through the valve if for any reason the flow is reversed, this opposing flow forces the disk against the seat, which in turn stops the flow. The major parts of a swing check valve are:
  - Body
  - Disk
  - Seat
  - Cap
  - Hinge pin

- **The lift check** valve has a guide-mounted, spring-loaded disc. A liquid exerting pressure on the bottom of the disc lifts the disc and the fluid passes through. If pressure exerted against the top of the disc exceeds the pressure exerted on the bottom of the disc, the valve shuts and ensures only one direction of flow.

- **A ball check** valve consists of a ball held against a ground seat by a spring. Due to this design, when pressure is sufficient to overcome the spring, the ball retracts, and the fluid flows. When the pressure cannot overcome the spring or pressure is exerted in a reverse flow, the ball seats against the ground seat, and the valve checks, or stops the flow.

There are various types of automatic pressure-regulating valves. These valves provide for pressure relief for situations where system pressure exceeds normal operating pressure or reduction and regulation of pressure. These valves are more complex than the basic valves you have covered, so pay close attention to these pressure relief and pressure regulation valves.
- **Relief valves** are automatic valves used on system lines and equipment to prevent over pressurization which would cause equipment failure or piping rupture which could seriously injure personnel. Relief valves open at a preset pressure and shut when the pressure drops below the lifting pressure.

- **Sentinel valves** are small spring-loaded relief valves installed in some systems to give audible warning of impending over pressurization.

- **Safety relief** valves are important in any plant that operates under pressure. These fully mechanical devices are designed to open completely at a specified pressure and remain open until a specific reset pressure is reached. When the pressure is reached, the valve closes again.

Pressure-reducing valves are automatic valves that provide a steady pressure into a system that is at a lower pressure than the supply pressure. You can find reducing valves in steam, air, lube oil, seawater, and other systems. A reducing valve can normally be set for any desired downstream pressure within the design limits of the valve. Once the valve is set, the reduced pressure is maintained automatically. This is true regardless of changes in the supply pressure as long as the supply pressure is greater than the demand pressure. Two basic designs of pressure reducing valves in use are the Spring-Loaded and the Air-Pilot Operated Diaphragm Control types.

- **Spring-loaded reducing valves** are used in a variety of applications such as: low-pressure air reducers, seawater reducers, and some reduced pressure steam applications. The types of spring-loaded reducing valves in use are the piston operated, the internal pilot operated, and the remote sensing. In the spring-loaded pressure-reducing valve, pressure regulation is accomplished using a spring, adjustment screw, and a diaphragm. The spring always exerts pressure to try to keep the valve open. Spring-loaded reducing valves can be adjusted to change the output pressure they supply. The amount of pressure the spring exerts is dependent upon the position of the adjustment screw. If the screw is turned clockwise, it increases the spring pressure. With this increased spring pressure, a greater output pressure is required to close the valve, ultimately resulting in increased output pressure. If the screw is turned counter-clockwise, the spring pressure decreases, resulting in lower output pressure.

- **Decreasing Pressure, Valve Opening** - When the valve is in operation, and the pressure is falling below the valve’s pressure set-point, the pilot tube routes pressure from the reduced pressure side of the valve to the diaphragm chamber. The pressure felt in this chamber does not exert enough force on the diaphragm to oppose the spring pressure. When pressure in the reduced-pressure side of the valve falls below the set-point, the diaphragm chamber pressure and diaphragm cannot overcome spring pressure and the valve opens.

- **Increasing Pressure, Valve Closing** – When the valve is in operation, and the pressure is rising above the valve’s pressure set-point, the pilot tube routes pressure from the reduced pressure side of the valve to the diaphragm chamber. The pressure felt in this chamber does not exert enough force on the diaphragm to oppose the spring pressure. When pressure in the reduced-pressure side of the valve rises above the set-point, the diaphragm chamber pressure and diaphragm overcome spring pressure and the valve closes.

- **Air-Pilot Operated Diaphragm Control valves** are used extensively on naval ships when continuous and automatic regulating of pressure is needed. This valve is actually two valves that work in tandem. This combination consists of the air pilot and diaphragm control valve. The air pilots and diaphragm control valves are available in several designs to meet different requirements. These valves reduce pressure, augment pressure, act as unloading valves, or provide continuous regulation of pressure. Valves and pilots of very similar design can also be used for other services such as liquid level control and temperature control. The air pilot valve is supplied with compressed air at 22 PSIG. This compressed air modulated by the air pilot controls the diaphragm control valve.

  When reduced-system pressure increases:
  - Increased pressure on the reduced-pressure side of the diaphragm control valve is routed to the diaphragm of the air pilot.
  - Pressure in the pilot valve diaphragm chamber overcomes the spring pressure and begins to open the pilot valve, allowing increased control pressure to be routed to the diaphragm chamber of the diaphragm control valve.
  - This increased pressure overcomes the spring pressure in the diaphragm control valve, and begins to close the valve, reducing the output pressure.

  Reduced-system pressure decreases:
  - Decreased pressure on the reduced-pressure side of the diaphragm control valve is routed to the diaphragm of the air pilot.
  - Pressure in the pilot valve diaphragm chamber is insufficient to overcome spring pressure, and begins to close the pilot valve, reducing the air pressure that is routed to the diaphragm chamber of the diaphragm control valve.
  - This decreased pressure is insufficient to overcome the spring pressure in the diaphragm control valve, and the valve begins to open, increasing the output pressure.

- **A Reverse-acting pilot** uses a lever that reverses the pilot action. An increase in reduced-system pressure produces a decrease in control air pressure. The decrease in control air pressure throttles the diaphragm control valve down, reducing the output pressure. A decrease in reduced-system pressure increases control air pressure, which throttles the control valve up, increasing reduced-system pressure.

There are other valves that you will have to recognize and understand. These are the thermostatic valve, the steam trap, and the valve manifold.

- **Thermostat control valves** control the flow of a heating or cooling fluid in order to maintain the temperature of a system within certain limits. These valves open or close in response to the temperature of the fluid that runs through them.

- **Steam traps** are installed in steam lines and drain condensate from the lines without allowing steam to escape. There are many different kinds of steam traps. They consist of a valve and a temperature sensing device, a liquid level sensing device, or some other arrangement that causes the valve to open.

- **Valve Manifolds** are used where suction must be taken from one or more sources and discharged to one or more locations. Manifolds centralize the location of these valves.
In this lesson, we will focus on gauges, meters, and their functions. It is vital since they provide the first indication of a problem and the data obtained from them is used to conduct trend analysis of the equipment. You must be able to identify the various types and functions of temperature, pressure, and liquid level indicating devices.

Terminal Objective - Demonstrate an understanding of the various types of temperature, pressure, and liquid level indicating devices.

Enabling Objective - Identify the various types and functions of temperature, pressure, and liquid level indicating devices.

VARIOUS TYPES AND FUNCTIONS OF TEMPERATURE, PRESSURE, AND LIQUID LEVEL INDICATING

To understand meters and gauges, several terms are needed to be understood. Some of them may be known to you, but it is important that you have a clear idea of how they relate to this topic. 

- **Temperature** is a degree of hotness or coldness measured on a definite scale.
- **Pressure** is the force applied on a surface by an object or a fluid. It is measured in force per unit area. A common unit of pressure is Pounds per Square Inch (PSI), which is the amount of force in pounds applied to one square inch, the very air you breathe is exerting pressure on your body.
- **Atmospheric pressure** is the pressure exerted by the atmosphere. When a pressure reading is taken, it is important to note if the atmosphere’s pressure has been taken into account.
- **Pounds per Square Inch Gauge (PSIG)** is the pressure indicated by a gauge. If the unit for a pressure reading is in PSIG, it means that the pressure indicated is gauge pressure and pressure has been taken into account.
- **Pounds per Square Inch Absolute (PSIA)** is gauge pressure plus atmospheric pressure, this means that you have taken the atmospheric pressure into account. Atmospheric pressure at sea level, is approximately 14.7 PSIA. This pressure will change based on elevation, temperature, and weather conditions, but for our purposes just remember that atmospheric pressure is 14.7 PSIA.

MEASURING DEVICES

Pressure gauges are used to measure pressure, depending on the application; pressure gauges are read in PSI, PSIG, PSIA, PSID, inches Hg, or inches Water. Gauges that read in PSI are assumed to mean PSIG. On today’s ships you normally will encounter Bourdon Tube Gauges. These are C-shaped, curved, or twisted tubes that are open at one end and sealed at the other. The open end of the tube is fixed and cannot move, while the sealed end moves as pressure changes. Bourdon Tube Gauges fill a variety of roles and they will vary depending on the function performed. Some gauges use a red hand to show minimum or maximum operating pressures, while other gauges use two red hands to show both pressures. Depending on the application, most of these gauges will have one or two needles. The face of each gauge displays increments of the unit of measurement. There are five types of Bourdon-tube gauges you will encounter onboard ship:

- **Differential gauge** measures the pressure difference between two separate points. This is known as Pounds per Square Inch Differential (PSID). It is constructed of two Bourdon tubes; however, it needs only one needle to display the pressure difference.
- **Duplex gauge** measures and displays simultaneously pressure readings from two separate points. This is known as Pounds per Square Inch Absolute (PSIA) or gauge pressure plus atmospheric pressure, this means that you have taken the atmospheric pressure into account. Atmospheric pressure at sea level, is approximately 14.7 PSIA. This pressure will change based on elevation, temperature, and weather conditions, but for our purposes just remember that atmospheric pressure is 14.7 PSIA.

TEMPERATURE MEASURING DEVICES

Temperature Measuring Devices are used to measure temperature.

- **Bimetallic Expansion thermometers** look like gauges and use two dissimilar metals, such as copper and silver, which are fused together. They all share certain characteristics: Each metal has a different expansion and contraction, according to temperature change. With a given temperature change, one metal will expand or contract faster than the other. The metal is wound into a flat spiral or helix. One end is fixed so it cannot move and the other end is attached to a pointer that is positioned so it moves on a revolving chart.
- **Filled-system thermometer**, also known as distant reading thermometers, are used in locations where an instrument display must be placed some distance away from the location where the temperature is measured. It consists of a hollow metal sensing bulb at one end of a small-bore tube. The other end is connected to a Bourdon tube or other similar pressure indication that reacts to volume or pressure changes. The system is filled or partially filled with a fluid that expands or contracts with temperature changes. The expansion and contraction exerts pressure on the gauge, moving the needle to indicate the temperature.
- **Liquid-in-glass thermometers** are the oldest, simplest, and most widely used devices for measuring temperature. Some of characteristics are: graduations may be etched onto the glass or placed on a piece of metal attached to the glass, and they may read in Celsius or Fahrenheit.
- **Pyrometer** derives from the Greek word for fire and is used to indicate temperatures ranging from 300 degrees to 3000° Fahrenheit. Those temperatures would damage the regular thermometers. This type of thermometer is found on diesel and gas turbine engines to measure a range of temperatures. It has a thermocouple and a meter, is made up of two dissimilar metals that are joined together, and an electrical current is created when heat is applied to these metals. This electrical current is then sent to a meter. The meter converts the electrical current to a temperature reading. The hotter the temperature, the more electrical current is received by the meter.

LIQUID LEVEL INDICATORS

There are two categories of liquid level indicators:

- **Direct Reading Devices**, onboard ship you will normally encounter three direct reading devices: sounding tapes, sounding rules, and sight glasses.
  - **A sounding tape** is a measuring tape that is attached to and wound onto a drum or reel. The tape has a non-sparking plumb bob attached to the end. The tape is marked in feet and inches.
  - **Sounding rules** are constructed of joined metal segments that fold into compact units. This rule reads in feet and inches.
  - **A sight glass** is a vertical glass tube located outside a tank and is piped into the tank at the top and bottom.
- **Indirect Reading Devices**, the main type of Indirect Reading Device you will see for measuring liquid levels will be a Tank Level Indicator (TLI) device that consists of one or more level sensors or transmitters, a measuring circuit, one or more indicators, and a power supply. The Navy commonly uses the magnetic float type of sensor. It has three major components.

- **Fluid level detection device** which is a magnetic reed switch installed in a tank to convert the fluid level into an electrical signal. These switches are contained within a stainless steel tube surrounded by a rubber tube.

- **Receiver device**, converts the electrical signal to the deflection of a pointer on a meter, usually marked in gallons or pounds of fluid.

- **Remote level indicator** indicates the tank level from a central station a distance away from the tank. This indicator may be connected directly to the tank level sensors or may be connected to another indicator located at another station.
Piping diagrams are used to locate pipes, fittings, valves, and other components using standard symbols. Normally, these diagrams have a symbol list or legend to indicate the components present. However, some small piping diagrams do not include a symbol list. In these situations, you must be able to identify the symbols used in piping diagrams, even when there is no symbol list available. In this lesson you will learn how to draw each and what their purpose is.

**Terminal Objective** - Distinguish the piping system components and their standard symbols used in piping diagrams.

- **Enabling Objective** - Identify components and their standard symbols used in piping diagrams.

**Identifying Components and Their Standard Symbols**

Piping is used to transport fluid from one component to another. A single-line drawing shows piping, either straight or bent, on a single plane only. Piping sometimes crosses paths without actually being connected. When drawing a pipe in front of another pipe, it is drawn as a solid line. When drawing a pipe that is behind another pipe, it is drawn as an interrupted line. A permanent pipe connection, such as a welded connection, is drawn using intersecting lines where the pipes connect. A detachable pipe connection, such as a flange or a union, is drawn as a single thick line.

Pumps are used to keep fluid circulating through pipes and hoses. You need to be familiar with pumps before moving on to the next component.

![Centrifugal Pump](image)

![Reciprocating Pump](image)

![Rotary Pump](image)

![Jet Pump](image)

Fluids, as well as steam, must remain free of contaminants. This is done using strainers. Three types of strainers are used aboard Navy ships.

![Y-strainer](image)

![Simplex Strainer](image)

![Duplex Strainer](image)

Many different types of valves are used in day-to-day ship operations. You should be familiar with each of them.

![Gate Valve](image)

![Globe Valve](image)

![Reducing Valve](image)

![Butterfly Valve](image)

![Swing Check Valve](image)

![Relief Valve](image)

The heat exchanger is used for efficient heat transfer from one fluid to another. Select the heat exchanger to see how it’s drawn.

![Heat Exchanger](image)

The tank has a vent and sight glass illustrated in its piping diagram symbol. The sight glass is also known as the liquid level indicator. The liquid level indicator indicates the fluid level in the tank. The highlighted portion on the symbol shows the sight glass. This may be missing from the symbol if the tank doesn’t have a sight glass. Some tanks don’t have sight glasses or vents. These tanks may be drawn a little differently.

![Tank with Vent](image)

![Tank with Sight Glass](image)

Pressure gauges are used to monitor system pressure.

![Simplex gauge](image)

![Duplex gauge](image)

![Vacuum gauge](image)

![Differential gauge](image)

Any changes in temperature within the piping system can be monitored using thermometers. Filled-system thermometers and distant-reading thermometers are examples of dial thermometers.
The Salinity Indicators measure the conductivity of a solution. Noticed that the symbol is not as intuitive as some of the others, to help you remember this symbol, imagine the two curly lines are wires that carry the electrical current to test the conductivity of the solution.
ELECTRICAL FUNDAMENTALS

Even the very basics of light, interior communication and auxiliaries rely on electrical power. Without it, the rudder’s hydraulic system couldn’t steer the ship and the radio, radar and sonar systems wouldn’t function. A ship could not possibly operate as a fighting or supporting unit and would be practically defenseless against enemy attack. Gun turrets, missile launchers and systems, and weapons control all rely on electricity to operate. Electrical power is essential onboard. In this lesson you will learn to identify electrical safety precautions, alarm color codes, and basic terms related to electricity. You will also learn to identify the major components of a typical shipboard power distribution system.

Terminal Objective - Demonstrate an understanding of the safety precautions, alarm color codes, and major components of a shipboard power distribution system.

- Enabling Objective - Identify electrical safety precautions, alarm color codes, and basic terms related to electricity.
- Enabling Objective - Identify the major components of a typical shipboard power distribution system.

ELECTRICAL SAFETY PRECAUTIONS, ALARM COLOR CODES, AND BASIC TERMS

The purpose of the Electrical Safety Program is to equip all hands with the ability to identify common shipboard electrical shock hazards and to enable them to take appropriate safety precautions to avoid both personnel injury and equipment damage. Compared to other environments, the potential for electrical shock onboard ship is increased due to high-powered equipment, 115 volt (V) to 440V circuits, and the presence of saltwater. Contact with an ordinary 115V household current can prove to be deadly, and contact with commonly found 15 and 20 Amperes (Amp) circuits can cause fatal electrical shocks, depending on the resistance of the human body.

This resistance is contingent on factors such as whether the skin is wet, the path of current through the body, and the duration of the contact; the lower the resistance in a circuit (or body), the higher the current and thus, a better chance for serious injury. Even 100 milliamp current levels can prove fatal, especially if the path is across the chest. Shocks of this intensity can stop the human heart. In cases where breathing or heart muscles are incapacitated, CPR is required to maintain life support until medical treatment is available. Great care must be exercised to secure the source of electrical power before any contact is made with a victim of electrical shock.

Because the ship is an ungrounded system, several safety precautions should be taken when working on or near electrical equipment. Signs regarding safety precautions, operating instructions, wiring diagrams and artificial respiration instructions are posted prominently in all work areas. You need to learn the electrical safety precautions applicable to your assigned duties and duty station. By thoroughly understanding electrical safety precautions, you will help prevent injury to yourself and damage to equipment. Report all electrical shock incidents to your supervisor.

-Observe and follow all pertinent instructions and electric warning signs. Ensure electrical equipment is properly grounded; three-prong plugs should have all prongs functioning.
-Comply with all safety precautions regarding portable electric lights and tools. Use Electrical rubber gloves, Face shield and goggles. Do not use manually operated hand battle lanterns for unauthorized purposes or remove them from their locations.
-Apply your common sense in regard to electrical safety. Do not use electric cable runs to hoist or support any weight. Do not use the wire-ways for storage. Do not touch bare electric wires or connections; assume all circuits are LIVE / ENERGIZED. Do not start or operate electrical equipment when flammable vapors are present. Finally, keep water out of electrical equipment.
-Remember, a flame, spark, or lighted cigarette can cause a disastrous battery explosion. Electrolyte from a storage battery can cause severe burns and damage equipment and clothing. If you are ever in doubt about the operating condition of electrical equipment, contact a supervisor. Your personal electrical equipment should be checked through the electrical/electronic officer and shop, and tagged or marked to verify that it can be used aboard ship.

A fundamental knowledge of electricity and electrical theory is necessary to understand what happens when power is applied to any piece of machinery, even a light bulb. Let’s begin with the terminology:

-An electron is the carrier of electrical charge in a circuit. It is a subatomic particle with a negative charge.
-Current is the movement of electrons past a reference point, measured in Amperes (Amps). There are two types of current: direct and alternating. Direct current occurs when the movement of electrons remains constant in amplitude and polarity. With alternating current amplitude and polarity constantly change at regular intervals.
-Resistance is the opposition to current flow. An Ohm (Ω) is the unit of measurement for resistance. Conductors and insulators are two more terms that are related to resistance. A conductor is any material with many free electrons, which readily allows for current flow, while an insulator is any material with limited free electrons that reduces current flow.
-Voltage is the electrical pressure or force that causes current to flow through an electrical conductor.
-Power, measured in Watts, is the rate of expending electrical energy, or the rate of doing work. Power ratings are commonly measured in Kilowatts (1000 Watts).

A Circuit is a complete path over which an electric current can flow. There are several different types of circuits; each relates to the path that the electric current takes.
- A short circuit is an unintentional current path between two components in a circuit or between a component and the common ground.
- An open circuit is an incomplete path for current flow caused by breaking the continuity of one or more conductors of the circuit.
- In a parallel circuit, the ends of each element are connected so that the potential across the elements is always the same.
- A series circuit supplies energy to a number of devices connected in a series. The same current passes through each device in completing its path to the source of supply.

Alarm color codes are commonly used to indicate the status of the system.
- A white or clear indicator light simply means that the system is energized and power is available.
- A green indicator light means that the system is operational with no existing alarm conditions.
- A blue indicator light means that there is a closed circuit breaker in the system.
- A yellow indicator light means that there is an open circuit breaker in the system.
- An amber indicator light means that there is an abnormal condition.
- A red indicator light means that there is an emergency.

SHIPBOARD POWER DISTRIBUTION SYSTEM MAJOR COMPONENTS
The shipboard Power Distribution System is the vital link connecting the generators that produce electric power to the equipment that uses it. It transmits electric power from the power source to the load (power user). These systems are composed of several components that you need to be familiar with when working with electrical power aboard. These components include generators and motors, switchboards, bus ties, load centers, power distribution panels and bus transfers.

- **Generators** are devices that convert mechanical energy into electrical energy. All generators operate on the same principle. They produce or generate electricity using three elements: a magnetic field, a conductor, and motion. There are two types of generators aboard ship. The Ship's Service Diesel Generator (SSDG) uses the diesel engine as the prime mover of the generator. The Ship's Service Turbine Generator (SSTG) relies on the steam produced in the ship's boilers as its prime mover.

- **Motors** are devices that convert electrical energy into mechanical energy. Motors are the prime movers for most pumps onboard.

- **A motor controller** is used to start and stop a motor. Motor controllers also protect motors from low voltage. This can be accomplished in two ways, through low-voltage protection (LVP) or low-voltage release (LVR). When the supply voltage to a LVP controller is reduced or lost, the motor is disconnected from the power supply. Upon restoration of power, the motor will NOT start until you manually depress the start push button. An LVR controller also disconnects the motor from the power supply when the supply voltage is reduced or lost. However, when power returns to normal, the LVR will automatically restart the motor.

Much of the equipment that makes up a distribution system is mounted on switchboards or switchgear groups. The location of the switchboard depends on the ship’s layout and design; however, switchboards are located as far apart as feasible to minimize the risk of a single hit damaging more than one. A switchgear group essentially consists of two or more individual sections connected by cables and separated to localize damage from fire or shock. The two sections of this switchboard are referred to as the control section and the distribution section.

- **The control section** contains controls and instruments required to control the generators' output, such as the measuring instruments and indicating devices for the switchboard and its generator. One of the indicating devices on the control section of the switchboard is a Ground Fault Detector (GFD), which monitors phase-to-ground voltages using three lights. Ground detector lamps provide a means of simultaneously checking grounds on all phases of the 3-phase system. With a ground in any one of the phases, the lamp goes out on the grounded phase. The circuit may be provided with a switch to check for this condition.

- **The distribution section**, the operating controls for the switchboard, and the generator it is connected to, are located on the Distribution Switchboard. The distribution section contains all the circuit breakers that the power is distributed through, to the various power panels or individual equipment. The distribution system protects itself and its generators from damage that might otherwise be caused by faults in the system or connected equipment.

- **Generator Circuit Breakers** (GCBs) are used to connect the ship’s service generators to the Power Distribution System.

- **Circuit breakers** (CBs) are used to isolate faulty circuits, to protect against over-current conditions and to provide a means to mechanically disconnect the electrical power for equipment maintenance. A circuit breaker is a type of automatic switch that, when an excessive current condition exists, will trigger and turn the circuit off. After the circuit breaker has been "tripped" or activated, it is reset and used again.

- **Fuses** are used as protective devices in power and lighting circuits and must be replaced when it fails since it is an electrical protective device consisting of a fusible (easily melted) metal-alloy strip of wire encased in a cartridge. If the current exceeds a predetermined value, sufficient heat is generated to melt the wire in the fuse, causing an open circuit. This action will protect a circuit or equipment from possible damage due to excessive current.

- **Bus ties** consist of cables and circuit breakers that allow one generator to supply power to multiple switchboards or that allow the parallel operation of generators through their associated switchboards. Switchboards are interconnected to each other by bus ties.

- **Load centers** are usually located near the equipment that they feed. They allow the isolation of the electrical power from the switchboard within a specific zone in case of fire, flooding, or battle damage. A ship is normally divided into vertical zones containing one or more load centers.

- **The Power Distribution Panel** allows for the control of selected portions of the distribution system. Power Distribution Panels supply groups of loads that are located in close proximity to each other, or that operate together to perform a function. Power panels can also feed other power panels, distribution panels, or distribution boxes that in turn feed loads.

- **Bus Transfers** are used to switch power sources from normal to an alternate source.

There are two types of bus transfers: Automatic Bus Transfer (ABT) and Manual Bus Transfer (MBT).

- **Automatic Bus Transfer (ABT)** is a device that senses a power loss, automatically disconnects the load, and then connects to an alternate power source. Upon restoration of the normal voltage, most ABTs will automatically transfer back to their normal source of power. Vital systems connected to ABTs are the lube oil pumps, steering control distribution panels, and fire control distribution panels.

- **Manual Bus Transfer (MBT)** allows for the manual selection between a normal or alternate power sources. Items on MBTs are those that require power, but should not automatically come back on line after power loss, such as fire pumps. The watch-stander must manually flip the switch to change the power source.

The Casualty Power Distribution System permits the use of temporary connections to span damaged portions of permanently installed ship services and Emergency Distribution Systems. There are certain limits to the Casualty Power Distribution System. It is NOT intended to supply power to all the electrical equipment on the ship. Only the systems that keep the ship afloat and propel it out of a danger area or those that maintain sufficient combat system capability sustain internal control and monitoring, and support external communications are connected to the Casualty Power Distribution System.

The Shore Power System provides enough power to operate necessary machinery and provide lighting for habitability and accomplishing necessary work. When in port, groups of 400 Amp receptacles are provided for shore power connection at or near a suitable weather deck location. Only an ungrounded shore power source is acceptable for supplying electric power. Portable cables can be attached to these receptacles from the shore or from a ship alongside. The same connection can be used to supply power from ship service generators to a ship alongside.
Being able to identify the proper fastener to use in specific maintenance practices is a highly valued skill found in a successful engineer. Since it is very important for your own safety and the safety of others, this lesson will teach you how to identify threaded fasteners by type, material, grade, class, fit, inspection, replacement requirements.

**Terminal Objective** - Identify the proper application of threaded fasteners.

- **Enabling Objective** - Identify threaded fasteners by type, grade, material, fit inspection requirements, replacement and special applications.

### Threaded Fasteners

Fasteners are used to attach or join parts together; various types are used throughout the ship. At first glance fasteners may appear to be simple devices and in truth they are not complex mechanisms. However if you consider that the consequences for improper use or installation could result in failure of equipment or endangerment to the safety of your shipmates.

There are four basic types of fasteners:

- **A stud** is a fastener that has external threads on both ends or is completely threaded from end to end on its shank or body.
- **A bolt** is a fastener with external threads that has a head on one end and a body or shank that is either fully or partly threaded.
- **Nuts** have internal threads that match the threads of a stud or bolt.
- **Washers** are placed under a nut or bolt to relieve friction, prevent leakage, and distribute pressure.

Besides regular nuts there are two special types of nuts:

- **Lock nuts** differ from standard nuts in that they have pitted grooves built into them that are designed to interlock with protruding pieces in locking surfaces to create a more secure fastening hold and prevent fastener slippage. Most lock nuts have a nylon type insert which aids in preventing slippage of the fastener.
- **Jam nuts**, usually about 2/3 as thick as the main nut, are installed between the thicker main nut and the working surface to prevent the nut from turning. The thin nut is deformed by the wider nut and pressed against the working surface and threads.

In all fastener assemblies, bolts and studs must have at least one complete thread visible beyond the top of the nut. It is important to remember that excessive length of bolts and studs is hazardous to personnel because the excess threads may become exposed to corrosion and damage, making the fastener difficult to remove. Where possible, the number of threads that extend beyond the top of the nut should not exceed five and in NO case should thread protrusion exceed 10 threads.

### Fastener Locking Devices

Different types of fasteners can function as locking devices to prevent threaded fasteners from loosening such as the rotation of nuts, or even the complete loss of a fastener. Whether or not the stud or bolt needs to be removed from the assembly dictates which locking device should be used: lock-washer, safety wire, cotter key, self-locking nut, depiction of an old fashioned lock with keys.

- **Lock-washers** are used to prevent threaded fasteners from loosening. They are placed between the nut and the working surface. Lock-washers come in many different shapes and sizes: split, serrated, tooth, and split lock-washer.
- **Safety wiring** is used to prevent the nut, bolt, screw, or any other threaded part from backing off. A wire is installed around the fasteners in such a way that it tightens by pulling against the wire if the fastener loosens. Specific lock wiring diagrams may be used to show procedures for a given situation.
- **Cotter keys** are key shaped pins that are inserted through the pre-drilled hole on the stud and aligned with the slots on the top edge of the castellated nut to keep the fastener from turning. The ends of the key are then spread apart over the stud or flat against the nut.
- **Self-locking nuts**, there are many different types of self-locking nuts. The types can be grouped into the following two categories. Those that generate pressure between the threads of the nut and bolt in a way that permits frequent removal and those that cause some thread deformation; therefore, they should only be used when frequent removal is unnecessary, they are used where high clamping forces are not desired.

Thread inserts are used for the purposes of restoring damaged threads in castings or forgings, and to protect and strengthen tapped threads in light materials such as plastic and wood, as well as low-shear strength metals such as aluminum. Thread inserts are typically used in tapped holes for bolting flanges to aluminum valve bodies and valve bodies to aluminum sub-plates. When making repairs, inserts are used to restore damaged tapped holes or to replace damaged inserts previously installed in tapped holes.

### Fastener Material

Because the different types of equipment on board ship are built to perform specific functions they have unique design specifications to include different types of fasteners, this why fasteners are made in different sizes, configurations, materials and strength of materials. Identification of threaded fasteners is accomplished by grade and material. Material refers to the substance that was used to make the fastener and grade refers to a level of strength or the amount of stress that the fastener is able to withstand before failure. Correct material identification is extremely important when installing or replacing fasteners since installation of an incorrect fastener could cause failure of a piece of equipment or even an entire system.

The material of the fastener used, must be appropriate for the special design requirements of shipboard equipment to avoid oxidation and corrosion. The most common materials used for fasteners are brass and steel. For example high temperature, high pressure steam applications use high carbon steel fasteners, while flanges in a seawater piping system use brass fasteners. If a fastener of the wrong material is installed, the results could be fatal. A magnet, along with other Quality Assurance methods, should always be used as a verification tool when installing fasteners since steel fasteners are magnetic, while brass fasteners are not.

Correct material identification is extremely important when using fasteners. Permanent grade markings indicate the strength of a steel bolt and the number of slashes or lines on the head of the bolt identifies the grade. The more slashes the higher the strength of the bolt:

- **-2 lines** indicate grade 3
- **-3 lines** indicate grade 5
- **-4 lines** indicate grade 6
- **-5 lines** indicate grade 7
- **-6 lines** indicate grade 8.
Socket head cap screws present an exception to the requirement for material grade markings because a universal material grade marking has not been established for alloy steel socket head cap screws. NSTM Chapter 075 provides a table with the markings referenced against the material and grade. Grade and material identification of nuts is similar to that of bolts and studs. The grade and material of a nut should be identical to that of the matching bolt.

**THREAD CLASSES**

Standard thread classes have been established in the inch-based fastener system to control the amount of tolerance and allowance that is used in forming threads. This ensures that threaded components are interchangeable. Metric fasteners thread classes are different than those of the inch-based system. Where the inch-based system uses a limited number of thread classes the metric-based fastener system uses thread fit and tolerance parameters that allow a large number of combinations.

Basically, the higher the thread class number, the higher the fit. There are six clearance fit threads, three for external threads, 1A, 2A, and 3A; and three for internal threads, 1B, 2B, and 3B. The number indicates the class of fit and the letter indicates whether they are external or internal threads. The letter “A” indicates external threads and the letter “B” indicates internal threads. Allowance is specified only for classes 1A and 2A, and the allowance is identical for both classes. Tolerance decreases as class number increases. For example the tolerance class for 3A is less than that for class 2A or stated another way the higher the thread class number, the tighter the fit.

- **Class 1A and 1B threads** are intended for use where quick and easy assembly is necessary and where a liberal allowance is required to permit ready assembly, even with slightly bruised or dirty threads. In general, these classes are not in common use on board ship.
- **Class 2A and 2B threads** are the most frequently used thread classes for general shipboard applications. They provide a reasonable degree of strength since they are somewhat stronger than class 1. Class 2A and 2B threads have enough clearance to permit the application of corrosion-resistant coatings.
- **Class 3A and 3B threads** are used in specific applications where closeness of fit and accuracy of lead angle are important, such as for adjusting devices and for long thread engagements. Threads of this class require high quality production equipment and quality control.
- **Class 5 threads** are used where the set end of a stud needs to be restrained in its tapped hole against loosening in service or loosening when the nut is removed. Studs with a class 5 fit on the set end can have either a class 2 or a class 3 fit on the opposite end, according to the requirements of the application. The higher the thread class number, the tighter the fit. Normally, the class 5 fit for stud set end can be avoided by using a locking compound with a class 2 or class 3 fit. Also referred to as interference fit threads, class 5 threads are only available in the older National Coarse (NC) series.

**THREAD FIT**

Thread fit is determined by the class of the internal and the external thread used in the assembly. It describes the predictable amount of clearance between the external and the internal threads. The thread fit ranges from loose, class 1, to an actual interference fit, class 5, where the external thread pitch diameter or PD is larger than the internal thread PD. Common practice requires the mating of same class threads together. This creates a class 1, 2, or 3 fit. But for some applications the requirements for a specific thread fit is met by specifying an appropriate combination of different external and internal thread classes. For example, a class 1A external thread can be mated with a class 1B, 2B, or 3B internal thread to achieve a variety of thread fits. Class 5 fits present problems in installation, removal and repair unless careful sizing and installation procedures are followed. Wherever temperature limits permit, it is better to use class 3A studs with anaerobic thread-locking compound on the set end.

Some threaded fasteners require periodic inspection for proper torque and overall condition. Fasteners are not removed for inspection unless the joint has to be disassembled for other reasons. All fasteners removed during overhaul and repair operations should be cleaned and inspected prior to reinstallation. Damaged fasteners found during inspection should be discarded and replaced with new ones.

During a General Inspection you need to inspect flanges or covers for missing fasteners and for overall condition and tightness. Check for fasteners that are bent or cocked and where required, check for proper torque. NSTM Chapter 75 provides a Fastener Replacement Decision Tree to help determine if a fastener needs replacement.

In all cases, cracked fasteners or fasteners that have broken chipped or missing threads are not acceptable. Isolated minor defects are allowed. An isolated minor defect is a single nick, gouge, or flattened thread. Any combination of minor defects is acceptable and may be ignored, when the total combined length of the defects does not exceed 15% of one thread on one complete thread. One complete thread is defined as one complete rotation starting at a point along the thread. Clearance fit threads must engage by hand and self-locking fasteners must have a positive reinstallation torque. Cuts or tears in self-locking elements which are deeper than the existing thread impressions are not acceptable.

Once you determine that a fastener needs replacement do NOT rely on markings of the existing fastener to identify the replacement fasteners. The wrong fastener may have been installed in the past. Review technical documentation such as the parts list to order replacements. Some fasteners may come in a box with a part number. This part number may be used to identify the material, diameter, thread design, length, and other special features; however, fasteners of different grades and materials but of the same color, size and shape may be stored in the same container. Always ensure the correct replacement fastener is used. If in doubt about a fastener, ask your supervisor. Keep in mind that seawater systems suffer from corrosion and steam systems are under high pressure and extreme temperatures. Using materials designed for one system, in the other system can result in deterioration, failure, and casualties.
Material conditions of readiness establish the fighting integrity of the ship and maintain its survivability. Whether contact with the enemy is improbable, probable, or imminent, it is the responsibility of the Commanding Officer to determine which material condition of readiness is set throughout the ship. Although incidents aboard the USS Stark (FFG-37), USS Cole (DDG-67), and others were tragic, many lives as well as the ships were saved. The common key to survival was due in part to setting and maintaining proper material conditions of readiness. This lesson presents the information you need to identify each of the material conditions of readiness, as well as Damage Control, or DC programs and logs to function effectively during normal routine and in the event of an emergency aboard ship.

Terminal Objective - Demonstrate an understanding of the actions necessary to properly secure an area, to prevent shipboard damage and loss of life.
- Enabling Objective - Identify the material conditions of readiness.
- Enabling Objective - Identify damage control programs and logs.

MATERIAL CONDITION OF READINESS

Each of the three material conditions of readiness levels, X-ray, Yoke and Zebra, represents different degrees of air or watertight integrity. This is accomplished by dividing the ship into as many watertight compartments as practical. In casualty situations, this will aid in the control of flooding, fires, and the spread of toxic fumes. This compartmentalization is only effective if doors, hatches, scuttles and other fittings are properly closed and maintained. Doors, hatches, scuttles and many other fittings are marked with Damage Control, or DC symbols to categorize which material condition they must be closed. You must recognize these symbols and their meanings so that, when necessary, you can take appropriate action for the material condition in effect. Confusion about these markings in casualty situations can lead to catastrophic consequences.

Damage can occur to the ship at any time. Setting of the most stringent material condition will compartmentalize the ship into the smallest areas possible. Under normal conditions, such as when the ship is in home port, doors, hatches or scuttles that do not need to be opened should be closed to be prepared in case an emergency would arise. However, the maximum degree of watertight integrity is not maintained at all times, because it would adversely affect a ship’s normal routine. All Navy ships are required to be able to set and maintain the three material conditions of readiness:

- X-Ray
- Yoke
- Zebra

-Material condition X-Ray is set when the ship is in almost no danger of attack or natural hazard, in a well-protected harbor or secured at homeport, in fair weather, or during normal working hours. All closures and fittings classified X-Ray, even when logged open, remain closed at all times when they are not in actual operation. They are labeled with a black letter X. Prior to opening them, permission must be obtained and the fitting must be logged open in the DC Closure Log in Damage Control Central (DCC). The symbols are located on scuttles or in hatches leading to pump rooms, magazine rooms, access to unoccupied equipment rooms, and on entrances to berthing areas. During material condition X-Ray, the fire main is normally operated as a single system. All valves and fittings marked X are closed, and all other valves and fittings remain open. Pressure is maintained on the fire main by a minimum number of pumps as service demands require.

-Material Condition Yoke is always set and maintained at sea. Material Condition Yoke fittings are identified by a black letter Y. At the end of the day underway, it is checked. In-port during peacetime it is set outside of regular working hours and while entering or leaving port. When underway it is set and maintained. During Material Condition Yoke, all X-Ray and Yoke fittings are closed. You must request permission to open Yoke fittings. All open fittings must be logged in the DC Closure. It is common to find on ships today, that Material Condition Yoke is always set. In these instances, it is set in the morning and checked again at the end of the workday.

-Material Condition Zebra is identified by a red letter Z. It provides the maximum watertight integrity protection. It is set immediately when General Quarters (GQ) is sounded or when directed by the CO at times such as entering or leaving port during wartime. All X-Ray, Yoke, and Zebra fittings are closed during Material Condition Zebra.

SPECIAL DC CLASSIFICATION

As you transverse from Material Condition X-Ray to Material Condition Zebra of readiness, there are special conditions of readiness that can be ordered to permit flexibility of the material conditions. Sometimes, a need arises to move about the ship during a condition when the closures and fittings should be closed. In some instances you need obtain permission to open these fittings to make this movement possible. There are five special DC classifications for fittings that include:

- William
- Circle William
- Circle X-Ray/Circle Yoke
- Circle Zebra
- Dog Zebra

-William is identified by a black W on a white or plain metallic background. William-marked fittings are opened or operated regardless of the Material Condition of Readiness set. Fittings are secured only to prevent the spread of damage or the intake of chemical, biological, and radiological (CBR) contamination. These fittings are also secured to permit maintenance or to allow normal system or equipment shutdown. William fittings are vital to the operation of the ship and are not required to be closed under normal conditions. Examples of classification William include vital sea suction valves that supply the main and auxiliary condensers, fire pumps, and spaces that are manned. They also include vital valves that, if secured, impair the mobility and fire protection of the ship. In the event of CBR attack, all William fittings must be closed to prevent the contamination from spreading throughout the ship with the exception of those William fittings needed to support propulsion. The ship must be able to maneuver out of a contaminated area.

-Dog Zebra fittings are marked with a red Z inside a black D. These modified fittings are secured during material condition Zebra and dark ship conditions. You must have proper authorization to open fittings with this classification when the ship is at either condition Zebra or dark ship. Some examples of Dog Zebra fittings include doors to the weather deck, excluding those classified X-Ray or Yoke that do not have a dark-ship switch or a dark-ship curtain and portholes. While at sea each night at sundown, the order is given to set Darken Ship. This prevents any bright lights from escaping from the inside of the ship.
Your ship’s status dictates the responsibility for conditions. While in-port and underway, the division that is responsible for the space or fitting is responsible for preparing their area in accordance with the current conditions. During General Quarters, the repair party has responsibility for the area of the repair locker. The proper setting of the prescribed material condition is checked each morning prior to the start of the workday, each evening at the end of the workday, or when directed by the CO. Conditions are set and verified by the Division Duty Petty Officer or Damage Control Petty Officer (DCPO).

**DAMAGE CONTROL PROGRAMS AND LOGS**

Since watertight integrity is our primary defense against fire and flood damage, it is important to maintain the appropriate material condition of readiness at all times. There are damage control (DC) programs and logs to help ensure this state of readiness is constantly maintained.

**The DC closure log** is a constantly maintained record of the status of damage control closures and fittings. It lists:

- Name
- Rate
- Division of the person requesting permission to open or close the fitting.

It also lists:

- Fitting type.
- Classification.
- Number.
- Date the fitting changed from its original material.
- Time the fitting changed from its original material.
- Estimated time the fitting will be open.
- Name and rate of the person granting permission–normally the Damage Control Assistant (DCA), DC Central Watch, or the Officer of the Deck (OOD).
- The date and time the fitting is returned to a material condition.
- Fittings that are locked or otherwise obstructed.

To alter a previously set Material Condition of Readiness, you must obtain permission from DC Central or in some cases, the Officer of the Deck. These alterations are documented in the DC closure log. This log is usually maintained in DCC. In some cases, the log is maintained on the quarterdeck when manned. Only a limited number of fittings may be logged open in each zone; this varies according to ship class. The estimated time a fitting is open is not more than 24 hours. At the end of the 24 hours, the fitting is either logged open again or is logged closed. Anyone who violates the material condition of readiness in effect without permission to do so is subject to disciplinary action.

**Compartment Check-off List (CCOL)** each compartment and alcove aboard a ship has a CCOL displayed near each access. It provides the location and purpose of all classified closures, fittings, and other damage control, firefighting systems, and equipment for that space. The DCA maintains a master CCOL hard copy and a backup disc when the CCOL is computerized. If a compartment has two or more entrances, a duplicate copy of the CCOL is posted at each entrance, and is clearly labeled DUPLICATE. A partial copy is posted in alcoves, the recessed areas of a compartment. It must be clearly labeled PARTIAL and item numbers on the list only reflect fittings and other damage control and firefighting systems and equipment for that alcove. CCOL must be verified and signed by the Division Officer.
The shipboard nomenclature and numbering systems helps you to find your way around the ship. This lesson helps you to understand basic structural components of NAVY ships, the standardized compartmental numbering system, and damage control system identification markings. It is important to learn Shipboard Nomenclature and numbering in order to gain a full understanding of how the Navy labels the location of each space. Understanding how to get to each space on ship helps you respond to emergency situations quickly.

**Terminal Objective** - Demonstrate an understanding of the shipboard nomenclature, numbering, and damage control markings aboard a naval vessel.

- **Enabling Objective** - Identify the basic structural components of NAVY ships.
- **Enabling Objective** - Identify the standardized compartmental numbering system.
- **Enabling Objective** - Identify shipboard damage control system identification markings.

**BASIC STRUCTURAL COMPONENTS OF NAVY SHIPS**

Inside every ship, is a support skeleton welded and bolted together. As with the human skeletal system, this structure completes the inner framework of the vessel. Shipboard Nomenclature is simply the terminology we use when naming the structural components of a ship. Identifying the structural components of your floating city is the first step in helping you get from point A to point B efficiently. Aboard each vessel are the basic facilities of modern life, including damage control lockers, the local firehouse, the engine control rooms, and your local power company. Learning the names and positions of the ship’s compartments helps you master your journey to various locations in no time.

Each ship has a vertical and a horizontal support structure. The frames running from the front to the rear of the vessel, or parallel with the keel, are the longitudinal frames. Longitudinal frames are similar to the spine in a human skeletal system. These frames support the ship forward and aft. The athwart ship structure consists of transverse (side to side, or at a 90 degree angle to the keel) frames and decks. The decks run outboard from the keel to the turn of the bilge (where the bottom turns upward). This is where they are attached to the transverse frames that extend upward to the main deck.

**COMPARTMENTS**

There are many other parts or shipboard nomenclature to consider besides the skeleton of a ship. Within the vessel are walls, ceilings, and floors. The Navy has unique terms for these parts:

- **Levels**: is a general term used to designate deck heights above the main deck.
- ** Bulkheads**: vertical walls that divide the interior of a ship into compartments. Run both transversely and longitudinally and there are two types:
  - **Structural Bulkheads**: are capable of withstanding fluid pressure and divide the ship into watertight compartments.
  - **Non-structural bulkheads**: are lightweight partitions designed to separate activities onboard the ship and are not capable of withstanding fluid pressure.
- **Decks**: the floors of a ship; it divide the ship into layers from bow to stern.
- **Hull Plates**: are the outer covering of the ship.
- **Frames**: are strength partitions which transverse vertical girders that extend upwards to the main deck from the keel (like a ribcage).
- **Platforms**: are below the lowest complete deck and do not extend the length of the ship.
- **Keel**: is at the bottom center of the hull. It is the backbone of the ship and does not extend below the ship’s bottom. Its usual shape is that of an I-beam. The frames running from the front to the rear of the vessel, or parallel with the keel, are known as longitudinal frames. All other members used in constructing the hull are attached, either directly or indirectly, to the keel. The hull plating is fastened to the framework in longitudinal rows, called strakes. The hull forms the skin of the ship.

**STANDARDIZED COMPARTMENTAL NUMBERING SYSTEM**

Decks are divided into spaces called compartments. It is important to understand the compartmental numbering system so that personnel can find their way around the ship and perform their duties. The Navy uses compartment numbering to locate each compartment. Each compartment is assigned a letter and number that is marked on a label plate secured above the door or hatch leading into the compartment. Inside each compartment, located on a bulkhead, is the compartment’s Bull’s Eye. Bull’s Eyes consist of lettering which is two inches high and is applied over a 12 by 15 inch decal. It lists the compartment number and the division responsible for that compartment.

Compartment numbers consists of four parts, which identifies the following:

- **Deck number**: It is the first part of the compartment number, and identifies its physical level within the ship. The compartment number 01-83-2-L is located on the first level above the main deck.
- **Compartment frame number**: Is the second element of numbering and is separated by a hyphen from the first. It indicates the location of the foremost boundary of the compartment. Frames are the ribs of the ship and are evenly spaced from stem (the forward vertical extension of the keel) to stern (the aft most part of the vessel) on most ships. They are numbered consecutively from stem to stern. Compartments with low frame numbers are located in the forward section of the ship (towards the bow) and compartments with high frame numbers are located in the ship’s aft section. The compartment number 01-83-2-L indicates that the compartment forward most frame is 83. In rare cases, some compartments frames are identified by letters, instead of numbers, depending on where the compartment is located. So in the example 01-A-2-L, the frame letter is A. Frames located forward of the ship’s forward perpendicular (FP) are labeled with a capital letter, starting with “A,” and move forward with “B,” “C,” and so on. There can sometimes be an aft perpendicular (AP). Frames aft of the AP are lettered, starting with “AA,” and continuing aft with “BB,” “CC,” and so on. Additionally, the frame at the forward most bulkhead of the enclosing boundary for a compartment is the frame number location. If a compartment is split between frames, the frame number closest to the front of the ship is used. The forward perpendicular is known as frame zero.
- **Number indicating the relationship of the compartment to the centerline**: The third part of the compartment number, separated by a hyphen from the frame number, is the compartment’s location in relation to the ship’s centerline. So in the example 01-83-2-L, the compartment’s location in relation to the centerline number is 2. Just like most street addresses, compartments located completely to the port side of the centerline are assigned even numbers. Compartments located completely to the starboard side of the centerline are assigned odd numbers. In rare cases, two or more compartments share the same deck and frame number. In the instances when they do and are entirely to the port or the centerline, they are assigned consecutive higher even numbers. When they are located entirely to the starboard side of the centerline, they are assigned consecutively higher odd numbers. Some compartments fall directly over the ship’s centerline and those compartments are numbered 0.
- **Letter indicating the function and general use of the compartment**: The fourth and final part of the compartment number, separated by a hyphen from the centerline number, is the compartment’s usage identified by a capital letter. In 01-83-2-L, the compartment’s usage number is L. Look at the letters listed in the chart below. Some of the letters are self-explanatory, while others are not. Just as the rest of numbering is standard, so
are these primary usage letters. The only variance is on cargo ships. Since a cargo ship must carry its cargo, as well as its own stores, tanks and compartments designed to carry specific cargo, such as ammunition, receive double letters such as 01-83-2-MM.

<table>
<thead>
<tr>
<th>LETTER</th>
<th>Primary Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Storerooms</td>
</tr>
<tr>
<td>B</td>
<td>Battery Compartment (gunnery)</td>
</tr>
<tr>
<td>C</td>
<td>Ship Control and Fire Control</td>
</tr>
<tr>
<td>E</td>
<td>Machinery Compartment</td>
</tr>
<tr>
<td>F</td>
<td>Fuel Tank</td>
</tr>
<tr>
<td>L</td>
<td>Lubricating Oil Storage Tanks</td>
</tr>
<tr>
<td>M</td>
<td>Gasoline Tank</td>
</tr>
<tr>
<td>G</td>
<td>Machinery Compartment</td>
</tr>
<tr>
<td>L</td>
<td>(ammunition and passageways)</td>
</tr>
<tr>
<td>T</td>
<td>Trunks</td>
</tr>
<tr>
<td>V</td>
<td>Void Compartments</td>
</tr>
<tr>
<td>W</td>
<td>Water Tank</td>
</tr>
</tbody>
</table>

**DAMAGE CONTROL MARKINGS**

Much like the compartmental numbering system, many systems have unique identification designations as well. These designations allow damage control parties to quickly locate and identify equipment in the event of a shipboard casualty. Quickly isolating certain systems during a casualty can greatly enhance the damage control effort. Imagine trying to fight a growing fire without the ability to secure flammable liquids, ventilation that continues to supply a space with fresh oxygen, or dangerous electrical current. Without these designations, damage control efforts would be delayed for extensive amounts of time; therefore, it is important to identify shipboard damage control system identification markings.

Valves handles and piping in each system are painted unique colors to identify them quickly and accurately. The table shown here illustrates the colors that are used for each system. In a damage control situation, this color coding designation allows personnel to make decisions quickly and correctly when securing valves.

Individual valves are identified by markings inscribed on the rims of the hand-wheels, by a circular label plate secured by the hand-wheel nut, or by label plates attached to the ship’s structure or to the adjacent piping. Since the valves for the piping systems are associated with propulsion plant systems, a three-part designation sequence identifies these valves:

*The shaft or plant number:* The associated propeller shaft or plant number for this valve. If the system is not associated with a particular shaft or plant, this portion may be omitted.

*The system designation letters:* These letters will change according to the actual use of the pipe, tube, or duct.

*The individual valve number:* These numbers are assigned in sequence from origin to termination and are higher further down the element.

For a valve with the designation 01-FM-76, this would mean that this was associated to #1 shaft or plant, installed in the Fire Main System, and is the 76th component identified in this system.

To allow Sailors to work and live in relative comfort, heat, air conditioning, and fresh air ventilation must reach every compartment. There are thousands of ducts and vents within the air circulation system. If a fire or other emergency occurs in one compartment, the ventilation system could transport dangerous smoke and fumes throughout the ship. To protect the rest of the ship from an isolated incident, the system has a series of damage control checkpoints. Each element of the system is labeled with damage control closure classifications for ventilation, heating, and air conditioning. The labels are installed directly on valves, fan coils, closure housings, and various other parts of the system.
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DAMAGE CONTROL REPAIR STATION EQUIPMENT

Knowing the location and types of DC Repair Equipment is important in order to respond to an emergency efficiently and perform damage repair effectively, as well as to perform duties as Damage Control Petty Officer (DCPO) onboard ship. If you are unable to find the proper equipment in times of emergency, valuable time is wasted and the severity of the damage increases and you could easily become a casualty if you cannot properly identify the tools and supplies necessary to repair damage or combat fire and flooding.

Terminal Objective - Recognize each damage control (DC) kit found in the damage control locker.
- Enabling Objective - Locate and identify the equipment found in the DC repair kits
- Enabling Objective - Locate and identify repair equipment.

DAMAGE CONTROL REPAIR KITS

Most engineers are assigned to a repair locker for their general quarter’s station. This means that when general quarters are sounded, you must go immediately to your repair locker. You need to learn how to properly identify the equipment to use in cases of emergency. Locating and identifying the repair equipment is important because once the damage has been found and isolated, repairs need to be made. If repairs are not made, a small casualty can turn into a huge catastrophe. At each repair locker, a number of repair kits are put together and stowed in canvas bags. These kits are kept ready to be taken to the location where damage has occurred.

The kits are constructed and packaged to fit through the smallest watertight scuttle on your ship. Extra kits, such as those for plugging and pipe patching, are made up for the engineering spaces. These extra kits are inventoried and maintained by the personnel assigned to the engineering spaces.

- CBR Monitoring Kit: Each ship is equipped with a team specifically trained to seek out and isolate damage caused by chemical, biological, and radiological (CBR) attacks. The CBR Monitoring Team uses the CBR Monitoring Kit to determine whether chemical, biological, or radiological contamination is present. Remember, Condition William fittings are ordered closed when there is suspected CBR contamination. The following tools are required to be packed in the kit when responding to CBR emergencies: hazardous material or HAZMAT markers, bandage scissors, twine, timer, white chalk, black Chinese marker, and message blank.

- Investigator’s Kit: The Investigator Team uses the Investigator’s Kit to report conditions about their assigned areas. When General Quarters is called on the ship, investigators will disperse throughout their assigned area to ensure that no further damage occurs outside the boundaries of the existing casualty. Investigators typically operate in pairs and travel assigned routes to report on any conditions that may need repair. It may be necessary to also access locked spaces to ensure their integrity while investigating in the assigned area. Investigators must have an in-depth knowledge of the ship’s layout and the systems that are in their assigned area. The Investigator kit has a variety of tools at your disposal to support your job of identifying and reporting conditions around the damaged area of the ship to the repair locker: waterproof flashlight, message blanks, ball point pen, tool belt, 15” adjustable wrench, 1” T-handle socket wrench, 3/8”, 1/2” and 3/4” socket wrenches, dogging wrench, electrician’s gloves, electric shell gloves, fireman gloves, and tape measure.

- Pipe patching Kit: is used to repair holes or breaks in damaged pipes. Damaged piping systems can cause flooding in compartments. Normally, you will isolate the damage by securing the cutout valves on each side of the damaged section of piping. The amount of time that a damaged piping system can be secured depends on the type of service that system provides. The following materials and tools are required to be packed in your kit: 12” hacksaw frame and Blade, canvas duck cloth, cut resistant gloves, 2-lbs ball peen hammer, type C hatchet, 2-ply marlin, spun oakum, rubber sheet, emergency water patch and 12” tape. The following materials and tools are required to be packed in your kit: type 2 caulking iron, cold chisel, hand hammer, type C lashing, carpenter’s pencil, carpenter’s square, claw and hand hammer, and 15” hand saw, shoring materials also include lumber and steel shoring.

- Shoring Kit: Its purpose is to place support against a structure to prevent metal fatigue, sagging, and bulging. Shoring is also used to support hatches and decks, provide support for equipment that has broken loose or holding cofferdams and patches in place. The basic materials required for shoring are shores, wedges, sholes, and strong backs. There are also other shoring materials and tools that are required to be packed in two additional kits as follows: Shoring Tools Kit: 4’ – 7’ batten, 7’ – 12’ batten, 5 lbs. maul, 4” nails, 25’ tape measure, 6” and 8” C clamps, carpenter’s pence, carpenter’s square, claw and hand hammer, and 15” hand saw, shoring materials also include lumber and steel shore.

- Plugging Kit: Its purpose is to plug holes in the hull. As an interim measure, all holes should be partially plugged if they cannot be completely plugged. Even a partial plug can substantially reduce the danger of sinking by dramatically reducing the amount of water entering the ship. The following materials and tools are required to be packed in your kit: type 2 caulking iron, cold chisel, hand hammer, type C lathing and maal hatchet, hand saw and spun oakum, wood plugs in sizes 1” x 0” x 3”, 2” x 0” x 4”, 3” x 0” x 8”, 4” x 1” x 10” and wood wedges in sizes 2” x 2” x 8”, 3” x 3” x 12”, 3” x 6” x 12”, 2” x 12”, 1 ½” x 3” x 12”, 2 ¼” x 3” x 18”.

- Electrical Repair Kit: Emergency repairs are not limited to pipes aboard ship. Electrical systems require routine maintenance as well as emergency repairs from time to time. The Electrician’s Mate uses the electrical repair kit for their DC responsibilities. The following materials and tools are required to be packed in your kit: tool belt, hacksaw frame and blade, cold chisel, face shield, rubber floor mat, fuse, hand hammer, volt frequency indicator, diagonal pliers, lineman pliers, slip joint pliers, fireman boots, rubber gloves, shell electric gloves, talc powder, fuse puller, flat tip screwdriver, spectacles, cable strippers, twine, electrical tape, adjustable wrench, and canvas bag.
BECC 2.0 Student Workbook

BECC-33
FIRE WATCH DUTIES AND RESPONSIBILITIES

During the course of this lesson, you are going to learn the job of a fire watch, you will go over the things you need to do to stand a successful fire watch and emergency situations you may encounter while standing watch.

Terminal Objective – Determine the responsibilities, duties, and procedures to prepare for, and stand, a fire watch.

Enabling Objective – Identify the duties required of a fire watch.

Enabling Objective – Identify the procedures a fire watch follows during emergencies and abnormal conditions.

DUTIES REQUIRED OF A FIRE WATCH
Standing watch is one of the most important jobs on a ship. Watch standers play a vital role in casualty control. If something happens, let’s say a fire is started by sparks from a welding; the watch stander is the first emergency personnel there. You must know who to contact and what actions you can take to prevent further damage. First and foremost, every sailor standing a fire watch needs to know the different classes of fire, the type of extinguishing agent that is effective on each of those fires, and the personal protective equipment (PPE) you should use when addressing each class of fire. When standing a fire watch, you need to know how to signal the person conducting the hot work, and methods for confining hot work (including the use of welder’s curtains). You are also required to know the hot work permit system currently in effect, what the system is intended to accomplish, and who will monitor the performance.

Let’s take a moment to go over a few terms:
Hot work is any operation that produces temperatures of 400°F Fahrenheit or higher, such as flame heating, welding, torch cutting, brazing or carbon arc gouging. A person performing hot work is known as a hot worker. Always maintain a safe distance from hot work while standing a watch. If a single fire watch is provided for several hot works, the fire watch must be within 50 feet of all hot work operations and have an unobstructed view.
Gas Free Engineer (GFE), or the Gas Free Engineer Assistant (GFEA), issues gas free certificates for entry, work, or both, on tests and inspections personally conducted. You must have a certificate prior to performing hot work in or on compartments, tanks, voids, or piping systems near explosive materials, liquids, or vapors. You can verify the validity of a gas free certificate by checking the location of the space and the date and time of the certificate (good for an eight-hour period from the time the certification is issued). The gas free certificate is logged in the Gas Free Certification Log Book and is maintained by the GFE.

There are a number of fire watch general tasks that must be explored, these tasks are crucial to a successful watch. There are some things that you must know and do before hot work operations can begin. You need to know the location of the compartment where you are standing watch. For safety, unless you have specific GFE instructions, do not permit hot work when flammable liquids, flammable atmospheres, or explosive materials are present. Where practicable, relocate all combustibles at least 35 feet from the work site. If relocation is impractical, protect the combustibles with metal or guards and curtains made of non-flammable materials. You must also verify that the extinguishers are fully charged and properly sealed. You must know how to operate extinguishers to address flammable liquid and ordinary combustible fires. It is your responsibility to ensure that the fire watch on the other side of the bulkhead, deck, overhead, or other structures ensures that the hot work is not going to damage materials or equipment on their side of the operation. To avoid getting shocked, don’t forget to de-energize all electrical equipment exposed to the hot work. Last, but not least, you must be sure that you and the fire watch, are properly placed.

A fire watch duty must muster, obtain, and inspect equipment. Muster with the Fire Marshal, or in some cases, the Engineering Duty Officer (EDO). Obtain the correct PPE for the type of watch you are standing. This PPE includes goggles, protection gloves, National Institute for Occupational Safety and Health (NIOSH) respiratory equipment, hearing protection, and a fire extinguisher. Inspect the hot work equipment. The type of equipment depends on the hot work being performed, that is, CO₂, PKP, AFFF, or water extinguisher. Both the hot work personnel and the fire watch must understand the potential hazards on all sides of the hot work area. Fire watch personnel must coordinate with other fire watches to ensure all areas are covered. Communications are established by using wire free communication (WIFCOM), sound-powered telephones, the tapping method, and messengers.

Once the hot work is underway, your duty is to maintain a vigilant watch over the hot work area by staying in communication with other fire watches in adjacent compartments. You will need to pay close attention to any combustible material in the area that cannot be removed. Also maintain coordination with the hot worker and equipment in the affected space. Maintaining this surveillance ensures that the hot work does not transmit fire hazards to the space, or other spaces, by overheating the connective deck, overhead or bulkhead. Positioning another fire watch in an adjacent compartment prevents the spread of fire hazards to the compartment. Depending on the type of hot work, you must understand the proper extinguishing method and equipment.

As the watch stander, you inspect the hot work area in order to prevent any, or all, possible combustible materials from igniting, and to ensure that the space, and adjacent spaces, is available for re-entry. This inspection enables the GFE or GFEA to conduct a further evaluation of possible hazards that may have developed after hot work. While inspecting an area after hot work is completed, there are crucial safety precautions that you must observe. After verifying that the hot work is completed, you must remain on station for at least 30 minutes to ensure the area is cool to the touch and that no smoldering embers remain. If the hot work was conducted on fuel tanks, vent spaces or adjacent spaces containing flammable materials, allow the GFE or GFEA to further evaluate the space for possible hazards.

Inspect and return the fire watch equipment, each type of equipment has a particular inspection procedure. This is done to ensure that the equipment is maintained and accounted for, all preventive maintenance is up-to-date, and damaged equipment is fixed and tested. Inspect equipment for any damage, including the CO₂ hose, horn and bottle, AFFF aerating hose nozzle and bottle, and the water pressure in the bottle.

PROCEDURES A FIRE WATCH FOLLOWS DURING EMERGENCIES AND ABNORMAL CONDITIONS
When standing a watch, there are a number of emergencies that may arise, identify the abnormal conditions and emergencies, if any should come up. You will need to become familiar with them.

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If you lose communication with the hot worker or other assigned fire watches to your hot work, you have an emergency. You must immediately cease hot work operations and re-establish communication, either by radio or verbally, and attempt to determine why you lost communications. Maybe it was a dead battery or perhaps you have some problems with the reception, caused by atmospheric interference or dead spots. Although it may be painful to admit, it could be simple operator error by you, the hot worker, or perhaps both of you. When you lose communications, your operations are limited because you have to shut down hot work to prevent a compromise of personnel safety. Of course, stopping hot work delays you finishing the job; however, if hot work is not stopped, you cannot remedy the situation. You must re-establish those hot worker communications and create a backup plan in case you are confronted with the same situation again.

Fire is an emergency that requires your immediate attention. The first requirement when a fire is spotted is to stop hot work. Next, find the exact location of the fire, notify Damage Control Central (DCC), and then extinguish the fire. Stop firefighting operations if the extinguishing agent cannot handle the fire and wait for the fire party to arrive. If you are in a shipyard, transmit alarms by using the shipyard fire alarm system. Otherwise, use the ship's communication system. If a fire occurs that you cannot extinguish, send an alarm to the Officer of the Deck (OOD) at the quarterdeck (if you are in-port), or the bridge or DCC (if you are at sea). Probable causes for fire are combustible materials left in the space, materials in adjacent spaces that were not removed, or equipment failure.

If immediate action is not taken to correct a fire, other emergencies or malfunctions may occur. The fire may transfer through the deck, overhead, bulkhead, or structure to another location and the atmosphere may become uninhabitable due to fire in the space and adjacent spaces. Fire affects other operations, equipment, and watch stations in several ways. Equipment that was not exposed to hot work is exposed, due to the fire, and hot work ceases. Fire in a related compartment may damage equipment in or near the space. Once the situation has been addressed, there are required follow-up actions. The Fire Marshal, EDO, and GFE or GFEA inspects and tests the space for safety and entry. If the space is deemed safe, hot work may resume.

Malfunctioning fire extinguishing equipment has no alarms to alert you to this emergency, a good indication that a malfunction exists is when an extinguishing agent does not work properly, such as a ruptured hose or a squeezed grip valve assembly that does not work. When you are confronted with an emergency, act immediately and get another extinguisher or extinguishing agent. If you do not immediately take action to correct the malfunctioning fire extinguishing equipment, other emergencies or malfunctions may occur such as a fire that cannot be extinguished and continues to spread, causing an uninhabitable atmosphere. After you have identified the malfunctioning fire extinguishing equipment, your required follow-up is to resume hot work, replace the malfunctioning equipment you identified, find out why the equipment malfunctioned, and perform the proper maintenance to reduce the chance of another malfunction.

Excessive smoke, fumes, or a combination of both from hot work is an abnormal condition to which the fire watch must respond. Indications and alarms for this condition primarily consists of seeing or smelling the smoke or fumes. The smoke and fumes could be caused by combustible material left in the space, materials in the adjacent space that were not removed insufficient ventilation, or equipment failure. Smoke or fumes can limit operations by causing hot work to stop, reducing visibility, or raising the possibility for a casualty to occur. If you see or smell smoke or fumes, immediately stop hot work and find the location of the excessive smoke and fumes. Notify DCC, and extinguish the cause of the smoke or fumes, or if the extinguishing agent cannot handle the fire, cease the firefighting operations and wait for the in-port Fire Party (if your ship is docked) or the Underway Fire Party (if your ship is at sea). Once the situation has been addressed, the Fire Marshal, Engineer Duty Officer, and GFE or GFEA inspect and test the space for safety and entry. If the space is declared safe, you may resume hot work.
BECC-38
BASIC CHEMISTRY OF FIRE

Your understanding of this topic can affect your chances of survival when faced with combating a fire at sea. If you think about it, a steel ship can become a floating furnace when fed by the combustible and flammable materials onboard. Before you can learn how to extinguish a fire, you need to understand the chemistry of a fire. Understanding the chemistry that makes up a fire helps you determine the type of extinguishing agent you choose to combat that fire. Navy personnel are required to train and participate in shipboard firefighting.

Terminal Objective - Distinguish which firefighting agent to use to extinguish the four classes of fire.

- Enabling Objective - Define terminology associated with the basic chemistry of fire.
- Enabling Objective - Distinguish the different classes of fire.
- Enabling Objective - Distinguish how different extinguishing agents affect a fire.

DEFINING TERMINOLOGY ASSOCIATED WITH THE BASIC CHEMISTRY OF FIRE

Navy personnel are required to train and participate in shipboard firefighting, so you must be able to understand the chemistry that makes up a fire in order to help you determine the type of extinguishing agent you will be using. You will learn the different terminology associated with the basic chemistry of fire, you will be able to distinguish different classes of fire, and you will be able to distinguish how different extinguishing agents can affect a fire.

Fire is a reaction of combustion, displayed in light, flame, and heat which is a rapid oxidation of matter. In contrast, rust is the result of slow oxidation, the combining of iron with oxygen; however, rusting does not produce light or measurable heat. Three elements are required to create a fire; these elements are heat, fuel, and oxygen. If you remove any of these elements the fire cannot exist and it extinguishes.

- Atmospheric oxygen content is normally 19.5% to 22%; however, combustion can occur in a lower percentage, but at a slower rate. For example, 3% oxygen can support a smoldering fire. Some materials contain their own oxygen source, an oxidizer. Oxygen, combined with the correct amount of combustible vapors or dust, in an enclosed space, can be violently explosive.

- Fuel is a combustible solid, liquid, or gas, that burns when heated to its ignition temperature. Ignition temperature is the minimum temperature to which a substance must be heated in order to initiate or cause self-sustained combustion, independent of another heat source. Ignition temperatures vary, depending on the type of flammable material.

- Heat is a form of energy. It is considered the elevation of the temperature of an object as compared to its surroundings. Heat is required for materials to reach their ignition temperature.

Fuel, heat and oxygen cause surface glowing or smoldering; but if you throw in an uninhibited chemical chain reaction, we have ourselves a full-fledged fire. Just to let you know, a flame is the rapid burning of gases that are created by combustible substances when they are heated to the ignition temperature. The requirement for a flaming fire is illustrated by the Fire Tetrahedron. A tetrahedron is a solid figure with four triangular faces. It is useful for illustrating the combustion process because it meets the chemical chain reaction requirement and each face touches the other three sides. Remembering that the Fire Triangle loses its functionality if any one of the three elements (sides) is removed, the Fire Tetrahedron loses its functionality if any one of the four sides (elements) is removed, causing the combustion to stop. Halon and dry chemical fire extinguishing agents work by interrupting the chemical chain reaction, thus interrupting the Fire Tetrahedron.

As with any profession, there is terminology that is used within the firefighting community. It is important for you to know these terms not only so you can understand what your fellow fire fighters are talking about, but so they know what you are talking about.

- Auto Ignition: the auto ignition, or self-ignition, point is the lowest temperature to which a flammable material must be heated to give off vapors that will ignite without the application of a spark or flame. The auto-ignition point is the temperature at which spontaneous combustion occurs.

Heat transmission is an important part of fire. Understanding the process of how heat moves will help to keep you from getting burned. Heat is transmitted from a warm or hot material to a cooler material until a thermal equilibrium or balance is reached. In general, heat flows from a hot to a cold material by three processes: Conduction, convection, and radiation.

- The conduction process is the act of heat transfer from particle to particle along an object or between two or more stationary objects in physical contact. For example, fire on the one side of a steel bulkhead that is transferring heat to the other side.

Heat classification is normally 19.5% to 22%; however, combustion can occur in a lower percentage, but at a slower rate. For example, 3% oxygen can support a smoldering fire. Some materials contain their own oxygen source, an oxidizer. Oxygen, combined with the correct amount of combustible vapors or dust, in an enclosed space, can be violently explosive.

- The convection process is the act of heat transfer in a gas or liquid by the circulation of currents from one region to another; for example, heated gases traveling through a ventilation system.

- The radiation process is the act of heat transmitted from a hot material to a cooler one by means of heat waves. For example, heat from the sun.

FIRE CLASSIFICATION

Fires are classified by the flammable material that is burning. Different fire sources or fuels require different extinguishing methods. If you use the wrong extinguishing agent, you could damage equipment or cause an explosion, ultimately making the fire hazard worse. So, it is important for you to distinguish between the classes of fire and how to properly extinguish each. There are four classes of fires: Alpha, Bravo, Charlie, and Delta.

- Class Alpha Fires are caused by the burning of such materials as wood, clothes, plastics, upholstery, and organic substances like animals and humans. Class Alpha fuels have a relatively high ignition point, approximately 400º Fahrenheit and above. Things that might help you recognize an Alpha fire are ashes and smoke. Alpha fires can burn rapidly or smolder, depending on how much oxygen is supplied. If you come across a smoldering class Alpha fire, be cautious; it can give off deadly carbon monoxide gas. There are four extinguishing agents effective on class Alpha fires. Water is the primary extinguishing agent.
- **Class Bravo Fires** involve flammable liquids of a petroleum base such as gasoline, diesel fuel, jet fuels, hydraulic fluid, lube oil, alcohol, paints and solvents. You can also find class Bravo fires involving deep fat fryers. These fires give off black smoke and explosive, flammable vapors. There are five extinguishing agents effective on class Bravo fires. AFFF is the primary extinguishing agent. It is used in engine rooms, flammable liquid storerooms, flammable fuel pump rooms, and auxiliary spaces. Halon 1301 is used in enclosed spaces and machinery rooms. Spaces must be evacuated when using Halon. Water, used as high velocity fog, can be used only when AFFF is not available. PKP portable extinguishers are effective for small flammable liquid fires. A portable PKP is effective on small fires less than 10 square feet. CO2 extinguishing agents have limited effectiveness on Bravo fires. Portable CO2 extinguishers will effectively cover a Bravo fire of 4 square feet or smaller.

- **Class Charlie Fires** involve electrical current. You can recognize Charlie fires by their blue flame and smoke caused from arching and sparking. Be careful when fighting these fires; there is a great risk of electrical shock. The most effective tactic is to de-energize the source and handle the fire as a class Alpha fire. However, it is not a class Alpha fire. Since it is on fire, it could be damaged internally to the point that we can’t be sure that opening the breaker actually secured all power. CO2 is the preferred extinguishing agent for Charlie fires because it leaves no residue and does not conduct electricity. Halon 1301 is also effective, but the compartment must be evacuated when the Halon Flooding System has been initiated. PKP leaves a corrosive residue on electrical components and should only be used if nothing else is available. Water can be used with little or no danger of electric shock if the nozzles on fog pattern are operated at least four feet away from the energized source. This works for equipment or cables carrying up to 4160 volts.

- **Class Delta fires** occur in combustible metals, such as magnesium, titanium, and sodium. A flare would be considered a Delta fire. Special techniques have been developed to control this type of fire. If possible, you should jettison the burning material overboard. Most class Delta fires are fought by applying large amounts of water on the burning material to cool it down below its ignition temperature. However, a magnesium fire can be smothered by covering it with a large volume of dry sand.

**EXTINGUISHING AGENTS**

There are many materials available for you to use as fire extinguishing agents.

- **Water** is a cooling agent and is readily available aboard the ship; in fact, the sea provides an inexhaustible supply. If you can manage to lower the surface temperature of a fire below the fuel’s ignition temperature, the fire will extinguish. Water is most efficient when it absorbs enough heat to raise its temperature to its boiling point, 212 degrees Fahrenheit (100 degrees C). At this temperature, the seawater absorbs more heat until it changes to steam. The steam carries away the heat which cools the surface temperature. Water is effective on all types of fires, Alpha, Bravo, Charlie, and Delta. Be advised, the stream of water will affect how it extinguishes that class of the fire.

- **Aqueous Film Forming Foam (AFFF)**, when proportioned with water, works three ways to extinguish fires. First, an aqueous film is formed on the surface of the fuel which prevents the escape of the fuel vapors. Second, the layer of foam effectively excludes oxygen from the fuel surface. Third, the water content of the foam provides a cooling effect. AFFF is effective on Alpha and Bravo Fires.

- **Carbon Dioxide (CO2)** extinguishes a fire by diluting and displacing its oxygen supply. When gaseous CO2 is directed into a fire, sufficient oxygen to support combustion is no longer available, thus causing the flames to die out. Depending on the fuel, this action will occur when the 21 percent oxygen content, normally present in air, is diluted with CO2, making the oxygen content fall to 15 percent. CO2 is effective on Alpha, Bravo, and Charlie fires.

- **Halon** chemically inhibits the flame front. Halon is effective on Bravo and Charlie fires.

- **Potassium Bicarbonate (PKP)**, when applied to fire, the dry chemical extinguishes the flame by breaking the combustion chain. Just keep in mind that PKP does not have cooling capability. PKP is effective on Alpha, Bravo and Charlie fires.

- **Aqueous Potassium Carbonate (APC)** is used onboard naval ships to extinguish burning cooking oil and grease in deep fat fryers and galley ventilation exhaust ducts. Upon contact with the burning surface, APC generates a soap-like froth that removes oxygen from the surface of the grease or oil, and the fire is extinguished. Grease or oil fires are Bravo fires.
Smoke can be a major problem onboard ship. Any sailor who has fought a fire onboard ship can relate to the difficulties of performing firefighting duties in zero visibility. Your life and that of your shipmates depends on your ability to maintain and operate the Navy Infrared Firefighting Thermal Imager (NiFTI) Talisman K90. By detecting differences in thermal radiation, the Talisman K90 sensing device allows you to see heat sources through darkness, dense smoke, and light steam.

Terminal Objective - Identify the operation of heat sensing equipment.
- Enabling Objective - Identify the operation of the Talisman K90.

OPERATING THE TALISMAN K90

If there is a fire aboard your ship, chances are the power will be lost or secured in the area of the fire. This will dramatically reduce visibility. Add smoke from a fire and the visibility will be zero. The Talisman K90 thermal imager is essential because it allows the firefighter to identify heat sources through low visibility conditions and can help to direct firefighting efforts to minimize further damage.

The Talisman K90 is a portable, hand-held unit that allows you to see under adverse, low visibility conditions, even in flammable environments. All objects give off infrared signals. The camera senses these signals. The hotter the object, the brighter (whiter) it will appear on the viewfinder screen. You can use the Talisman K90 to locate the seat of a fire, find and guide rescuers to injured or trapped personnel, set and maintain fire boundaries, and locate ignition sources during a fire overhaul. During firefighting, the Attack Team Leader normally uses it to direct the other hose team members in applying firefighting agents.

The Talisman K90 consists of nine functional components that should be reviewed prior to its use.

- **The battery compartment** is located on the bottom of the Talisman K90. Release the battery lock by pushing the latch lock up and forward (towards the lens). Install a fully charged, single battery into the compartment. Place the battery so that the metal side mates with the camera's contact points. Then close the battery compartment cover by pushing the latch lock back and down to seal the battery compartment.
- Two **Nickel-Metal Hydride batteries** are normally supplied with the unit. Only one is needed to power the Talisman K90. When fully charged, the battery allows the Talisman K90 to operate for up to 4.85 hours.
- **Red power button**, located on the bottom of the Talisman K90. After pressing the power button, a green Light Emitting Diode (LED) indicator light will be illuminated below the viewing screen. The sensor activates in approximately 15-30 seconds (up to 60 seconds in very cold weather). To turn off the thermal imager, press the red button.
- **Pistol Grip Handle**, the Talisman K90 is equipped with a detachable quick connect pistol grip handle. To attach it, carefully turn the Talisman K90 over to view the bottom side. Match the two attachment points on the K90 with the attachment points on the pistol grip. Slide the pistol grip into place. You should hear and feel the pistol grip lock into the. To unlatch the pistol grip, unlock the pistol grip lock tab on the left side of the handle and slide the pistol grip toward the front of the K90.
- **Hand straps** - there are two easy to use and adjustable on the sides of the K90. To adjust, loosen the buckle on the hand strap to give enough room for your hand to slide between the hand strap and the case and so your fingers can grab the side of the case.
- **Lanyard** - is used as a secondary securing point to help maintain positive control of the Talisman K90. It goes around the back of your neck and attaches to the two D-rings on the left and right side of the K90.
- **Lens** - has a 59º field of view. It is located on the front of the K90 and has auto focusing capabilities from 1 meter to infinity.
- **Viewfinder Display** - is a 3.5 inch (diagonal) display with visor located at the back of the. When powered on, the battery level indicator displays at the bottom. Ten (10) bars indicate a fully charged battery. The bars disappear as you use the battery. The words “Low Battery” appear when there are 3 bars remaining.
- **Video Overlay** - when the V/O button located on top of the K90 is pressed; it allows firefighters to obtain a standard video image of the scene, superimposed on the thermal image. The effect is a combination of a thermal image and a video image display of the scene. A second press of the V/O button deactivates the video overlay.

The Talisman K90 is a simple but effective piece of equipment to operate. To turn it on, press the red power button on the bottom. A green LED indicator light will illuminate, which is located below the viewfinder display. After approximately 15 to 30 the infrared sensor will activate and the Talisman K90 is ready for use.

TALISMAN K90 ACCESSORIES

- **AA Battery Adapter**, supplied with the K90, it will fit 10 alkaline AA batteries. The AA battery adapter fits into the battery compartment, just like the Nickel Metal Hydride (NiMH) battery. It should be used as a backup for the rechargeable batteries.
- **Battery Charger with Power Supply Cord** is used to charge the NiMH battery. Do not use it to charge any other batteries. After plugging the power supply cord into a standard 110v outlet, a flashing red indicating light tells you the charger is in “Stand-by” mode. If a battery is placed in the charger and the flashing red LED light continues, then the battery isn’t making a good connection with the charger or the battery isn’t capable of holding an adequate charge. If a battery is placed in the charger, a flashing green LED indicating light tells you the battery is charging, while a continuously illuminated green LED indicating light tells you the battery is fully charged and in “Maintenance” mode.
- **Hard Shell Carrying Case**, is use to keep the K90 in when not in use. There should be one K90 for each repair locker onboard your ship.

A fully charged NiMH battery provides up to 4.85 hours of operation. With a fully charged battery installed, the viewfinder displays 10 vertical bars and the word “BATTERY” in the bottom center of the viewfinder display. As you use it, the bars start to disappear because the battery is losing its charge. When the battery indicator gets down to 3 vertical bars, the words “LOW BATTERY” appears next to the bars. If the situation allows, it is recommended that the battery be charged at this time. The K90 will function properly if you understand how to take care of the device and know its operating limitations. Water, dirt, or soot distorts the image if it’s on the viewing lens. You can maintain a clear picture by cleaning soot and wiping condensation from the lens with a soft, clean cloth. If cleaning is required, clean with warm soapy water. Avoid solvents and abrasive cleaners. Store it in the case in a temperate environment (between 59 - 95º F) when not in use. Operate in temperature ranges from 5º to 840º F. Prolonged exposure to excessive heat could damage it. Inspect the battery for leakage prior to use. Ensure the battery contacts in the battery compartment: the battery and the battery charger are free from corrosion and undamaged. It may not be fully operable topside due to the electromagnetic interference. Do not use to locate fire by viewing through glass windows. While you are viewing a fire, avoid the spray pattern of the nozzle to prevent the black curtain effect, which shields anything behind the water.
In all operating machinery rooms, you can find at least two elements of the fire triangle; oxygen and heat. Therefore, you only need a fuel-system leak, especially one under pressure, to start a major class Bravo fire. You can’t call the neighborhood fire department. You are part of the fire department.

**Terminal Objective** - Identify the operation of the AFFF Fire Extinguishing System.
- **Enabling Objective** – Identify the component functions for the AFFF Fire Extinguishing System.
- **Enabling Objective** – Identify the operating procedures for the AFFF Fire Extinguishing System.

**COMPONENT FUNCTIONS FOR AFFF FIRE EXTINGUISHING SYSTEM**

One of the most valuable pieces of firefighting equipment found aboard your ship is the Aqueous Film-Forming Foam (AFFF) Fire Extinguishing System. The use of this installed firefighting equipment aboard the ship can save your life, your shipmates, and the ship itself. One of the most dangerous environments aboard ship is found in the engineering plant. Rotating machinery combined with air, fuel, oil, and high operating temperatures, creates an environment ripe for a class Bravo fire. The AFFF system aboard your ship is the most effective way to combat a class Bravo fire. You must be able to operate this system.

You are required to familiarize yourself with the components and their functions and the operating procedures for the AFFF Fire Extinguishing System and the safety precautions that must be followed when operating the AFFF system. Safety is paramount and you need to make this a common practice. You should never become complacent or purposely ignore the safety precautions. Your ship is your home away from home and you must do everything possible to prevent a fire from damaging her. It is like a floating city, and unlike your home, when the ship is underway the fire department will not be coming up to put out the fire. You are a key element in the overall fire prevention aboard.

Using a combination of valves, pipes, electric motors, pumps, hose connections, service tanks, and motor controllers which make up the AFFF system, you can effectively reduce the chances of a class Bravo fire ruining your ship. The AFFF Fire Extinguishing System supplies the correct mixture of AFFF concentrate and seawater to produce an effective foam firefighting agent to spaces particularly susceptible to class Bravo fires. The generating equipment is usually located on the damage control (DC) deck to supply firefighting hose reels and bilge sprinkler systems within the engineering spaces.

You may see three slightly different configurations. They are identified by their type of pump, type of nozzles, and type of control. Different ships use different setups. However, once you understand the basic operation of the system components, you should be ready to use the AFFF system configurations aboard any Navy ship. Discharge rates depend on the installed equipment configuration.

Subsystems are a part of a whole system. The system is divided into three subsystems. Each subsystem has its own color code. With a distinctive color code of red, the first is the Fire main Supply subsystem. The second sub-system is the AFFF Supply and Recirculation subsystem, which is color-coded with a light blue and red strip. The third sub-system is the combination of AFFF and seawater from the Fire main supply, which is color-coded with a dark green and red strip.

Fire main Supply subsystem supplies seawater to the AFFF Fire Extinguishing System, the system consists of several components:

- **The fire main supply line** is a pipe that carries seawater to the subsystem via the fire main root cutout valve.
- **The fire main root cutout valve** is a William fitting that allows the flow of seawater to the AFFF Fire Extinguishing system. The William fitting is tamper sealed in the open position and shut only to complete Planned Maintenance system (PMS) requirements.
- **The marine strainer** filters out marine growth and debris. It is opened by moving the handle to a position that is parallel to the body of the strainer. This allows the strainer to be flushed.
- **The Hycheck valve** is a normally open, hydraulically operated control valve, with a check feature, located between the ratio controller and fire main. Pressure to close the valve (stand-by position) comes from the fire main through the Master Solenoid Operated Pilot Valve (SOPV). The valve will automatically open when the pressure from the fire main through the solenoid operated pilot valve is relieved. The Hycheck valve consists of a body, a removable seat and a diaphragm assembly. The body of the Hycheck valve provides a flow path for liquid. The removable seat insert mates with a disc to form a fluid tight seal. The Hycheck valve is a directional valve and must be installed for the correct direction of fluid flow.
- **The Powertrol valve** allows the flow of AFFF/seawater solution through the distribution system or controls seawater flow on the flight deck injection system. This valve has a control line installed on it. This line is fitted with a valve that allows the pressure in the control line to be relieved.
- **The control piping root cutout valve** is located on the DC deck. It is a William fitting that allows for maintenance and is tamper sealed in the open position.
- **The wy-trainer** filters out debris and growth and prevents contamination from entering the Solenoid Operated Pilot Valve (SOPV).
- **The lift check valve** (81-M) allows fluid flow in one direction only.
- **The fire main control line** supplies fire main pressure to the Master and Service SOPV’s.
- **Pressure gauge** identifies the available fire main pressure to the AFFF system. The gauge has its own cutout valve; if you see that the pressure is very low or at 0 PSI, first check the cutout valve leading to the gauge to ensure that it is open. The class of ship determines the normal fire main pressure reading.
- **The Solenoid Operated Pilot Valve (SOPV)** is used to provide power to valves electrically operated or manually operated. The Master Solenoid Operated Pilot Valve provides a means of controlling the Hycheck and Powercheck valves. It can be electrically operated remotely or locally at the station via pushbuttons. Manual operation of the valve can be done by turning the T-handle or knob. Turn the handle clockwise to align fire main pressure to the Hycheck valve diaphragm, closing the Hycheck valve; while allowing fire main pressure to drain off of the Powercheck valve diaphragm, closing the Powercheck valve. This is the standby position. Turn the handle counter-clockwise to align fire main pressure to the Powercheck valve diaphragm opening the Powercheck valve, while allowing fire main pressure to drain off of the Hycheck valve diaphragm opening the Hycheck valve.
- **Magazine sprinkling systems** are used for emergency cooling and firefighting, and are normally found in magazines and where munitions are temporarily held in readiness. There are three types of magazine sprinklers that you may find aboard your ship. The automatic dry type is installed with open sprinklers. The automatic wet type is installed with closed sprinklers. There is also a manually operated dry type. AFFF Supply and Recirculating subsystem supplies AFFF to the AFFF Fire Extinguishing System and consist of various parts:
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-Service tanks vary in size from 50 to 2,000 gallon tanks of AFFF, depending on the size and number of spaces protected. They are made up of a 90/10 percentage of copper-nickel. It has a liquid level indicator assembly, which includes an external sight glass, a drain and vent valve, and a guard to protect the sight glass, and also a fill connection and vent.

-The tank drain valve is an X-ray fitting that is tamper sealed in the shut position.

-The pump suction valve is a William fitting that is tamper sealed in the open position, if shut, it prevents the AFFF concentrate from reaching the injection pump.

-The wye-strainer is located in the suction line to filter the AFFF concentrate.

-AFFF pump and motor assembly supply concentrate to the proportioner. The motor is a 440 VAC, 3-phase, motor. The pump is a positive displacement vane type pump that is used to inject AFFF into the system, the size and displacement depends on the configuration or type of ship. The motor controller provides electrical control for pump operation and controls the ON/OFF Emergency run capabilities of the motor. There are several switches and lights found on the controller. A power available light, illuminated white, indicates the power is available at the controller. A motor run light, illuminated green indicates the motor is running. A failed fuse indicator light, illuminated neon orange, indicates a blown fuse.

-There are three switches located on the controller. The first is a normal or local run. Set in the normal position, it allows the motor to be started from a remote pushbutton. The switch in the local position allows for operation at the controller. A second switch is the Normal or OFF, which allows the system to be reset. The third switch on the controller is the Emergency Run, or Reset button. This allows the unit to run, bypassing the motor overloads, and allows for restart of the motor if stopped by tripping or overload. Usually, permission must be granted from higher authority to operate the motor controller with this button. The power panel supplies power to the motor controller. It receives power from the AFFF Automatic Bus Transfer switch or ABT for short, which leads us into our next electrical component. During a casualty in the engineering plant, parts of the ship could lose power to vital equipment and systems. The AFFF system is a vital system to the ship and therefore, it has two sources of power, a normal and an alternate source, available to the power panel. The automatic bus transfer switch automatically receives electrical power from an alternate source when the normal power source fails.

-Powercheck Valve is hydraulically operated and is located in the AFFF concentrate line between the pump and the ratio controller to control the concentrate flow to the ratio controller. It is normally closed (stand-by position) and can be opened by pressure from the master solenoid operated pilot valve.

-Back pressure regulating valve is designed to balance the flow pressures between the AFFF concentrate discharge line and the fire main supply line. The AFFF concentrate discharge line pressure is less than the fire main supply line pressure, the greater fire main supply line pressure causes the valve spool and diaphragm to be forced down and close the two valve orifices. This decreases the amount of concentrate that can flow through the valve. The decrease of concentrate flow through the valve increases the pressure in the AFFF concentrate discharge line. When the AFFF concentrate discharge line pressure is equal to or greater than the fire main supply line pressure, the greater pressure forces the diaphragm and valve spool upward to open the orifices and balance the two line pressures.

AFFF and Fire main Supply subsystem supplies AFFF and seawater mixture to a single hose reel on the DC deck and hose reels in the machinery space it consists of;

- The proportioner, or ratio controller, mixes AFFF concentrate and seawater at a ratio of 94% seawater to 6% AFFF concentrate. The system has a capacity of 60 to 1000 GPM of AFFF and water solution.

-The emergency hose connection valve allows for an extra firefighting hose connection.

-The re-entry hose reel cutout valve is a circle X-ray fitting. This valve is tamper sealed in the shut position and will be opened during re-entry of the fire party.

-The re-entry hose reel is for the AFFF and water solution or the water alone. It is located on the DC deck, near the main machinery space access. It is 1 ½ inches in diameter and non-collapsible, is equipped with a 95 GPM bail operated vari-nozzle.

-The machinery space hose reel cutout valve is a William fitting that is tamper sealed in the open position.

OPERATING PROCEDURES FOR THE AFFF FIRE EXTINGUISHING SYSTEM

The AFFF Fire Extinguishing System pumps AFFF concentrate into the distribution piping, combining the concentrate and the seawater to produce the AFFF/water solution. You can activate the system remotely by using the AFFF system remote “start” pushbutton or manually by operating the SOPV “T” handle. Operating the SOPV “T” handles is considered Emergency/Local activation. The bail cutout valve in the AFFF line to the re-entry hose reel located on the DC deck must be opened to charge hose reel. Log the time that AFFF is activated and relay information to DC Central via the responsible repair locker. Do not use gasoline or other flammable solvents to clean the equipment. Fluid being pumped is hazardous to your health. To avoid possible irritation to your skin and eyes, do not swallow the fluid. Take precautions to prevent spillage. Keep all fluids in a sealed container. Solvents are toxic. Avoid breathing vapors and contact with eyes, skin and clothing. Work in a well-ventilated area and clean up spills immediately.

To avoid inadvertent operation of equipment and/or electrical shock, make sure the power source is de-energized and the circuit is tagged “Out of Service”. Before performing any maintenance, make sure input power to the selector switch has been disconnected or turned off and tagged. Rotating parts such as couplings, pulleys, and external fans should be permanently guarded against accidental contact with hands or clothing. This is particularly important when the parts have surface irregularities, such as keys, keyways, or set screws. Stand clear of any rotating machinery. Do not allow the pump to run dry for more than 30 seconds to avoid rapid wear or damage. Discharge pressure should build up to at least 15 PSI, or the pump is running dry and not delivering fluid. Do not apply belt dressing or any form of lubrication to the machinery. Do not allow the pump to run dry for more than 30 seconds to avoid rapid wear or s
Press the remote OFF pushbutton. This closes the Powertrol valve, but does not stop the motor. If an OFF button is not present, proceed to the next step.

Momentarily switch the NORMAL/OFF switch to the OFF position. The switch has a spring return to NORMAL. This action stops the motor.

Replenish AFFF concentrate as necessary.

To secure the AFFF System that was activated locally or in an emergency situation, use the following procedure.

- Press the remote OFF pushbutton at one of the remote stations. This closes the Powertrol valve, but does not stop the motor. If an OFF button is not present, proceed to the next step.
- Momentarily switch the NORMAL/OFF switch to the OFF position. The switch has a spring return to NORMAL. This action stops the motor.
- Close both the Master SOPV and service SOPV "T" handle valves, rotating them in a clockwise direction.
- Replenish AFFF concentrate as necessary.
Navy ships are equipped with portable desmoking equipment used to ventilate compartments onboard. You need to know what equipment to select and the proper operation in order to prevent damage or personnel injury.

**Terminal Objective** – Recognize the types, operational procedures, and personnel safety precautions for Portable Desmoking Equipment and Smoke Barrier Devices.

- **Enabling Objective** – Identify the various types of Portable Desmoking Equipment and Smoke Barrier Devices.
- **Enabling Objective** – Recognize personnel and equipment safety precautions during the operation and use of Portable Desmoking Equipment and Smoke Barrier Devices.
- **Enabling Objective** – Identify Portable Desmoking Equipment and Smoke Barrier Devices operational procedures.

Desmoking equipment falls into two categories: Desmoking Fans and Smoke Barriers. Portable desmoking fans are stored in repair lockers throughout the ship. There are two primary types of fans: Box Fan and Ram Fan.

**- The box fan** is a medium capacity desmoking device used to remove smoke, fumes, and contaminated air in emergency situations. All box fans have an explosion proof, thermally protected electric motor, a 50 foot power cord, a simple ON/OFF switch, and operate on 110 volt power.

**- The ram fan** is a high capacity, portable blower used to remove smoke and other hazardous gases when electrical power is not available. The ram fan is operated by water pressure, supplied by a standard one-and-a-half inch fire hose, which spins the fan’s turbine.

Removing smoke is only half of desmoking. You must also keep it from entering new spaces. Smoke curtains and smoke blankets contain smoke and create a path to get it where you want it to go.

- **A smoke curtain** is a two-piece blanket made from flame resistant fiberglass material. Smoke curtains control the spread of lateral smoke at doorways and passageways.

- **Smoke blankets** control the spread of vertical smoke at hatchways. A smoke blanket is made from flame resistant fiberglass material, generally fourteen feet by fourteen feet in size.

**DESMOKING FAN AND SMOKE BARRIER SAFETY**

Fires are dangerous, but smoke is even more dangerous. You are three times more likely to receive injuries from smoke inhalation and poisonous gases than from fire. The box fan is a medium capacity, electric powered fan, the ram fan is a high capacity, water powered fan; as a result, each has different safety considerations.

The box fan is an electrically operated, medium capacity desmoking device; there are specific safety considerations when operating the box fan in a wet or potentially explosive environment.

- **- Motor:** The box fan has a 110 volt explosion proof motor. If the tamper seal is missing from the unit, do not use the fan in a potentially explosive environment.

- **- Guard:** Do not use a box fan with missing guards, and always keep the guards free of paper, plastic, cloth, or other materials that can interfere with airflow. Even with a guard in place, keep fingers clear of the moving fan blades.

- **- Door Bar:** To prevent the box fan from falling, ensure the hooks and door bar are securely installed.

- **- Energizing** - The box fan has a simple ON/OFF switch. When energizing and de-energizing the fan, wear rubber gloves to prevent electrical shocks.

- **-Power Cord:** Inspect the power cord and plug for any cracks, breaks, or exposed wire. If any defects are suspected, DO NOT USE the fan. A faulty power cord can cause an explosion or electrocution.

The ram fan is a water powered, high capacity desmoking device. The water powered operation of the ram fan creates specific safety considerations.

- **- Vent Duct:** Select the most direct and safe route to run the ducting, and never lay ducting over ladder steps, passageways, or doorways.

- **- Ground Wire and Clamp:** As water pressure turns the ram fan’s turbine, it causes static electricity to build up. Static electricity creates an explosion hazard. Before operating the ram fan, clamp the ground wire to bare metal.

- **- Fire Hose:** A standard ½ inch fire hose feeds the ram ran. To achieve usable water pressures, inspect the fire hose for pliable connection gaskets before operation. To prevent flooding, always attach another fire hose to the discharge swivel connection and direct the discharge overboard.

- **- Swivel Connections:** Do not over tighten fire hoses to the ram fan; they should be hand tight only. If hoses are too tight, damage is likely to occur when tools are used to separate the fittings.

- **- Operating Pressure Label:** Maximum operating pressure is 250 PSI.

Smoke curtains and smoke blankets have many uses. Ensure both curtains and blankets form a tight seal over the hatch, scuttle, or opening, they cover. Continuous contact must be maintained to prevent gaps through which smoke will leak.

**DESMOKING FAN AND SMOKE BARRIER OPERATION**

After a fire has been extinguished, fire parties often must use portable desmoking equipment to desmoke and ventilate each affected compartment. Compartments filled with smoke and other chemical gas toxins are often deadlier than compartments actually on fire. After a fire, desmoking clears the ship’s passageways and compartments of deadly smoke. Since is not a frequent operation, it’s essential to identify why is important, and what equipment is required during desmoking operations. When a fire occurs below deck, shipboard ventilation systems transport harmful smoke from one compartment to the next. Portable desmoking equipment must be used to remove the smoke and bring in safe air. The two main types of desmoking fans used are the box fan and the ram fan.
The box fan can rapidly desmoke compartments in areas where exhaust ducting is not needed. It produces a tight spiral of smoke to prevent recirculation into the area being desmoked. The box fan is convenient and easy to rig, and is normally installed in openings leading to the weather.

- Install the door bar approximately two-thirds to three-quarters of the way up the doorframe.
- Hang the box fan from the door bar using two hanging hooks.
- Position the smoke curtain on the doorframe around the box fan then secure the curtain to the doorframe using ten springs.
- Unwind the power cord from the box fan. Inspect the power cord and plug for any cracks, breaks, or exposed wire. If the power cord and plug are serviceable, plug the power cord into a 110 volt outlet.
- To start desmoking, energize the box fan by setting the power switch to the ON position. Once the smoke has cleared, de-energize the box fan by turning the power switch to the OFF position. Unplug and rewind the box fan power cord.
- After the box fan power cord has been secured, remove and stow the ten smoke curtain spring clamps. Remove and stow the smoke curtain.
- To uninstall the door bar from the door frame, press the release lever on the door bar to release the tension then remove the device.

The ram fan can rapidly desmoke compartments in areas not adjacent to the weather. It is compact and lightweight, being only 18 inches in diameter and weighing less than 35 pounds, and can easily be carried below decks. Connecting multiple exhaust duct segments together allows an unlimited run of exhaust ducting.

- Position the smoke curtain on the doorframe, and then secure the curtain to the doorframe using ten spring clamps.
- Place the ram fan on the deck near the entrance to the space between the doorframe and a weather deck. Connect a section of 10 inch duct to the intake end of the ram fan and a section of 10 inch duct to the exhaust end. Route the intake duct through the top of the smoke curtain. Ensure that the exhaust duct is routed externally to the weather deck to exhaust the smoke from the space.
- Attach a standard 1 ½ inch fire hose connected to a fireplug (or P100 pump) to the ram fan inlet swivel connection and hand-tighten. Attach the standard 1 ½ inch fire hose to the ram fan discharge swivel connection and hand-tighten. Direct the discharge to the weather deck and overboard. Ground the ram fan by attaching the spring clamp of the static electrical ground wire to a bare metal surface.
- Close both Y-gate valves. Open the fireplug valve to charge the fireplug. Slowly open the Y-gate valve that is connected to the fire hose leading to the inlet side of the ram fan. Adjust the ram fan RPM by throttling the fireplug valve. Close inlet side Y-gate valve after the compartment has been cleared of smoke. Secure the fire plug.
- Loosen the fire hose connections on the ram fan with a spanner wrench. Disconnect and stow the fire hoses.
- Disconnect and stow the ram fan’s intake and exhaust ducts.
- Disconnect the static electrical ground wire and spring clamp and stow the ram fan.
- Remove and stow the smoke curtain. Remove the (10) smoke curtain spring clamps. Remove and stow the smoke curtain.

Smoke boundaries contain smoke and establish a controlled path for exhausting smoke to the weather decks. Smoke curtains and smoke blankets aid in establishing that path and help maintain smoke boundaries when doors and hatches are opened by firefighting personnel. Smoke curtains have two-panels made of a fiberglass material and are used to control the spread of horizontal smoke at doorways and passageways.

- To attach a smoke curtain to a watertight door, first inspect the curtain for holes, and damaged Velcro closures.
- Next, inspect the clamps checking to see the spring is not loose.
- If everything checks out, attach the curtain to the knife-edge using the clamps, and ensure the curtain is in continuous contact with the knife-edge of the door to prevent gaps and create an effective smoke boundary.

A smoke blanket is used to control smoke moving vertically and may also serve many general purposes during firefighting operations. It is 14 feet by 14 feet; they are often used as salvage covers, heat shields, and coverings for large openings and equipment. To reduce the spread of smoke, drape a smoke blanket over an open hatch area, and attach it to the knife-edge using clamps. Check to ensure the smoke blanket is in continuous contact with a knife-edge, bulkhead, or deck to prevent gaps and create an effective smoke boundary.
After reporting aboard your ship, your first priority is to become proficient in the operation of firefighting equipment. This lesson introduces you to portable firefighting equipment which includes the AFFF extinguisher, the CO2 portable extinguisher, and the PKP portable extinguisher. Your understanding and ability to correctly use these extinguishers may determine whether you or your shipmates survive a fire on board ship.

**Terminal Objective** - Use portable extinguishing equipment to fight shipboard fires.
- Enabling Objective - Identify the different types of portable extinguishing equipment.
- Enabling Objective - Demonstrate an understanding of how to operate the portable extinguishing equipment.

**PORTABLE EXTINGUISHING EQUIPMENT TYPES**
Understanding the correct extinguishing agent for a given situation is imperative to fighting a fire. There are two basic portable fire extinguishers designs: stored pressure and cartridge-operated. Stored pressure units store the propellant in the same chamber as the firefighting agent while cartridge-operated extinguishers contain the expellant gas in a separate cartridge that is punctured prior to discharge. The three different types of portable fire extinguishers common to U.S. Navy ships include:
- CO2 portable extinguisher.
- PKP portable extinguisher.
- AFFF portable extinguisher.

-**Carbon dioxide (CO2) portable fire extinguishers** are stored pressured devices that use CO2 as a fire suppressant. CO2 is a naturally occurring chemical that is made up of two oxygen atoms bonded to a single carbon atom. It is a gas at standard temperature and pressure and exists in Earth's atmosphere in this state. CO2 is considered a clean agent because it does not leave any residue after discharge which can damage electronics and documents. The carbon dioxide contained within CO2 portable fire extinguishers is a highly pressurized non-flammable gas. CO2 is heavier than oxygen; these extinguishers work by displacing or taking away oxygen from the surrounding area. CO2 is not suitable for use on fires containing their own oxygen source such as metals or cooking media. They are used primarily for small Class Charlie, and have limited effectiveness on Class Bravo fires. Because they do not leave a residue they are preferred in fighting small electrical fires. CO2 extinguisher’s rated capacity, by weight, is 15 pounds. This type of extinguisher discharges CO2 for approximately 40 seconds under continuous use and has an effective range of four to six feet as measured from the end of the horn.

-**Potassium Bicarbonate Dry Chemical (Purple-K-Powder (PKP))** portable fire extinguishers are cartridge-operated devices. When applied to a fire, the dry chemical extinguishes the flame by breaking the combustion chain, an opaque cloud is formed in the combustion areas. This cloud limits the amount of heat that can be radiated back to the heart of the fire. Less fuel vapor is produced because of reduced radiant heat. PKP leaves a residue that may be difficult to clean. It is primarily used to fight Class Bravo, but can be used to fight a Class C fire if no other extinguisher is available. It comes in 18 and 27 pound versions. It is cartridge-operated using carbon dioxide as the propellant force to discharge the dry chemical. On the 18 pound version the CO2 cartridge is mounted on the outside of the extinguisher cylinder while the 27 pound version has the CO2 gas pressure cartridge mounted inside the cylinder. The 18-pound has an effective range of 19 feet, with a minimum discharge time of 10 seconds, while the 27-pound 21 feet and a minimum discharge time of 11 seconds.

-**Aqueous Film-Forming Foam (AFFF)** portable fire extinguisher is a stored pressured device that uses a detergent based non-toxic, liquid concentrate as a fire suppressant. The concentrate, commonly found in five-gallon containers, is amber in color and when discharged produces foam. The extinguisher is comprised of a stainless steel cylinder that stores two and a half gallons of a pre-mixed solution of detergent concentrate and fresh water. It is primarily used to extinguish small Class Bravo fires or to protect a flammable liquid fuel spill from igniting by floating on top of the liquid and forming a vapor seal. It can also be used on a small Class Alpha fires and for use in standing fire watch during hot work. It is not recommended for use on Class Charlie. However, an AFFF extinguisher can be used on a Class Charlie fire if the nozzle is kept at least four feet from the energized electrical source. Air inside the cylinder is pressurized to 100 psi at 70° Fahrenheit. When fully charged the extinguisher weighs approximately 28 pounds. The film forming capability is very effective in blocking oxygen from feeding the fire. As the liquid leaves the cylinder it expands to approximately sixteen gallons of foam with a 55 to 65 second continuous discharge time. The initial range is 15 feet which decreases as the pressure in the container subsides. One AFFF portable extinguisher effectively extinguishes 20 square feet, 4-1/2 feet by 4-1/2 feet, flammable liquid fire or vapor secures a fuel spill up to 40 square feet, approximately 6 feet by 6 feet, in size. Fuel spills should be confined, within direct stream reach of the extinguisher and entirely visible. A fuel spill which is spread over an area larger than 40 square feet is not accessible, or entirely visible, warrants use of an AFFF fire hose or AFFF bilge sprinkling system.

**OPERATING PORTABLE EXTINGUISHING EQUIPMENT**

-**CO2 portable fire extinguishers** are used primarily for Class C fire, they are normally located in close proximity to types of equipment that have a high potential for electrical fires. Your first action when fighting an electrical fire is to ensure that the power is turned OFF. They are normally located within 30 feet of equipment with a high potential for electrical fire. Compartment that are normally outfitted with portable CO2 extinguishers are shops, repair stations, flight deck catwalks, compartments containing electrical motors, switchboards and panels, electronic and navigational areas, weapons cleaning and fire control areas, galleys, and machinery spaces. There are safety concerns when using the CO2 portable fire extinguisher. As the CO2 flows out of the extinguisher, it rapidly expands causing a pressure differential. The difference in pressure between the inside of the extinguisher and the surrounding atmosphere results in a severe cooling effect. To prevent the possibility of frostbite to exposed skin only hold the horn at the handle. Additionally, the high velocity at which the CO2 exits the nozzle will cause the accumulation of static charge. To avoid shock and prevent the possibility of the static electricity igniting flammable vapor-air mixture you should always ground the CO2 cylinder to the deck before operation. Using the CO2 extinguisher is fairly simple.

- Check the tamper seal. If it is intact, break it and remove the safety pin.
- Remove the extinguisher from the security bracket.
- Ground the bottle, test it, and squeeze the grip release valve. Always direct the horn at the base of the fire.
- Extinguish the fire using sweeping motions. All the remaining CO2 is held indefinitely without danger of leakage.
PKP portable fire extinguisher is primarily used to fight Class B fires but can be used to fight a Class C fire if no other extinguisher is available. They should be located in close proximity to spaces where combustible fuels, hydrocarbons, or solvents are used and compartments in which flammable or combustible liquids may be stored. They should also be stored in Damage Control Repair Lockers or temporarily available at locations where portable fuel tanks are being handled. The CO2 cartridge on a PKP extinguisher supplies the propellant force to discharge the dry chemical. CO2 is released through the gas tube when the puncture lever is depressed. Keep in mind that the disk, which is punctured by this operation, is also a safety seal disk, which will rupture at 4,050 to 4,500 psi internal pressure. Discharge of CO2 due to disk rupture or puncture of unattached cartridges is directional and, unless precautionary measures are taken, causes the cartridge to become a missile. To operate the PKP extinguisher:

- Check the tamper seal. If it is in one piece, break the seal and remove the safety pin.
- Ensure that the fill cap is tightened.
- Remove the extinguisher from its securing bracket and maintain control over the bottle, hose, and the nozzle.
- Push the puncture lever; the puncture lever is marked "PUSH."
- Squeeze the valve at the end of the hose to test the cylinder for the extinguishing agent.
- Carefully approach the fire, direct the nozzle at the base of the fire, and apply the PKP in a rapid, side to side sweeping motion.
- To secure the PKP extinguisher, turn the bottle upside down and squeeze the lever to release the pressure from the cylinder. Replace the safety pin. All used extinguishers are turned in to the Damage Control Petty Officer.

AFFF extinguishers are used to fight Class B fires and to secure small fuel spills. Remember that this type of extinguisher is not recommended for Class C fires but as a last resort may be used as long as the nozzle is kept at least four feet away from the energized source. Extinguishers are typically located at Damage Control Repair Stations. They are also located near large pulper installations and near deep fat fryers on surface ships. To properly operate the AFFF fire extinguisher:

- Check the extinguisher pressure.
- Check the tamper seal. If the tamper seal is broken, there is a chance the extinguisher won't work. If the seal is intact, break it and remove the safety pin from the extinguisher.
- With one hand, hold the extinguisher by the carrying handle and, with your free hand, hold the discharge hose.
- Squeeze the operating lever to test the extinguisher.
- Approach the fire and always point the hose at the base of the fire. Use a sweeping motion as you squeeze the operating lever to extinguish the fire.
- When the fire is out, replace the safety pin and turn in the used extinguisher to the Damage Control Petty Officer.
On any Navy ship, there is a lot of cooking going on throughout the day. Because of this known danger, there are special fire extinguisher systems installed on the cooking equipment to detect and extinguish a fire. The Deep Fat Fryer system is an important extinguishing agent and safety system for shipboard galleys. For this reason, galley personnel, as well as Damage Control team members, should be familiar with the capabilities and operation of the system. Although the Deep Fat Fryer system is automated, you need to know what to do if the automated part of the system fails.

Terminal Objective - Identify the operation of the Deep Fat Fryer Fire Extinguishing System.
- Enabling Objective - Distinguish the function of the components for a Deep Fat Fryer Fire Extinguishing System.
- Enabling Objective - Identify the operation of a Deep Fat Fryer Fire Extinguishing System.

DEEP FAT FRYER FIRE EXTINGUISHING SYSTEM COMPONENT FUNCTIONS
You need to know about the Deep Fat Fryer Fire Extinguishing System. This system protects the shipboard galley deep fat and doughnut fryers, and their exhaust systems, against fire. The fire-extinguishing chemical, Aqueous Potassium Carbonate (APC), discharges through nozzles located over the fryers. When the APC makes contact with burning oils, a soapy foam forms. This foam prevents the air from mixing with the oil, preventing combustion, and ultimately extinguishing the fire. Because APC is the firefighting chemical, the Deep Fat Fryer Fire Extinguishing System is sometimes referred to as the APC System.

There are five types of APC systems that you might see. Each system is very similar, with the difference being in the size and number of storage cylinders used. The system is made out of eight major components of this system: Grease Interceptor Hood, Cylinder Assembly, Nozzles, Detector Assemblies, Pressure Release Control Box, Remote Manual Control Box, Cable Release System, and Discharge System.

- The grease interceptor hood is located directly above the deep-fat fryer unit, or units. Since the heat rises from the fryer, the grease interceptor hood collects grease vapors and releases them to the atmosphere.
- The cylinder assembly mounts on the bulkhead, close to the rest of the system. It controls and stores the APC solution and the propellant. The Lever Control Head mounts directly to the cylinder valve and controls the automatic or manual discharge of the cylinder assembly. It is secured with a pin and anti-pilferage seal. The Cylinder Valve allows the discharge of the APC solution. It is the interface between the storage cylinder and the discharge piping. A pressure gage monitors the cylinder pressure.
- The nozzles are the components that actually disperse the APC to extinguish a fire. There are three types of nozzles: the appliance nozzle, duct nozzle, and plenum nozzle.
- The detector assemblies control the automatic operation of the system. Fusible links, designed to melt at 360°F, join the sections of the release cable. When a link melts, it releases the tension of the cable and allows the pressure release control box to activate the system. Appliance detectors are normally located over each fryer. Duct detectors are located in the exhaust duct, about 12 feet from the hood opening, but are optional if the APC system is installed with a standard grease interceptor hood, called a Gaylord hood.
- The pressure release control box provides the automatic control for the system. It is located in the grease extractor hood and consists of Spring, Release Pin, Turnbuckle, Cable, Detectors and Remote Manual Control Box, Copper Tubing to Lever Control Head of APC Cylinder, Pressure Gauge, Nitrogen Cartridge to 300 PSI +/- 50 PSI.
- The remote manual control box enables you to manually operate the system. The box, mounted on the bulkhead on either side of the fryer, consists of the release pin with an anti-pilferage seal, a clamp block, and a release cable.
- The cable release system uses 1/16 inch cables. The cables feed through conduit piping and corner pulleys to connect the remote manual control box, detector assemblies, and the pressure release control box.
- The discharge system consists of the discharge tubing, a vent plug, and strainers. The strainers are either in line, or nozzle with an integral strainer.

DEEP FAT FRYER FIRE EXTINGUISHING SYSTEM OPERATION
The operation of the Deep Fat Fryer Fire Extinguishing System is normally automatic. The system has a manual backup at the storage cylinder lever control head, the pressure release control box, and the remote manual control box. Automatic operation is when all the events that take place are done automatically. When fire erupts in one of the fryer units, excessive heat caused by the fire melts one of the fusible links in the hood right over the fryer. When the fusible link melts, it releases the cable tension. The extension spring in the pressure control box pulls the operating lever mechanism down. The pressure release cartridge is activated. Nitrogen gas from the pressure release cartridge activates the lever control head of the storage cylinder. The storage cylinder discharges the APC solution. The solution is sprayed on the fire to extinguish it.

If the automatic operation fails or you notice the fire before the APC system activates, respond quickly by manually actuating the system from the cylinder assembly, the pressure release control box, or the remote manual control box.
- To manually operate the APC system at the remote manual control box, remove the remote manual control box release pin completely. This disconnects the anchored end of the release cable, releases the tension, and allows the extension spring to activate the system as described under the automatic operation.
- To manually operate the APC system at the pressure release control box, open the pressure release control box, remove the release pin completely. This disconnects the release cable and allows the extension spring to activate the system as described under the automatic operation.
- To manually operate the APC system at the cylinder assembly, remove the lever-control head release pin completely, manually operate the lever. This discharges the cylinder directly.

When you operate a deep fat fryer in the galley, you must monitor the grease temperature, the cooking oil cleanliness, and the pressure gauge on the APC cylinder. You also need to keep the fryer areas clean and well ventilated. Handle the APC solution with care, as it may cause skin irritation. Handle the pressurized nitrogen cartridge and the storage cylinder carefully, ensure your firefighting equipment remains in top working condition.
You have learned about several fixed firefighting systems aboard your ship, now you will learn about Carbon Dioxide (CO2) Flooding System and the CO2 Hose Reel System. Because of the potential danger, some systems are installed to protect the entire compartment, while others are installed to fight small isolated fires. To ensure crew safety and contain possible damage during class Bravo and Charlie fires, you must be familiar with the Carbon Dioxide Flooding and Hose Reel Systems. You will also learn how to properly activate the Carbon Dioxide Flooding and Hose Reel Systems at the appropriate times.

**Terminal Objective** - Identify the two types of installed Carbon Dioxide (CO2) Systems.

- **Enabling Objective** - Identify the function, components, safety precautions, and operation of installed CO2 Flooding systems.
- **Enabling Objective** - Identify the function, components, safety precautions, and operation of installed CO2 Hose Reel Systems.

**FUNCTION, COMPONENTS, SAFETY PRECAUTIONS, AND OPERATION OF INSTALLED CO2 FLOODING SYSTEMS**

The purpose of the fixed CO2 Flooding System is to provide a dependable means of protecting compartments that present a more than ordinary potential for class Bravo and Charlie fires. This system is commonly found in paint issue rooms, flammable liquid storerooms, diesel generator rooms, some gas turbine spaces, and smaller compartments where personnel can easily be evacuated. In a small space like the paint issue room, where there are lots of flammable items, the CO2 can fill the space quickly, eliminating the oxygen needed to breathe. It is important to recognize that when a CO2 system is discharged in the compartment, the area needs to be evacuated.

The System consists of one or more 50 lb. CO2 cylinders attached to discharge piping, remote manual actuators, ventilation shutdown controls, and audible and visual alarm indicators. There are two models, one manufactured by Ansul and a second by Kidde. These systems have similar components although they are not interchangeable. The pressure operated switches are mounted outside the protected area near the access to the space and operated by CO2 pressure or manually. The switches are utilized in each of the protected spaces to shut down the ventilation, light the red lamp in the circuit, and sound the alarm bell. The watertight glass pull boxes for the Ansul and Kidde are quite different. They both provide a method of actuating the system from a location removed from the protected area, permitting the operator to remain outside of the danger zone. There are two locations where you can activate the CO2 Flooding System. The local pull box will be near the access of the affected space, while the remote pull box will be away from the intermediate area. Each provides a hammer to break the glass so that you can pull the handle attached to a cable to activate the system from outside the protected space. Directions for activation are also printed on the pull box.

The multiple pull mechanism connects the local and remote pull boxes to a single cable that is shielded. The CO2 is stored in liquid form in two shatter proof steel cylinders, each having a 50 lb. capacity, which is pressurized to 850 PSI at 70°F. The cylinders are also equipped with safety discs that rupture between 2650-3000 pounds per square inch or PSI to prevent over pressurization. They are usually mounted against a bulkhead either inside or outside the protected space. The cable operated control heads are the activation components for the control cylinders. They are attached to the threaded connection at the side of the cylinder flood valve. Pulling the cable will advance a wheel assembly which depresses a lever. The action of the lever advances a plunger which unseats the flood valve disk permitting gas to be routed to the discharge head. The ½ inch diameter flexible loops connect the cylinder discharge heads to the discharge manifold, which distributes the CO2 through multi-jet nozzles throughout the affected compartment. The discharge time delay is installed in the piping on all CO2 total flooding systems and provides adequate time for personnel to evacuate the space. The amount of time required for this operation depends upon the length of the tube.

**FLOODING SYSTEM SAFETY PRECAUTIONS**

For the safety of you and your shipmates, the following precautions must be observed by personnel in the space where a CO2 Flooding System has been discharged. Remember, CO2 is an odorless and colorless gas and is extremely dangerous since it is not recognizable by human senses. Evacuate the space. DO NOT re-enter for at least 15 minutes. You must re-enter with a Self-Contained Breathing Apparatus (SCBA). If time permits, ship's regulations may require authorization from the Engineering Officer of the Watch (EOOW), Officer of the Deck (OOD), or Command Duty Officer (CDO), before flooding a space with CO2.

**FLOODING SYSTEM OPERATION**

If remote activation of the system is needed, break the watertight glass pull box and pull the handle until the cable can be seen. The first cylinder bank should discharge and acts as a pilot for the remaining cylinders. The automatic control operation is commonly found in diesel enclosures and gas turbine modules where they are activated by flame or heat sensors.

**FUNCTION, COMPONENTS, SAFETY PRECAUTIONS, AND OPERATION OF INSTALLED CO2 HOSE REEL SYSTEMS**

The purpose of the CO2 Hose Reel System is to provide CO2 only in nuclear ship main spaces and electric propulsion motor spaces of electric-driven ships. In contrast to the Fixed Flooding System, the CO2 Hose Reel Systems are intended to support manual firefighting of small localized fires which can be effectively extinguished with a local application system.

Unlike the CO2 Flooding System, the CO2 Hose Reel System is primarily operated manually. The CO2 is stored in liquid form in two shatter proof steel cylinders, each having a 50 lb. capacity, which is pressurized to 850 PSI at 70°F. The two cylinders are also equipped with safety discs that rupture between 2650-3000 PSI to prevent over pressurization. They are usually mounted against a bulkhead inside the compartment it protects. The lever operated control head is attached to the threaded connection at the cylinder flood valve. The flood valve is attached to the discharge head. The dual CO2 cylinders are joined together by a discharge line/piping that connects to the CO2 hose/hose reel assembly. Each cylinder is actuated independently. Equipped with a high pressure hose stowed on a permanently mounted hose reel, the reel contains a connection axle, packing gland, and swivel nut, to ensure the CO2 does not leak by. Equipped with an on/off control; that is a stirrup valve (found on Kidde models), or the squeeze-type grip (found on the Ansul models). The horn shaped nozzle, made of non-conductive material, is designed to direct CO2 towards the base of the fire.

When discharging CO2, the horn will have frost on it and can cause frostbite to exposed skin, therefore, don’t touch the horn and nozzle assembly. If you need to discharge CO2 from the CO2 Hose Reel System, charge the system first, and follow the directions provided for your system. Run the hose and discharge horn from the hose reel to the scene of the fire. Then, pull the stirrup-type handle (Kidde) or squeeze the squeeze-grip lever (Ansul) on the discharge horn control valve to open the valve and discharge CO2. Next, direct the CO2 at the base of the flame. As the flame recedes, continue with a slow methodical sweeping motion.
Of all the four types of fires possible aboard a ship, Class Bravo fires are among the most dangerous and most destructive. Consider the fire triangle, all the ingredients for a major fire are in the main engineering spaces. You have heat, oxygen, and lots of fuel. Class Bravo fire situations can get out of hand very quickly. In machinery spaces of surface ships when a fire cannot be extinguished quickly, and evacuation of the space is necessary, Halon 1301 is the primary firefighting agent for putting out that Class Bravo fire. Halon, short for halogenated hydrocarbons, became the extinguishing agent of choice for Class Bravo fires in the Navy in the late 1970s. There are many advantages to using Halon to extinguish fires. It is great for use when an electrically non-conductive firefighting agent is desirable, or where clean-up of other agents may pose a problem. Weight versus extinguishing potential is also a factor, but the bottom line is, Halon is effective where other agents are ineffective.

**Terminal Objective** – Identify the components, operational procedures, personnel, and equipment safety precautions for the Halon-1301 Total Flooding System.

- **Enabling Objective** – Identify various installed components of the Halon-1301 Total Flooding System.
- **Enabling Objective** – Recognize personnel and equipment safety precautions during the operation and maintenance of the Halon-1301 Total Flooding System.
- **Enabling Objective** – Identify Halon-1301 Total Flooding System operational procedures.

**HALON 1301 FLOODING SYSTEM COMPONENTS**

Halon extinguishes fires by chemically interrupting the combustion process leaving no residue. This fast acting, colorless, odorless in its natural state, electrically nonconductive, heavier-than-air gas can be used against most Class Alpha, Bravo, and Class Charlie fires. However, it is ineffective for Class Delta fires. Halon is stored as a liquid by using super-pressurized nitrogen, which also generates a rapid discharge. Since Halon is five times heavier than air, there is rapid flooding of the space with no long term smothering effect. On ships today, besides main machinery rooms, Halon systems are installed in virtually every space containing or using fuel, and spaces where flammable liquids are stored or issued.

Ansul and Kidde are the two manufacturers that produce shipboard Halon systems. There are individual component differences and several different configurations of the system in use by the fleet, so it is important that you have a thorough understanding of the basic system and how each part works. The activation side of the Halon system uses CO2 to initiate the discharge process. The activation equipment consists of several components that are designed to provide maximum safety by allowing personnel time to evacuate a space and follow a known sequence up to the time of discharge. There are several components to the system:

- **The CO2 actuator cylinder** is the principal means of triggering the system into action. It consists of a cylinder containing a 5 lb. charge of CO2 fitted with a manual valve. Once the manual valve is operated, pressurized CO2 from the cylinder is used to activate the system, beginning with warning alarms, lights, and ventilation shutdown.

- **Two-position manual control lever**, to release the CO2, break the tamper seal then pull the locking pin. You can then work the manual control lever. When working the control lever, remember there are differences between the two manufacturers of Halon systems. On Ansul cylinders you must press the lever down to the locked open position to activate the system. On a Kidde cylinder, you must pull the lever up to the open position to activate the system. The action of the lever depresses a plunger; releasing the CO2, activating the system. There are at least two actuator cylinders in each system; the first one is located within the space where the Halon is released, the second outside the space allowing for remote actuation. Some cylinder valves are manufactured with a solenoid valve to allow electrical remote operation of the Halon system.

- **Flexible actuation loops** are designed into the ¼ inch discharge lines to absorb the vibration caused by the rapid expansion of CO2. Flexible actuation loops are made from ¼ inch high-pressure tubing and used for routing the CO2 to the fixed actuation manifold piping. Halon system components that include the CO2 actuator cylinder, time delay assembly, pressure operated switches, and Halon cylinders, are all connected to the fixed manifold piping by ¼ inch flexible actuation loop tubing.

- **Check valve**, a ¼ inch check valve is welded to the actuation manifold piping. It is used throughout the system in high pressure CO2 lines to isolate actuation stations, time delays and pressure switches. Allowing the gas to flow in one direction only and prevents the backup of gas pressure in the opposite direction.

- **Actuation manifold piping**, a fixed, rigid pipeline, each component, from the CO2 actuation cylinders to the Halon cylinders, is connected to it by ¼ inch flexible actuation loop tubing.

- **Pressure operated switches**; the system allows time for evacuation of the space. It also gives the ventilation system the time necessary to shut down, so that the Halon will not be exhausted out of the space. The system has pressure operated switches that provide automatic control of electrical equipment. These pressure actuated switches initiate actuation alarms, ventilation system shut downs, vent closure operation, and discharge alarms. They are activated by CO2 pressure or manually by pulling on a plunger, and require 120 volts, 3 phase, and 60 hertz power. The pre-discharge alarm switch energizes an audible alarm and red rotating warning lights inside the protected space. Outside the space the switch activates another audible alarm and an indicator light on a panel having an amber light, meaning the system has been activated. The ventilation switch de-energizes all supply and exhaust ventilation to the protected space. Besides all ventilation being secured, any entries or exits to the space must be closed in order to contain the Halon gas, allowing it to extinguish the fire. The release switch activates remote alarms and illuminates a red warning light on the indicator panel in the space, as well as at remote actuating stations, signifying the Halon is discharging.

- **Time delay assembly** is installed in the CO2 actuation system between the CO2 cylinders and the Halon cylinders. It allows personnel time to secure accesses to the compartment, evacuate the space, and for the ventilation system to shut down, before Halon is released. All manned spaces, like machinery rooms, get a 60 second timed delay before discharged, and unmanned spaces, like a paint locker or flammable liquid storeroom, get 30 seconds.

- **Bypass valve**; just in case the time delay assembly doesn’t work, the time delay bypass/override can be manually operated by a quarter turn ball valve that will provide immediate discharge capability. The time delay bypass valve should not be operated until after the full delay (30 or 60 seconds) has passed.

- **Vent fitting** is installed on the outlet side of the time delay assembly. It relieves excessive CO2 pressure after Halon discharge.

The discharge components are the parts of the system that get the Halon to the fire so it can be extinguished:

- **Cylinders** are painted red with white and gray bands to make them easily identifiable. They come in several sizes: 10, 15, 60, 95, and 125 lb. cylinders, with 95 and 125 lb. cylinders the most commonly found. When fully charged, the cylinders contain Halon in its liquid form, which is being super pressurized by nitrogen at 600 to 675 Pounds per Square Inch (PSI) at 70° F. Each cylinder has its own pressure gauge, which reads from 0 to 1500 PSI, and indicates the total pressure in the cylinder at any time. Within the cylinder valve, there is a rupture disk, which ruptures between 2650 and 3000 PSI to release the Halon and prevent over pressurization of the cylinder.
- **Actuator valve**, each Halon 1301 cylinder has a pressure operated actuator valve screwed into the top of the cylinder. The actuator valve is where the inlet for the ¼ inch flexible actuation loop tubing is attached. When CO2 reaches the actuator valve through the flex tubing, the mechanism in the actuator valve allows the Halon in the cylinder to be released.

- **Flexible discharge hose**, Halon will flow through this hose once released from the cylinders. The system uses 1½ inch flexible discharge hoses to connect the cylinder valve on each cylinder, using a swivel female fitting. The hose is then routed to hard piping, called discharge manifold piping, where it is connected by a male fitting.

- **Discharge manifold piping** is similar to actuation manifold piping. It is a fixed, rigid pipeline that runs between the cylinders, which are hooked up to it by 1½ inch flexible Halon discharge hose; the piping then runs all the way to the discharge nozzles in the space.

- **Discharge nozzles** control the rate of Halon coming through the discharge manifold pipelines by constriction. This effectively regulates the dispersal of Halon throughout the compartment. The nozzle orifice size is based on the volume of space being protected, and by the pressure of the Halon when it reaches the nozzle. As liquid Halon discharges from the nozzle orifices, it immediately expands to a gas vapor and is directed into the protected space.

**HALON 1301 FLOODING SYSTEM PERSONNEL AND EQUIPMENT SAFETY**

The real danger to personnel is the products of combustion due to the fire. Combustion products such as CO2, combined with the oxygen depletion, heat and smoke pose a much greater hazard to personnel than Halon. Since Halon gas is five times heavier than air, and has such a short discharge time, 10 seconds or less, it keeps the thermal decomposition products well below lethal concentrations.

Personnel should not remain in a space where Halon has been released to extinguish a fire unless a breathing apparatus is worn. If the space reaches 900° F or above, Halon will emit a toxic vapor (hydrogen fluoride and hydrogen bromide). After discharging, a waiting period of 15 minutes is required before reentry of any personnel. This allows the space to cool down sufficiently to prevent re-flash, caused by the oxygen let in upon reentry. If Halon is released into a space, personnel can be exposed to a 5 to 7 percent concentration of Halon for a period up to 10 minutes without danger to health. The normal discharge concentration of Halon for manned spaces is between 5 to 7 percent. However, even though Halon is considered a nontoxic and non-suffocating extinguishing agent, spaces should be evacuated when the system discharges. The space must be ventilated at high speed for at least 15 minutes and then gas free tested before any reentry by personnel without a breathing apparatus.

**HALON 1301 FLOODING SYSTEM OPERATIONAL PROCEDURES**

The correct procedure for initiating the Halon system is designed to work as follow: break the tamper seal and pull the safety pin out on the CO2 bottle. With the pin out, the lever on the actuator can be fully operated. At 100 PSI, the released CO2 actuates two pressure switches. The pre-discharge alarm switch turns on the red rotating warning lights and audible alarms within the space. It also sends a signal to energize the audible alarm and the amber system activated light on indicator panels located outside the space at remote actuating stations and space accesses. The ventilation switch de-energizes all supply and exhausts ventilation to the space and operates installed vent closures. The time delay gives manned spaces 60 seconds to evacuate and ventilation to be fully secured. Unmanned spaces only get 30 seconds. CO2 pressure then flows to the Halon cylinder valves causing Halon to discharge through the discharge manifold to its associated nozzles. Meanwhile, a third pressure switch, the Halon release switch, downstream of the time delay device activates the red light on remote indicator panels, indicating Halon discharge. Operation stops when all the Halon is discharged and CO2 pressure has bled down through the vent fitting.

The Halon 1301 Flooding System is a superior fire extinguishing system. There are several safeguards built into the system to bypass so that someone who knows the system can light off the Halon quickly if the primary actuation fails. If the primary CO2 actuator cylinder fails to operate, immediately operate the remote actuator. If a pressure switch fails to function properly, pull out the reset/actuation knob to manually operate the switch. For a time delay failure in a manned space, wait 70 seconds and operate the bypass/override valve for a 60 second time delay. In an unmanned space wait 35 seconds, and operate the bypass/override valve for a 30 second time delay. Reset all pressure switches and replace used Halon cylinders, and replace used 5 lb. CO2 actuator cylinders whether the system was set off intentionally for a fire, maintenance, testing, or accidentally.
There is one class of fire that will be more challenging or even impossible and potentially lethal when trying to suppress with firefighting agents. These fires are special hazard fires, which are commonly referred to as class Delta fires. Class Delta fires have caused great loss of life onboard ship. As part of the damage control organization, you may be called upon to act at a moment's notice, so it is of utmost importance that you become familiar with these materials and how to extinguish them.

**Terminal Objective** – Identify the Special Hazard Fires in accordance with Naval Ships’ Technical Manual Chapter Five, Fifty-five, volume one, series, Surface Ship Firefighting.

- **Enabling Objective** – Identify the extinguishing agents used and hazards associated with Special Hazard Fires.

### EXTINGUISHING AGENTS AND HAZARDS ASSOCIATED WITH SPECIAL HAZARD FIRES

Class Delta fires are special due to their special characteristics and the methods used to extinguish them. Materials causing these fires do not react in an ordinary manner when normal extinguishing agents are applied. These types of material fires require special methods and extinguishing agents. Everyone knows any fire can be deadly. What makes these fires different from Alpha, Bravo, and Charlie fires is that the Delta fire has greater volatility, is more toxic and explosive, and poses a serious threat to life and ship survivability.

There are several types of materials used throughout the Navy that if combined with an ignition source, could potentially ignite and become a class Delta fire. In this section you will learn about these materials and where they are commonly found.  

- **Magnesium**, the first and probably the most common material found onboard are magnesium. Magnesium can be found in aircraft engine parts, wheel rims, and other parts that are commonly alloyed with aluminum. If you are going to be a Machinery Repairman (MR), you may work with magnesium in the machine shop as a solid, in shavings and/or chips.

- **Otto fuel** is the propellant used in many torpedoes including the MK46, MK55, MK56, and MK60 and may be located around torpedo magazines and launchers. It is a bright red, free flowing, oily liquid that is heavier than water (insoluble). Containing its own oxidizer, it has a flash point of 266º F (129º C).

- **Magnesium flares**; mark forty-five magnesium flares are mainly found onboard aircraft carriers and used for nighttime illumination. It is commonly used in ordnance equipment and certain types of shells (star shells).

- **Phosphorus** can be found in various munitions. Supplied in stick or flat pieces with a waxy appearance, phosphorus is normally immersed in water when stored. Sodium comes in various forms and can be found in flares, fuses, and bombs. It is a soft metallic substance, silvery white in color that oxidizes rapidly in air. Sodium is normally stored in a petroleum distillate (kerosene, naphtha, etc.).

### EXTINGUISHING AGENTS AND HAZARDS

You need to recognize the proper firefighting agents to use and the potential hazards associated with class delta material fires.

- **Magnesium**: The recommended extinguishing agents for magnesium fires include dry sand, graphite, and calcium carbonate (although large enough quantities are not usually available onboard ship). Use water fog versus solid stream to cool surrounding areas and materials. Solid stream will cause an increase in the burning rate because the intense heat of the fire will break down the water into its molecular components of hydrogen and oxygen. This in turn creates a potential for multiple explosions which will spread and scatter the burning materials. More than likely, this material will have to be jettisoned over the side because it cannot be salvaged. Do not use CO2 or PKP on a magnesium fire. These extinguishing agents cannot sufficiently cool or smother the magnesium and it will continue to burn. Use care if you routinely handle magnesium. This material is highly explosive in flame or powder form (possibly found in machine shops), and can be ignited with a match. In solid form, such as engine parts, magnesium will ignite when subjected to intense heat. The flames are so intense that it can cause flash burns to unprotected eyes (the same effect as an arc welder). When magnesium burns, it produces a dense white toxic smoke. Magnesium particles that have entered the skin can cause gangrene if not removed.

- **Otto fuel**: The key to controlling a fire containing Otto fuel is to quickly cool the propellant below its flashpoint. The recommended extinguishing agent would be water fog or AFFF. Don’t use a solid stream of water, because it may cause small explosions. If CO2 is used, use it only as a secondary agent. The use of PKP is ineffective for fires involving Otto fuel. The major problem with a fire involving Otto fuel is that the fuel contains an oxidizer which creates a constant source of oxygen for the fire. If you are assigned to duties that involve the handling of Otto fuel, ensure that you wear the proper personal protective equipment (PPE). Inhaling Otto fuel vapors can cause nasal blockage, headaches, nausea, and blood pressure changes. If Otto fuel is ingested, induce vomiting and seek immediate medical attention.

- **Magnesium flares**: The recommended extinguishing agent for a fire involving a magnesium flare is water fog. The magnesium (in granular form) is cooled and washed away. The oxygen is reduced, causing the magnesium to explode and blow itself out. The flare will normally extinguish in less than 30 seconds. An alternate method is to have a sailor fully outfitted in a proximity suit, cut the shroud line, pick up the flare by the cold end and jettison it over the side or remove it to a clear area if ashore. Just like a regular magnesium fire, PKP and CO2 have no effect on this type of fire. The storage of large numbers of MK45 magnesium flares could cause widespread damage and loss of life.

- **Phosphorus**: When combating a phosphorus fire, you can use the recommended extinguishing agent, water fog or even try to immerse the phosphorus in water. You could also try AFFF, sand, or dirt, if available. Do not use CO2. Although CO2 controls the flames, the phosphorus can re-ignite easily due to its low ignition temperature. Because the ignition temperature is only 86º F, phosphorus can ignite on contact with air. Since your normal body temperature is 98.6º F, your body heat could cause phosphorus to ignite. Therefore, it’s easy to see that even the heat from the sun can cause ignition. Phosphorus burns with a yellow flame, produces a white smoke that is extremely toxic, and will damage your lungs, nose, and throat. If your skin is exposed to phosphorus, try to remove or brush off as many particles as possible, or your skin will continue to burn. You might even attempt to immerse the affected area in water or cover with wet materials (for example, clothing). No matter how you try to treat it, seek medical attention immediately.

- **Sodium**: The recommended extinguishing agents for sodium fires are all “Dry” products. Dry soda, dry sodium chloride, dry graphite, or dry sand is the most effective agents. Do not use water, AFFF, or CO2 on this type of fire. When sodium makes contact with water, the hydrogen is released and creates heat, which in turn will cause additional fires and explosions. Since AFFF is 94% water, it will also have the same effect. If you attempt to use CO2, it will react with the smoke of the burning sodium, which, if inhaled, forms a caustic chemical called sodium hydride that will damage your lungs and respiratory system. Protect yourself by wearing a SCBA. In reality, CO2 has no effect on this type of fire. Therefore, the caustic chemical, sodium hydride should not be an issue as long as CO2 is not used. Sodium burns may be neutralized with vinegar, but personnel should still seek immediate medical attention.
Extinguishing fires aboard your ship is everyone’s responsibility. Due to smoke, toxic gases, or insufficient oxygen levels, you will need an external source of air in order to combat a fire. The Scott Air-Pak 4.5 provides you with the life-sustaining atmosphere needed to perform as a firefighter. A Self-Containing Breathing Apparatus (SCBA) enables you to breathe independently of the outside atmosphere by means of a self-contained air source. Although you have worked hard during your time in the Navy to fine-tune the muscles in your body, you can’t work for very long to put out a fire if you can’t breathe. We are going to discuss the function of the components, and then the donning and doffing procedures for the Scott Air-Pak 4.5.

Terminal Objective - Demonstrate an understanding of the operation of the Scott Air Pak 4.5.
- Enabling Objective - Identify the function of the components of the Scott Air Pak 4.5.
- Enabling Objective - Identify the donning and doffing procedures for the Scott Air Pak 4.5.

FUNCTION OF THE COMPONENTS OF THE SCOTT AIR PACK 4.5
- **Cylinder:** is yellow in color, contains high-pressure (4500 PSI) compressed air. It is held in a fully wrapped composite, aluminum liner wrapped with fiberglass and coated with a hard, protective epoxy. The air cylinder holds breathing quality air, not oxygen. Air cylinders are rated at 30, 45, or 60-minute durations, based on a breathing rate of 45 liters per minute. The cylinders are either stored on the SCBA backpack or in bulk storage as spares. Each one has a 15-year service life, and must be hydrostatically tested every three years. They are labeled with the manufacturer name, date of manufacture, and hydrostatic test information.

- **Air Cylinder Valve Assembly:** located at the neck of the air cylinder. Open means to fully open the valve, then back off (shut) the valve one quarter turn. When you open the valve, the air flows to the first-stage regulator (pressure reducer) via the high-pressure hose. It uses a standard connection for breathing air in a pressure range between 3001-5000 PSI. The SCBA will burst the disc inside the valve if the pressure inside the air cylinder reaches about 7200 PSI.

- **Pressure Indicator:** The pressure indicator is located on the valve assembly at the neck of the air cylinder. It displays a continuous readout of air cylinder pressure. It does not require calibration or a “No Cal Required” sticker.

- **First Stage Regulator:** Consists of two adjustable shoulder straps and an adjustable waist strap with pads. It holds the backpack securely on your back. The waist buckle has a quick release and two adjusters, one on each side. The shoulder straps have pull up, push-to-release adjusters for you to adjust for fit quickly. The harness is made of flame and heat resistant Kevlar material.

- **High Pressure Hose:** The high-pressure hose is located between the first-stage regulator (pressure reducer) and the cylinder valve. It delivers air at the cylinder pressure to the first-stage regulator (pressure reducer) and attaches to the air cylinder valve by the coupling nut.

- **First Stage Regulator:** Mounted on the wire frame of the backpack, left of the air cylinder as you are facing the air cylinder. This regulator reduces the air pressure from the cylinder to about 100 PSI throughout the entire operating pressure range of the cylinder and delivers this air to the second-stage regulator. It uses a redundant dual path reducing system. The secondary system automatically supplies air if the primary system fails. When the secondary system is in operation, the alarm activates to warn you of a problem.

- **Pressure Relief Valve:** Located on the side of the first-stage regulator (pressure reducer). It prevents damage to the first-stage and second-stage regulators and the associated hoses from excessive pressure, it can be re-seated.

- **Second Stage Regulator:** Located at the end of the low-pressure hose. It connects to the face piece, making it a mask-mounted regulator. It is a positive pressure-demand regulator that maintains a positive pressure in the face piece at all times (about 1.5 inches of water column, 0.05 PSI). If you have a broken face seal or a breached face piece, air will free flow from the regulator to prevent any toxins from entering your face piece.

- **Purge Valve:** Red valve located on the left side (when wearing your face piece) of the second-stage regulator. When open, the purge valve manually overrides the second-stage regulator to provide a constant flow of air to the face piece if a second-stage regulator failure occurs. You can also use the purge valve to clear your face piece when fogged. To open, rotate the valve handle counterclockwise.

- **Air Saver Switch:** Located on the top of the second-stage regulator. It stops the airflow from the second-stage regulator. You can press and release this switch to actuate it, with no need to hold it in position.

- **Removal Lever:** Located on the right side (when you’re wearing your face piece) of the second-stage regulator. It is used to “unlock” the second-stage regulator from your face piece in order to remove it. This is done with your thumb, by pushing the lever away from your face and holding it to unlock the second-stage regulator.

- **Alarm Assembly:** Known as the Vibralert, is contained in the second-stage regulator. When about 20-25 percent of the cylinder air remains, the alarm vibrates and emits a sound to warn of a diminishing air supply. It also activates to indicate a problem with the first-stage regulator (pressure reducer). The alarm activates even though the cylinder pressure is greater than the low air pressure range. When this alarm activates, go to a safe area and investigate the problem.

- **Face Piece:** There are three sizes of face pieces, or face seals, shown above. The standard size fits 90 percent of the population. The face piece is secured to the lens by a U-shaped channel frame with snap retainers. It is constructed of a blend of natural rubber and synthetic rubber.

- **Lens:** Located in the front of the face piece. It is a single, replaceable, wide angle, clear lens that is made of polycarbonate with a silicone based coating to resist abrasion and chemical attack.

- **Head Harness:** Connected to the face piece by quick-adjusting buckles and snap retainers. It is made of synthetic rubber and holds the face piece snug against your face to form the face seal.

- **Voice Amplifier:** Located in the mounting bracket over the right side voicemitter when wearing the face piece. It amplifies your voice and is powered by one 9-volt battery. There are voicemitters on both sides of the face piece. While wearing the face piece, you should speak in a loud, clear, and calm voice so others will hear you.

When you inhale and exhale, the air pressure inside the face piece is greater than the air pressure outside the face piece (the atmosphere). This positive pressure prevents any contaminants from entering the face piece if you lose the face piece seal integrity. When you breathe in, you create a demand on the respirator, and it supplies you with the air you need.
SCBA OPERATION
When open, the air cylinder valve allows compressed breathing air from the cylinder to travel to the first-stage regulator (pressure reducer) via the high-pressure hose. Air is also delivered at the cylinder pressure to the remote pressure indicator. The first-stage regulator reduces the pressure to approximately 100 PSI throughout the entire operating pressure range of the cylinder. This reduced pressure air is delivered to the second-stage regulator. The second-stage regulator connects to the face piece. With the face piece donned, you can inhale sharply to start the airflow. The second-stage regulator is a positive pressure-demand regulator that maintains a positive pressure in the face piece at all times (0.05 PSI). Upon inhalation (demand), the regulator supplies you with air. The SCBA is an open circuit type system. This means that the air is exhaled to the atmosphere.

DONNING AND DOFFING PROCEDURES FOR THE SCOTT AIR PAK 4.5
Donning the SCBA is a three-step process. The first two steps are getting into battle dress and donning the flash hood and the Firefighter's ensemble (FFE) or fire retardant coveralls. Conduct an inspection, the face piece is the part that mounts to your head, this is as good as any a place to start your preoperational inspection. Check for any rubber deterioration, cracks, tears, holes, or tackiness. Check the head harness for any breaks, missing straps, loss of elasticity, and missing fasteners.
Inspect the lens for cracks, scratches that would impair your normal vision, and loss of tightness with the face piece rubber. Inspect the second-stage regulator inlet coupling for any sign of looseness or damage. Visually inspect the second-stage regulator casing, purge valve, and air saver switch for any signs of damage or failure. Check the outlet of the second-stage regulator for dirt or debris. Visually inspect all the SCBA hoses for being worn or frayed. Visually inspect the backpack, shoulder straps, waist strap, and the air cylinder strap for any signs of damage or failure. Check the air cylinder pressure to ensure that there is at least the minimum pressure for use, 4000 PSI.

DONNING METHODS
After performing your preoperational checks, you can don (putting on) the SCBA. There are two procedures you will use to don the SCBA.
- Over-the-Head Method: Hold the air cylinder upside down (valve at the top) and away from you. Check overhead and behind you for obstructions, drop to one knee, lift the backpack over your head and allow it to rest on your shoulders as you extend your arms thru the shoulder straps. Adjust the straps so the weight is supported by the waist belt.
- Coat Method: Stand up straight to adjust the air cylinder on your back and tighten the shoulder straps by pulling them downward. Adjust them so that the waist strap is worn around your waist. Connect the waist strap buckle and adjust the waist strap for the proper fit. Most of the weight of the SCBA should be worn around the waist. Check all of the straps for the correct adjustment and tuck in excess straps. When wearing an FFE, the excess straps will be minimized.

Once the cylinder is secured on your back using either method above, don your face piece. To don your face piece after you have pulled the flash hood down around your neck, grasp the face piece harness; spread the straps from inside with your thumbs. Put your face into the face piece by doing the following:
- Place your chin in the chin cup.
- Pull the head harness over your head.
- Smooth the head harness down on the back of your head.
- Ensure that your hair especially bangs, do not extend through the face seal.
- Tighten the head harness straps by simultaneously pulling the left and right straps straight back.
- Tighten the chin straps first.
- Tighten the temple straps next. The head harness should now be centered on the back of your head.

Perform a negative pressure check by doing the following:
- Remove the second-stage regulator from the waist belt.
- Attach the second-stage regulator to the face piece.
- Inhale until the face piece is drawn against your face.
- Hold your breath and count to ten. If the face piece does not seal, remove the second-stage regulator, adjust the face piece, and check the seal again. Once a seal is obtained, doff the second-stage regulator and store it in your waist clip.

Open the air cylinder valve:
- Ensure that the alarm vibrates and sounds.
- Perform a remote pressure indicator check. Ensure the remote pressure and the air cylinder pressure indicators are within 500 PSI.

Don the rest of your PPE. To do this, perform these steps in the following order:
- Pull the flash hood up and over your head.
- Secure the FFE collar.
- Don the Firefighter’s helmet.
- Don the Firefighter’s gloves.

After all your PPE is donned, open the SCBA air cylinder valve and locate the second-stage regulator, which is in the protective waist strap.
- Attach the second-stage regulator to the face piece.
- Ensure that the second-stage regulator locks in your face piece.
- Inhale sharply to start the air supply. Once the air supply starts, the proper breathing technique is to inhale through your nose and exhale through your mouth.
There are two methods of replenishing your breathing air. These are the quick charge and the air cylinder change-out methods. Neither method requires you to doff your SCBA, providing you have some help. Take the SCBA off, to doff the SCBA, perform the following:

- Release the removal lever, then turn and depress the air saver switch.
- Disconnect the second-stage regulator from the face piece.
- Close the air cylinder valve.
- Bleed the air from the SCBA by opening the purge valve.
- When the purging is finished, close the purge valve.
- Stow the second-stage regulator in the protective clip.
- Loosen the head harness straps and remove your face piece.
- Loosen the shoulder straps and unbuckle the waist strap.
- Perform the required maintenance after each use.
- Stow the SCBA.

Observe the following safety precautions when donning and activating the SCBA. Do not wear eyeglasses or contact lenses under the face piece. Use only the approved spectacle kit for the SCBA mask. Ensure your face is clear of excessive facial hair. Return to fresh air immediately if you experience unusual sensations such as nausea, dizziness, eye irritation, unusual odor or taste, excessive fatigue, or difficulty breathing. Do NOT remove the face piece or disconnect the second-stage regulator in a contaminated atmosphere. Do NOT use tools to tighten the coupling nut; it is designed to be hand-tightened. Do NOT use alcohol to clean the SCBA parts. Do NOT try to adjust or repair the low-pressure relief valve. Tampering may change the relief valve setting, resulting in serious personal injury, death, or damage to equipment. Ensure all pressure is relieved from the system and the air cylinder valve is closed prior to disconnecting any of the fittings.
Fire represents one of the greatest shipboard dangers you might encounter because evacuation from your ship is a last resort, rather than your first instinct. Shipboard fire stations play an important role in the ship’s safe operation. In this lesson we will address key components of the shipboard fire station and maintenance procedures used to keep these stations in excellent working order. Fire station operation and maintenance could very well be a matter of life or death.

Terminal Objective - Identify components and maintenance procedures for Shipboard Fire Equipment.

- Enabling Objective - Identify various components of Shipboard Fire Stations.
- Enabling Objective - Identify maintenance procedures for Shipboard Fire Station Equipment.

SHIPBOARD FIRE STATION EQUIPMENT COMPONENTS

Fire stations can reach all compartments with fire hoses because of their strategic placement around the ship. All personnel need to know how to operate fire station equipment and maintain it in the highest degree of readiness. Fire hose stations are commonly referred to as either a fire station or a fireplug. It consists of a fireplug, fire hose, vari-nozzles, spanner wrenches, and other associated equipment.

-A fireplug is the firefighting water valve at a fire station and controls the flow of water to that station. Each fireplug is a branch of the fire main system, which supplies water to all the fire hose stations. Smaller sized ships have 1 ½ inch fireplugs, while larger ships will have fireplug valves of 2 ½ inches. Larger ships have more area to cover, hence the larger capacity fireplug. Any ship requiring the installation of a 2 ½ fireplug must be able to provide firefighting water coverage for the main weather deck and any area on the lower decks from at least two fire hose stations with 100 feet of hose. On superstructure areas of the ship, two fire hose stations must be able to reach an area within 50 feet of hose.

-The vari-nozzle is a multipurpose nozzle used for the delivery of seawater and Aqueous Film Forming Foam (AFFF). It has various spray patterns from a solid stream of water to 90 or 110 degree fog spray, depending on the manufacturer of the nozzle. The spray pattern is adjusted by using the black shroud at the end of the nozzle, called a pattern selector. It is available in two sizes, 1 ½ inch nozzle and a 2 ½ inch nozzle. The 1 ½ inch nozzle is operated by holding the pistol grip handle while actuating the barrel handle turns the water on and off. The end of the nozzle is also marked to indicate the flow rate in gallons per minute, or G.P.M. The 95 GPM nozzles are used within the skin of the ship to help control the amount of water used and the 125 GPM nozzles are used on the Flight Deck Vertical Replenishment, or VERTREP area and the Hangar Deck AFFF hose lines. The 2 ½ inch nozzle flows at 250 GPM, does not have a pistol grip handle, and is used on all-weather decks. There are three variable spray patterns marked on the vari-nozzle.

-The solid stream is used for smoke filled spaces or areas at a great distance from the firefighter.

-30 degree narrow angle fog is the most often used pattern. It is a general firefighting pattern that sprays water in a thirty degree spray angle. It provides a “push” to flame fronts and in ideal conditions, can be effective out to 50 feet.

-A wide angle fog is 90 to 110 degrees wide, depending on who manufactured the nozzle. It is used for personnel protection, due to the heat absorption qualities of this setting. This protective umbrella can extend from 5 to 10 feet.

-Spanner wrenches are used to disconnect the fire station fittings or couplings. There are at least two spanner wrenches at each fire station. Never use spanner wrenches to connect or tighten fittings as this may cause damage. Fire hose fittings are always hand-tightened.

-Fire hoses are specialized pieces of equipment that are manufactured in standard 50 ft. lengths. They are made from a double jacketed synthetic fiber, surrounding a rubber or similar elastomeric lining. This characteristic allows the hose to recover to its original size and shape after being deformed, stretched, expanded, or twisted. The outer jacket of the fire hose is treated with substances that increase the wear resistance, slide more easily across decks, and color the hose orange, for instant identification. The ends, called couplings, are made of brass for corrosion resistance. There are three sizes found aboard ships, 1 ½, 2 ½, and 4 inches. The 1 ½ inch hose is used inside the ship, the 2 ½ hose is used on weather decks and hangar bays, and the 4 inch hose is used with the peri-jet educator, which is a device used for dewatering.

-A wye-gate allows a 2 ½ inch female inlet, on either a fireplug or a hose, to be reduced to two male 1 ½ inch outlets. Each 1 ½ inch outlet has its own stop valve with handle. In some instances there may be a wye-gate installed semi-permanently with one hose connected. In these installations, the one and a half inch outlet with no hose connected to it will be left open as a telltale for a leaking fireplug valve. Always ensure this valve is closed before opening the fireplug.

-The tri-gate is another reducing valve that is normally found in repair lockers. It has one two and a half inch female inlet and three one and a half inch male outlets with stop valves installed for each outlet like the wye-gate. Using this device, one two and a half inch hose can be attached to one outlet and two half inch hoses.

-The in-line educator is used to mix seawater and AFFF concentrate to produce firefighting foam for fighting class Bravo fires not confined to engineering spaces and as a backup re-entry hose for main spaces. It is used with a 95 GPM vari-nozzle. As seawater passes through the educator at 100 PSIG, it creates a suction that draws AFFF concentrate from a 5 gallon container or a 55 gallon drum and mixes it with the seawater providing firefighting foam at the nozzle. This AFFF concentrate mixes with seawater at a ratio of approximately 6%, using AFFF concentrate at a rate of 5 gallons of concentrate per minute.

Water pressure is greatly affected by friction, and on a typical 1 ½ hose, friction loss accounts for approximately 25 PSI for every 100 feet of hose. To minimize inlet pressure loss, the in-line educator is connected directly to a fireplug or used at the end of one 50 foot section of hose away from the fireplug. Also, when using the in-line educator, hose length downstream from the educator must be limited to three 50 foot lengths when fighting fires on the same deck or only one deck above you. If you go down one or more decks, as many as six lengths, or 300 feet of hose may be used downstream of the educator.

SHIPBOARD FIRE STATION MAINTENANCE

Your life may depend on how well shipboard fire stations are maintained. When emergencies do occur, firefighting equipment must be in 100% working order. The Damage Control Petty Officer (DCPO) is the person within your Division who routinely performs inspections and preventative maintenance on the fire stations, however, all hands need to know and understand the procedures required to properly maintain and stow shipboard fire station equipment.

Properly stowed gear is easier to deploy in an emergency and less obtrusive when not being used. It is vital for shipboard fire stations to be properly stowed. At each station, there will be either one or two 50 foot hoses, stored on a gently rounded saddle that has no sharp edges. Hoses stored on this saddle must have the bottom loops of the stored fire hose at least 6 inches off the deck to prevent chafing. Extra hoses are stored in repair lockers, in a specific manner. When they are stowed they are rolled into a coil, called a Fireman’s Roll, and sometimes secured with a small line.

The shipboard environment puts a lot of stress on equipment. Thorough inspections and maintenance on fire stations and their equipment are very important. Care must be taken with hose couplings, valves, and nozzles during drills,
maintenance, or an actual fire. Hose fittings can be damaged by cross-threading, being dropped, or being dragged across the deck. **Corrosion** is the most constant threat in the salt environment that Navy ships operate in. Failures can occur from corrosion on the insides and outsides of valves, nozzles, threaded couplings, or discharge connections, and prohibit their use in an emergency. Missing, damaged, or deteriorated gaskets can cause pressure loss, which leads to diminished nozzle performance. Hoses can be subject to abrasions, cuts, chafing, or other permanent defects. These must be found, and the hose replaced before it is needed in an emergency.
BECC 2.0 Student Workbook

**BECC-49**

**FIRE FIGHTING ENSEMBLE**

The engineering department, train hard to be ready for an outbreak of fire, and part of that training includes introducing you to the types of firefighting clothing, and teaching you the proper steps to don the firefighting ensemble.

**Terminal Objective** - Identify the function and proper use of the firefighting ensemble.

- **Enabling Objective** - Identify the types and functions of firefighting clothing.
- **Enabling Objective** - Identify simulation, don the firefighter’s ensemble.

**TYPES AND FUNCTIONS OF FIREFIGHTING CLOTHING**

There are three types of firefighting clothing aboard the ship: anti-flash clothing, the firefighter proximity suit, and the firefighting ensemble. The storage locations and the functions of the types of firefighting clothing are different. It is imperative to know when to use each type, as wearing the improper gear for a given situation can result in serious injury or death.

- **Anti-flash clothing** protects personnel from transient, elevated air temperatures resulting from the use of high explosive weapons, and from burns caused by fire. The clothing includes the flash hood and the flash gloves. These items are worn when personnel are directed to don battle dress. The Commanding Officer directs the relaxing of battle dress to prevent heat stress. The anti-flash clothing items are stored in the repair locker.

- **Firefighter proximity suit** provides the wearer with thermal protection while approaching and operating close to large fires. It allows firefighters to affect rescue of aircraft personnel when crash fires occur and to conduct rapid investigations following fire extinguishment. When not in use, hang it where it is readily accessible and where it will be safe from damage.

- **Firefighting ensemble** protects firefighters from short duration flame exposure, heat, and falling objects. In contrast to the proximity suit, the firefighting ensemble is not designed for use during aircraft rescues. Prolonged contact with flames may cause the clothing to transmit dangerous heat to the body, or may cause the clothing itself to burn, which could result in serious injury to the firefighter or death.

Firefighting ensemble consists of six items: the flash hood, coveralls, boots, the Self-Contained Breathing Apparatus (SCBA), a helmet, and gloves.

- **Flash hood** protects head, neck, and everything on the face area except the eyes. It can be worn with the SCBA. It has an elastic face closure and is made in a single size that fits everyone. If needed, pull the face portion of the flash hood up and over the nose to provide some additional protection for the face area.

- **Firefighter’s coverall** design is a one piece, jump suit style. It consists of an outer shell, a vapor barrier, and an inner fire-retardant thermal liner. The knees, bottoms of the thigh pockets, and bottoms of the legs are reinforced with leather for extra protection. It has reflective markings around the upper arms, lower legs, and torso to highlight the outline of the firefighter, for better view in dense smoke or dim light. The front closure and inside lower legs have brass zippers. There are bellows pockets with Velcro closures on the outside of each thigh and one in the front of the left upper arm. The coveralls have a corduroy faced collar with snap fasteners. The sleeves have an integral knit wristlet for wrist protection. They are available in five different sizes (small through extra-large). The sleeves should be labeled on the orange tape with the size of the coveralls for rapid identification.

- **Boots** provide protection from heat hazards (hot water), as well as other dangers. They are superior to normal work boots because they are knee-high with steel safety toes and puncture-proof steel insoles. The boots are made in sizes to fit everyone.

- **SCBA** gives respiratory protection by applying positive pressure to the face piece. It supplies breathable air from the pressurized cylinder. The exhaled air is expelled into the atmosphere. The major parts of a SCBA include one air cylinder, the air cylinder’s support harness back frame, a regulator, an alarm, and a face piece.

- **Helmet** is designed to protect your head, neck, and face from exposure to a short duration flash-flame, heat, and falling objects. It is made out of heat resistant fiberglass and has a face shield, a chin strap, an adjustable ratchet-type suspension, reflective markings, and a liner.

- **Gloves**, the five-finger cut, wristlet gloves protect hands against abrasions, short duration flame exposure, and heat. They are made out of leather, aluminized fabric, a waterproof vapor barrier, and a fire-retardant liner.

**DONNING PROCEDURES**

To don the firefighting ensemble, use the following procedures:

1. Remove unnecessary clothing.
2. Place the flash hood over your head.
3. Pull up the coveralls.
4. Don your boots.
5. Raise the coverall’s collar
6. Don the SCBA.
7. Pull the flash hood over your head and the SCBA.
8. Don your helmet.
9. Don your gloves.

The firefighting ensemble reduces the body's ability to dissipate heat; take measures to reduce heat stress. Effective measures include: donning the ensemble just prior to leaving the fire team staging area; donning the coveralls to your waist and pulling the flash hood down around your neck, when in the staging area; rotating firefighters every 30 minutes; removing the ensemble as soon as possible after exiting the fire zone; and drinking plenty of fluids.
Many ships have been lost or extensively damaged by fire. Fire has caused more damage than groundings, collisions, or flooding. Ships can become floating furnaces, fed by the combustible materials carried on board. Sound firefighting training and application are essential for the survival of ships. Aboard ships evacuation sometimes is not an option. The ability to put out fires and deal with the associated hazards could mean the difference between life and death for everyone onboard, this is why learning about basic firefighting techniques is so crucial.

Terminal Objective - Recognize techniques for Basic Firefighting Procedures.
- Enabling Objective - Identify Basic Firefighting Techniques.

MAIN SPACE FIRE DOCTRINE
The main space fire doctrine is a document tailored specifically for each ship. Copies of the main space fire doctrine are located in the Engineering Log Room, Main Control, Damage Control Central, and all Repair Lockers. It provides guidance for fighting machinery space fires for that ship. The main space fire doctrine also explains the role various firefighting systems found on the ship play in a fire, and outlines the procedures and the operations for using those systems.

FIRE CLASSIFICATION
The methods and extinguishing agents used on a fire is determined by the type of fire to be extinguished. There are four different classes of fire; these classifications are divided by the type of burning material that you will encounter with each type: Alpha, Bravo, Charlie, and Delta.

-Alpha fires consist of wood, cloth, paper, and similar products. They are best extinguished with water, with the vari-nozzle set to solid stream pattern, to penetrate and break up materials. Aqueous Film Forming Foam (AFFF) can be employed if the fire is deep-seated, as it is more effective than sea water and acts as a wetting agent that rapidly penetrates and extinguishes the fire.

-Bravo fire presents challenges not encountered in other types of fires, because it involves flammable and combustible liquids such as gasoline, diesel fuel, jet fuels, hydraulic fluid and lube oil. Any flammable liquid or gas can result in a Class Bravo fire. They are normally extinguished with AFFF, Halon, water mist, Heptafluoropropane (HFP) or potassium bicarbonate (PKP). A straight stream of water is ineffective for extinguishing Bravo fires and can cause a violent reaction if the water stream atomizes the fuel into the air causing a greatly increased surface area. AFFF is usually the preferred firefighting agent for this type of fire.

-Charlie fire is an energized electrical fire, and may be attacked with nonconductive agents such as CO2, Halon, or with low-velocity water fog. Special care must be taken to maintain a safe distance from energized equipment. The most common (and safest) method of dealing with a Charlie fire is to secure the electrical power, and treat it as an Alpha (burning insulation) fire. CO2 is usually the preferred agent to extinguish this type of fire.

-Delta fires involve combustible metals such as magnesium and titanium. Water in quantity, using fog patterns, is the recommended agent. When water is applied to burning Delta materials, there may be small explosions. The firefighter should apply water from a safe distance or from behind shelter. Metal fires on board ship are commonly associated with aircraft wheel structures.

A Chemical, Biological, and Radiological (CBR) environment may exist, as well as a firefighting scenario. The most likely scenario for encountering a fire in a CBR environment is a direct hit by a penetrating weapon delivering a chemical agent, with the fire resulting from the warhead, or unexpended missile fuel. The unlikely side effect in question relates to the remaining presence of a chemical agent. While it is possible that the agent, including vapor agents, may possibly be destroyed by the fire, extinguishing the fire takes precedence.

INITIAL RESPONSE
The initial actions by the person who first discovers a fire can make the difference between a controllable fire and an uncontrollable one that threatens every life on the ship. Even a small fire can create dangerous conditions within a small period of time, sometimes as short as two minutes. Any crewmember discovering a fire, or indication of a fire, must sound the alarm immediately. Whatever the means, the word of fire, including the type of fire, compartment number and the name of the space, must reach the Officer of the Deck or Damage Control Central immediately. Once the word has been relayed, the decision must be made to immediately start attacking the fire or start containment and isolation actions. If the fire is small and appears capable of being controlled, personnel with limited or no protection using portable extinguishers, such as PKP and CO2 extinguishers for Bravo and Charlie fires, respectively, can make the initial attack.

If the fire is too large to attack with a portable extinguisher, take action towards isolation and containment, setting condition Zebra to reduce the supply of fresh oxygen and limit the burning rate of the fire while the fire party is being staged. Where installed, sprinkler systems should actuate to extinguish fires that are large enough to force space abandonment. Ideally, if additional personnel are available, firefighting and fire containment can proceed together.

PROCEDURE
After the initial response has been made; the Rapid Response Team, On Scene Leader (OSL), or Damage Control Assistant (DCA) quickly take control of the fire. Whether with one hose, or multiple hoses, the fire attack steps are the same.

With the fire party on scene, the fire must be sized up and reevaluated. A fire in progress can change incredibly fast from the very first report. Investigators on scene, dressed out in personal protective equipment, verify the fire’s location with the aid of thermal imagers if the smoke is thick. Location and size is necessary to figure out where to establish fire and smoke boundaries, and to resolve what systems should be isolated, along with whether or not any other combustibles are at risk. Additionally, the Class of fire is also reestablished to confirm the best type of extinguishing agent and equipment, whether portable, installed, or fire hose, to use against the fire.
ATTACK

The attack on the fire should begin as soon as possible to gain immediate control and prevent its spread. After evaluation by the OSL and Attack Team Leader, the decision to attack the fire directly or indirectly is made. There are two different methods of attacking the fire, directly, and indirectly.

- **Direct attack**, if firefighters are able to enter the space, a direct attack is made by applying water directly on the seat of the fire, and or a fog attack into the overhead smoke and gases. If necessary, a direct attack can be conducted from a vantage point, such as a doorway.

- **Indirect attack**, if you can’t fully enter the space, an indirect attack should be used. Attack the fire using water from behind some type of cover such as a cracked door, a bulkhead, or overhead penetration. Following an indirect attack, enter the space and attack the fire directly. If conditions in the fire space still prevent access, steps should be taken to improve conditions to permit a direct attack, including venting the fire space to allow hot gases to escape.

The OSL ensures every effort is, or has been made, to secure and isolate the systems and equipment that are the root cause, or have the potential to feed the fire. Each ship supplements its main space doctrine with a list of local and remote controls, valves, switchboards, circuit breakers, and so forth, to aid in rapid mechanical and electrical space isolation. Normally, lighting is left energized, unless it poses an actual hazard to the firefighter, as when arcing or sparking exists. While fighting the fire, it is in everyone’s best interest to protect compartments exposed to fire. By doing so, the spread of fire by heat conduction through bulkheads or decks is prevented. This is done by removing combustible materials from adjacent bulkheads, and if necessary, using hose streams to cool bulkheads and decks.

BOUNDARIES

Fire and smoke boundaries are determined and set to limit the passage of flame and smoke, and provide protected staging areas for fire parties. Setting boundaries is fundamental to the safety and security of the ship. Any physical barrier can be a fire boundary. But in general, watertight subdivisions and bulkheads around the fire, and decks above and below the fire are used as fire boundaries. When setting a fire boundary, any openings to the area are closed and monitored for heat or smoke.

There are always two designated sets of boundaries, a primary and a secondary.

- **The primary boundary** is set using the bulkheads, deck, and overhead closest to and surrounding the fire. The next bulkhead, deck, and, overhead outside the primary fire boundary are then designated as secondary fire boundaries.

- **Secondary boundaries** are always set, regardless of whether the fire spreads past the primary.

Fire zone boundaries are similar to fire boundaries. The purpose is the same: to limit the passage of flame and smoke and confine the fire, in this case within a zone. But as any physical barrier can be a fire boundary, fire zone boundaries are specifically designed into a ship using selected main subdivision bulkheads and portions of decks. On damage control boundaries, these fire zones are designated FZ. Protected staging areas for fire parties are usually placed on the outside of a fire zone.

Large fires, or fires which burn for an extended period of time, may require boundary cooling. Boundary men search the fire boundaries looking for hotspots, sometimes using the Talisman K90 to help. If a hotspot is found, a single person may man and operate a 1½ inch fire boundary hose. Short bursts of water with a partially open vari-nozzle set at a low flow of 50-60 GPM directly onto hot spots is the safest and most efficient method of boundary cooling. Care must be taken by the cooling team as cooling hot boundaries can generate steam. Also, if boundary cooling is necessary inside of an electronics space, cooling should be coordinated with the space supervisor.

Smoke is the visible product of fire that makes unassisted breathing difficult or even deadly. In general, it is made up of carbon and other unburned substances. Smoke also carries vapors of water, acids, and other chemicals, which can be poisonous or irritating to the eyes, nose, and lungs when inhaled. Smoke also greatly reduces visibility. Firefighters should wear a breathing apparatus whenever possible in areas of fire and smoke for their own protection. Smoke boundaries are set to prevent smoke from spreading and to establish a controlled path for exhausting smoke out to the weather. Just like fire boundaries, inner and outer smoke boundaries are set around the perimeter of the fire.

The inner smoke boundary is set nearest the fire and normally coincides with the primary fire boundary. It is set by closing doors and hatches to the fire space, similar to the fire boundary, but is carried one-step further. Smoke curtains and smoke blankets can be used to maintain smoke boundaries when firefighting personnel open doors and hatches. They can also be used over doors and hatches that have been damaged and are no longer tight enough to control smoke, or to provide a measure of protection by covering equipment. The outer smoke boundary is a second smoke boundary, located farther away from the fire. When setting the outer smoke control boundary, consideration must be given to the establishment of a smoke control zone, which is the area between the inner and outer smoke boundary.

The goal of a smoke control zone, in conjunction with the inner and outer smoke boundaries, is to minimize the spread of smoke. To do this, and still attack the fire, access to the fire space must be within the smoke control zone. That way, when entering the fire space, smoke is trapped in the smoke control zone. In addition, the fire plugs and hose reels used by the fire party should also be within the smoke control zone to decrease penetrations of the outer smoke boundary. Only personnel wearing a breathing apparatus should enter the smoke control zone. If smoke conditions in the smoke control zone are especially heavy, active desmoking may be deemed appropriate. Active desmoking is removing smoke and heat from the smoke control zone prior to extinguishing the fire, to aid firefighting efforts and reduce smoke spread in the ship.

**ELECTRICAL ISOLATION**

There is another danger that must be taken away; electrical power in the fire space. Even though effective firefighting may start before electrical power is secured, it is secured as soon as possible to promote the safety of the firefighter, and further reduce ignition sources in the fire space. In a main space, complete electrical isolation is difficult due to the number of cables terminating within, and passing through, the space. Power down electrical equipment with a couple key exceptions, if they do not endanger the firefighter. Lighting and ventilation aids firefighters in dark smoky spaces. Halon IC circuits, AFFF Bilge sprinkling, and SOPVs (solenoid operated pilot valves) are left on for use if necessary. Any vent motor shut down interlocks, and vent damper closures should be secured from outside the affected space at a power distribution panel, load center, or even at the ship’s service generator, if necessary. It is the job of an electrician assigned to the fire team, to carry out electrical isolation of the space.

**VENTILATION**

The ventilation system is used to help contain smoke and toxic gases by two methods. In unaffected spaces, positive ventilation, supply fans on high and exhaust fans off, is ordered to provide a buffer of high pressure intended to prevent smoke from entering those spaces. Negative ventilation, supply fans on low and exhaust fans on high, is used in the fire space to remove smoke. This is important for evacuating personnel and for firefighters, who may not be fully dressed out with breathing apparatus during the initial attack on the fire with portable extinguishers.
COMMUNICATION
Communication is vital to the proper operation of damage control and firefighting teams. Information about the fire must be made available to all members of the firefighting team. Supervisors, such as the OSL, and the Attack Team Leader make decisions based on this information, and this information needs to get to the individuals actually fighting the fire. Clear, concise communication is vitally important to the success of a firefighting team. The most common method of communication during a fire takes place by normal voice exchanges between members of the fire party as they pass information to each other. Other methods include using voice amplifiers, which if available, are provided to at least 10 personnel in the fire party. The OSL uses ship’s phone, sound powered phone, or wire free radio communication (WIFCOM) to pass information to the repair party leader. Though the WIFCOM is a worthwhile communication tool, radio equipment has limitations during a major fire. In time, high heat causes a frequency shift; radios should be carried in an ensemble pocket to protect them as long as possible.

The limitations of radio equipment used while fighting major fires must be realized and accounted for. Attack Team Leaders must establish communications with the OSL using the best available methods, as there may be times when attack team members will only be able to focus only on breathing, survival, and the immediate task before them. Under severe conditions, the OSL must initiate actions as necessary without depending on communication from the attack team. If the scene leader needs information about the attack, he will send another hose man to the team.

The first technique of fighting a fire is gaining entry to the space by the hose team. The OSL determines the number of hose teams to use. Two hoses, Hose #1 and Hose #2, are rigged and positioned outside the door to the fire space. The #1 hose is laid out to open side of the door and the #2 hose is laid out to hinged side of the door. If the entry door needs cooling, it is carried out as necessary by a first responder until the fire party is manned and ready. The electrician, by direction of the OSL, has secured electrical power with the exception of lighting needed for visibility and a few vital circuits identified by the DCA. The hose team is in position, with all the necessary equipment on hand to fight the fire, and dressed out with their SCBAs on and operating. The hoses are charged and testing of the firefighting agent takes place at this point. Then wait for confirmation to enter the room from the OSL, who makes the determination.

ACCESSING THE SPACE
The OSL then asks the accessman, or nozzleman, about the condition of the door. The accessman checks the door for heat by using the back of his hand before undogging any dogs. The accessman then opens dogs on the hinged side of door first, checking for interior pressure by listening for air blowing or sucking. As long as there are no extreme indications the accessman continues to open the door, maintaining control by alternating the dogs to keep the door from buckling. On a Quick Acting Watertight Door (QAWTD), the lever lifts to the striker plate. With only one dog left the accessman shouts, ”Last Dog” and everyone on the hose team crouches down while the door is cracked six or eight inches. Opening the door slowly the rest of the way, the accessman secures the door open, and re-mans his position on the hose.

When the door is open, the team leader determines if it is safe enough for the fire party to enter the space. If it is safe, the #1 Nozzleman is the first to enter the space, followed by the Attack Team Leader. The #1 Nozzleman sweeps the deck with spray to clear it of any debris, if necessary. If necessary, the second team, led by the #2 Nozzleman, enters the compartment, staying low and charging the nozzle when directed by the Attack Team Leader or the #1 Nozzleman. When two manned hoses attack the fire together, the Attack Team Leader directs and coordinates the two nozzleman. If two manned hoses attack a fire area independently, they are considered to be two separate attack teams and require separate Attack Team Leaders.

When the firefighting effort is successful, the word is passed, “Fire contained!” and then, “Fire is out!” The Attack Team Leader, reporting by messenger, WIFCOM, or whatever means available to the OSL, makes these reports. When the fire is out, the team leader orders the #1 and #2 nozzlemen, “Water off!” The next command the hose team hears is the preparatory command, “Prepare to back down!” Once this command is given, the hose team discipline dictates the team member furthest from the nozzle, back up to the entrance of the space, and once in position, pass the word back to the team leader, ”Bite man set,” meaning keep tension on the hose. The hose team finally backs up after the attack team leader commands, ”Back down at nozzleman’s pace!” With the fire out, at least one fire hose is left charged and the #1 nozzleman usually serves as the first re-flash watch maintaining visual contact with the affected area, while the team leader reports to the OSL, “Reflash watch set!”

POST FIRE PROCEDURES
It is a huge relief that the fire is out, but there is still a lot of hard work left for the firefighting team. The fire must be overhauled and the area thoroughly examined. The space is still a dangerous place with smoke, water, and damage to contend with. Team members must remain dressed out in Personal Protective Equipment, (PPE) with their SCBAs in operation. An overhaulman, armed with a rake and axe, and the #1 nozzleman, armed with a charged hose, begin the procedure. Cleanup of the fire site varies slightly depending on what Class the fire was.

On Alpha fires, the overhaulman uses his rake and axe to break up piles of hot smoky material checking for hidden fire, while the nozzleman sprays and soaks it to prevent re-flash. Some material may have to be jettisoned. Bravo fires generally require more cooling by the nozzleman and careful inspection to ensure the fuel source is secured. In addition, Bravo fires cause material in the space to burn as an Alpha fire, so the process of breaking up and removing combustibles by the overhaulman and nozzleman also takes place. For a Charlie fire, an electrician ensures that there is no danger of electrical shock before the overhaulman and hose team start digging into the debris. Remember, after the electrical power is secured, this type of fire is treated as an Alpha fire.

After the initial overhauling of the fire, work continues with the dewatering and desmoking of the space. Three methods for desmoking are: natural ventilation, ship’s installed ventilation, portable desmoking equipment. Ventilation is a big step towards getting a space opened back up for personnel to enter without PPE. On completion of desmoking, the space must be tested by a Gas Free Engineer to make sure there are no residual explosive or toxic gases lurking about. Dewatering is the process in which water used to extinguish the fire is removed from the space. Finally, the electrician enters to ensure there are no shock hazards and see if it is safe to restore power.
Safety, especially when fighting fires, is always a top priority. Some safety precautions and procedures that are intended to keep everyone free from injuries:

- Always work together as a team; you’ll be much more effective, and remember your buddy is your backup.
- Once inside the compartment, remain low at all times to take advantage of the cooler air and greater visibility.
- Never leave a charged hose unattended; a wild hose can kill in more ways than one.
- You must continue to wear a breathing apparatus until testing is completed and the atmosphere is certified as safe.
- There are also some safety precautions for the firefighting agents themselves:
  - On any fire involving energized electrical systems, water or AFFF should be used only as a last resort, and do not approach the cables closer than four feet.
  - When using CO2, caution must be exercised in enclosed spaces. CO2 can cause oxygen deprivation. Also assure that you ground the CO2 bottle during use or static buildup can lead to explosive results. Also, watch out because contact with the CO2 or the discharge horn can cause a painful skin injury.
  - PKP is not used on electrical fires due to its corrosive properties, unless there is absolutely no CO2 available.
Damage control is everyone’s responsibility aboard the ship and therefore, everyone is a member of the Damage Control organization. To be an effective member of the Damage Control organization, the duties and responsibilities of all of the repair party team members need to be learned.

**Terminal Objective** - Identify the firefighting duties of shipboard personnel as direct by NTSM Chapter 555 Volume 1, Surface Ship Firefighting.

- **Enabling Objective** - Identify the duties and responsibilities of shipboard repair party personnel.

## Duties and Responsibilities of Shipboard Repair Party Personnel

Firefighting duties are based on the Standard Ships’ Fire Bills, as directed by the Standard Organization and Regulations Manual (SORM). A ship’s organization may vary, depending on the class of the ship. The Fire Bill specifies the Damage Control organization of a ship both in-port and at sea. The bill reflects the position of responsibilities for firefighting. It includes information on how the Damage Control repair or unit lockers is utilized and how to assign Damage Control qualified personnel.

Everyone has a duty to fulfill their responsibilities in the Damage Control organization, no matter how big or small. On the right side of the screen, select a repair party member and I will show you their position and tell you what that person does in the Damage Control organization.

- **Engineer Officer** – Also known as the Damage Control Officer (DCO) or Chief Engineer (CHENG) is responsible for the ship’s main propulsion and electrical plants, auxiliary machinery, and piping systems. The DCO controls the damage and supervises firefighting. Additional responsibilities include determining the adequacy of the Fire Bill and the responsibility of training and assigning personnel. Personnel assignments and duties may vary from ship to ship.

- **Damage Control Assistant (DCA)** – will be responsible under the Engineer Officer, for establishing and maintaining an effective Damage Control organization. This includes ensuring that the ship’s repair party personnel are trained in damage control, firefighting, and emergency repairs. The DCA will report to Damage Control Central (DCC) when the repair or unit lockers are manned, receiving reports on the status of the fire from the Accessman and the Engineer Officer. Controls the fireplug and WYE system (PHARS).

- **Rapid Response Team** – is comprised of a minimum of four personnel including the Fire Marshal, Electrician, and two team members. Sometimes called the Flying Squad, the Rapid Response Team proceeds directly to the scene and is equipped with portable fire extinguishers. Normally, they will not be in protective clothing, a SCBA, but will proceed to the repair locker when relieved by the fire party.

- **Repair Party Leader** – is in charge of the specific repair or unit locker area and personnel. The RPL ensures that the assigned personnel follow appropriate steps to localize and control damage. The RPL must communicate effectively. Communications must be maintained with DCC to keep the DCA informed of the status of a fire. They must also keep in contact with the OSL to coordinate the firefighting efforts, and other repair or unit locker personnel. They have the responsibility to ensure that assigned repair locker personnel set material condition Zebra and isolate the fire area by ensuring closure of all nonessential fittings, securing ventilation systems, and shutting off electrical power, as required. Their assigned personnel also set primary and secondary fire boundaries to prevent the fire from spreading. The RPL is also responsible for plotting firefighting information on isometric charts (DC Charts) to keep an accurate account of the events and actions of the fire and repair party personnel.

- **On Scene Leader** - is in charge of firefighting operations at the scene. This individual is equipped with an SCBA. One of the most important responsibilities is to determine the PPE requirements for the fire party, based on assessment of conditions found. By establishing communications with the Team Leader and Investigators, the OSL can report the status of the fire to the RPL. The OSL will have to make critical decisions including, assessing the extent of the fire to determine the type of extinguishing agents to be used and the method and direction of attacking the fire. The OSL must also know where to position the fire party to effectively combat the casualty.

- **Investigators** – always travel in pairs and are responsible for investigating the area to which they have been assigned. They are equipped with an SCBA and an investigator’s kit and will be patrolling fire boundaries while maintaining damage control settings. The specific duties are to follow the principles of investigation by thoroughly and rapidly investigating with caution. Any findings should be reported as soon as possible. They must continue to repeat investigations until the fire is out.

Communication is essential; therefore they continuously report information to the RPL or OSL until the fire is out. This communication is usually by use of standard message blanks with damage control symbology. The use of WIFCOM is another important communication tool for the investigators.

- **Team Leader** – is assigned by the OSL, as required for instances when the TALISMAN thermal imaging camera is needed, and is in charge of the attack team. The Team Leader will enter the space with the attack team and direct the nozzleman’s efforts and report the status of the fire to the OSL.

- **Nozzleman** – is a critical member of the repair party and is responsible for handling the equipment and directing the firefighting. They are in charge of handling hoses, directing other personnel, and ensuring the quick and effective handling of water and extinguishers. The nozzleman is the primary line that controls the water flow and extinguishes the fire.

- **Hoseman** – is responsible for handling the hoses and ensuring that they are properly directed and used in the firefighting process. They ensure that the hoses are properly connected and ready for use.

- **Plugman** – are responsible for handling the fireplug and ensuring that it is properly connected and ready for use. They also ensure the proper flow of water to the various parts of the ship.

- **Boundarymen** – is responsible for controlling the scene of the fire and ensuring that the limits of the fire are properly marked. They are responsible for controlling the flow of personnel and ensuring that the area is properly secured.

**Firefighting Duties**

- **Splicer** – splices hose and ensures that it is properly connected and ready for use.

- **Plugman** – closes the fireplug and ensures that it is properly connected and ready for use.

- **Engineer Officer** – controls the fireplug and ensures that it is properly connected and ready for use.

- **Repair Party Leader** – directs the firefighting effort and ensures that it is properly connected and ready for use.

- **On Scene Leader** – directs the firefighting effort and ensures that it is properly connected and ready for use.

 These positions are critical to the effective operation of the ship’s fire control system and are essential to the safe and efficient handling of the fire. The repair party team members must work together effectively to ensure the safe and efficient operation of the ship.  

## Glossary

- **Firefighter** – a person who is trained in firefighting techniques and procedures.

- **Damage Control Assistant (DCA)** – a person who assists the Engineer Officer in establishing and maintaining an effective Damage Control organization.

- **Rapid Response Team** – a team of personnel who respond directly to the scene of the fire and sets fire boundaries as directed.

- **On Scene Leader** – a person who is responsible for directing firefighting efforts at the scene.

- **Nozzleman** – a person who is in charge of handling hoses and directing other personnel in the firefighting process.

- **Hoseman** – a person who is responsible for handling hoses and ensuring that they are properly directed and used in the firefighting process.

- **Plugman** – a person who is responsible for handling the fireplug and ensuring that it is properly connected and ready for use.

- **Boundarymen** – a person who is responsible for controlling the scene of the fire and ensuring that the limits of the fire are properly marked.

- **Splicer** – a person who splices hose and ensures that it is properly connected and ready for use.
Phone Talkers – located in DCC, each repair locker and at the scene, if applicable. They operate on the DC communication circuits and use message blanks to maintain required communications, as necessary. They set up emergency phone circuits, and observe circuit discipline while speaking clearly.

Messengers – relay orders and information. They will carry messages to or from the OSL and repair locker, or from the RPL to DCC, if no other means are available. Messages may be oral or written, using standard damage control symbology and standard message blanks. Usually remaining in the vicinity of the repair and/or unit locker to which they have been assigned, they must be thoroughly familiar with routes and accesses through the ship.

Other Personnel – There are other qualified personnel that may or may not be required for every repair party situation. One such person that must be qualified, but hopefully not needed, is the Corpsman. Another such person is the Electrician, who is responsible for securing power or rigging casualty power at the scene when directed by the Fire Marshal or OSL. The power is secured to protect the firefighters and equipment, and should only be done by qualified Electricians. The Gas Free Engineer or Assistant will test the atmospheric conditions in the vicinity of the fire to ensure there is enough oxygen to support life and that there are no toxic gasses after the fire is out. The Smoke Control Team will set up desmoking equipment and the Dewatering Team will dewater any flooded compartments as requested by the OSL.
Despite all precautions, fires still break out suddenly and unexpectedly. Fuel in the bilge and atomized fuel fills the air and comes into contact with a bare steam line and ignites. The machinery space erupts in flames while smoke banks down from the overhead. After securing the electrical power, the Halon system along with the AFFF Bilge Sprinkling system actuate.

**Terminal Objective** – Function as part of the Firefighting team combating machinery space fires.
- **Enabling Objective** – Recognize the procedure for combating machinery space fires.
- **Enabling Objective** – Demonstrate the procedures for combating machinery space fires.

Each surface ship's Machinery Space Firefighting Doctrine (MSFD) will address underway, auxiliary steaming, and cold iron status. Each ship's Repair Party Manual and Casualty Control Manual will incorporate this doctrine. Onboard personnel, using the current version of NSTM Chapter 555 V1 for guidance, must specifically tailor each ship's Machinery Space Firefighting Doctrine.

The policies within this doctrine are in place to ensure the ship and the crew is safe. Items addressed in each ship's Machinery Space Firefighting Doctrine include policies and procedures for securing the space mechanically and electrically. It also addresses the activation of Halon and CO2 flooding systems, as well as the AFFF Bilge Sprinkling system. This doctrine describes personnel responsibilities and specific strategies, procedures and tactics you take for attacking a fire and criteria for sounding general quarters.

The MSFD includes detailed compartment checklists of specific systems, and the priorities for isolating spaces in the event of evacuation. It includes the device to secure, the location of the securing device, and the individual watch stander responsible for securing the space. MSFD defines specific duties and responsibilities of supervisory personnel, other watch station personnel involved in firefighting, and personnel in standby or back-up positions or the fire party relief team. Supervisory personnel can include the EOOW, RPL/Repair, and Repair 5 on Scene Leader.

According to doctrine there should be frequent and regular inspections of all spaces and equipment to identify and correct hazardous conditions. There are unique fire hazards associated with main and auxiliary machinery spaces.

- **Adjacent Spaces** - Machinery space fires frequently force abandonment of adjacent machinery spaces due to smoke ingestion. Strategic placement of breathing apparatus allows key personnel to remain in adjacent smoke filled machinery spaces. Maintaining positive pressure in adjacent spaces will also inhibit smoke ingestion.
- **Fuel Tank Hazards** - Do not fill fuel tanks with foam during machinery space fires. Exterior cooling of fuel tanks with seawater or AFFF spray is preferable.
- **Gas Turbine Hazards** - Fires occurring in gas turbine modules have a high potential for re-flash after being extinguished by Halon, due to air movement and leakage that dilutes Halon concentration.

**FIRE PREVENTION**

To reduce fire hazards, the CHENG, DCA, or the Fire Marshal have a few tasks to complete on a regular basis. They must inspect for properly stowed and protected combustible materials. They must also test and inspect flammable systems after they are repaired, including fuel oil piping systems. They must educate all personnel in the reduction of fire hazards, while the DCPO enforces fire prevention policies and practices. They are also responsible for ensuring proper maintenance of all firefighting equipment, machinery space damage control closures, and fittings. The E OSS operates and maintains systems and equipment in accordance with authorized plant procedures. Even a small fire can create untenable conditions within a space in as little as two minutes. Take action immediately upon the discovery of a machinery space fire, you should immediately sound the alarm. The report of the fire and its location, compartment number and name to the Space Supervisor and EOOW by whatever method is available.

In the event of a Bravo fire in a Machinery Space, there are specific procedures, assigned to specific individuals, as outlined in the Engineering Operational Casualty Control (EOCC) manual. Generally, the major steps involved in fighting the fire are:
- Establish communications with DC
- Locate the fire
- Report the fire
- Contain the fire
- Extinguish the fire
- Restore systems

The organization of the Damage Control system ensures that the firefighting effort is immediate and effective. Key personnel are assigned firefighting and damage control duties. The number of people assigned will vary depending on the nature of the fire and the number of people available. Some people may have to perform multiple functions and some functions are performed concurrently. It is important for you to understand the duties of these key personnel because they are the ones you will be reporting and taking order from during your involvement in the major steps in fighting a machinery fire.

The initial actions of the Watch stander or Space Supervisor are:
- Deploy portable PKP extinguishers and operate as needed.
- Activate AFFF Bilge Sprinkling, if installed. (One Minute Minimum).
- Leave space ventilation in operation, and set negative ventilation (Exhaust High/Supply Low).
- If evacuation is ordered or necessary, don the EEBD.
- Upon evacuation, activate the Halon and AFFF Bilge Sprinkling systems (if installed), if not already activated.
- Report to the Damage Control Repair Station (DCRS) or to the OSL.
The EOOW:
- Reports B fire to the Officer of the Deck (OOD)
- Requests the OOD set Condition II DC.
- Ensuresafff Bilge Sprinkling is activated, if installed.
- Ensures Watch standers in adjacent spaces shoulder an EEBD.
- Orders space evacuation if the fire is out of control, or other circumstances render that necessary.
- If evacuation is ordered, ensures Halon and AFFf Bilge Sprinkling are activated, if not already.
- Ensures negative ventilation is set up in affected spaces.
- Ensures positive ventilation is set up in unaffected spaces.
- Turns over control of firefighting efforts to the Damage Control Assistant (DCA) if/when the space has been evacuated.

The DCA is responsible for many actions during the firefighting effort:
- Communicate with EOOW and OOD on firefighting and personnel status.
- Verify Halon and AFFF system deployment if activated.
- Ensure that AFFF stations are manned, investigators are deployed, fire and smoke boundaries are set, and adequate fire main pressure is maintained.
- Order electrical and mechanical isolation of the affected space and all other firefighting actions.
- Order unaffected DCRS(s) to provide assistance as required.

Among other duties and responsibilities, the DCRS Officer or Leader will:
- Communicate with CCS/DCC and the OSL concerning firefighting and personnel status.
- Order and then report setting of smoke and fire boundaries.
- Ensure Investigators are deployed.
- When ordered, ensure the space is mechanically and electrically isolated.
- Muster evacuees.
- Verify activation and effectiveness of Halon and AFFF systems.

Main duties that the On Scene Leader is responsible for:
- Establish Communications with the DCRS.
- Verify Halon and AFFF activation. Also verify leak/space isolation and personnel evacuation.
- Order and report SCBA activation times.
- Direct Space re-entry when ordered.
- Report all firefighting and damage control effort status updates, such as fire contained and out, re-flash watch, desmoking/dewatering, and all other updates.

The Team Leader will:
- Direct firefighting efforts.
- Report firefighting and damage control effort progress.
- Request a Gas-Free Engineer in the space when appropriate.

The unaffected DCRS Officer or Leader assists the efforts by:
- Set assigned fire and smoke boundaries.
- Provide reliefs, as ordered by the DCA.
- Investigate the surrounding area, to minimize the spread of fire.
- Set-up a firefighting and SCBA change out area.

The Officer of the Deck shall:
- Set Condition II DC.
- Establish communications with DCC/CCS and EOOW.
- Maneuver the ship to avoid smoke ingestion by ventilation systems, if possible.
- Notify other ships as appropriate.
- Observe any changes in the quantity and color of smoke and report these changes to DCC/CCS.

**FIREFIGHTING SYSTEMS**
All ships have one or more firefighting systems or equipment. Use fire hoses for cooling bulkheads at fire boundaries. Use portable CO2 extinguishers to extinguish fires such as in an electrical control panel. PKP extinguishers are highly effective on oil spray fires. Use AFFF Bilge Sprinkling to prevent a fire by vapor securing a major oil leak in the bilge. Actuate the Halon system when evacuation of a space is decided.

An "on the scene estimate" of the situation should be done before choosing the firefighting equipment to use. You need to take into consideration the volume of flammable liquid, the form of the liquid, and if the area occupied is confined or unconfined. You must check the ability to secure the source, as well as how rapidly flame, heat, and smoke are threatening firefighting, and escape. There are also some general guidelines provided for consideration when selecting the proper Bravo firefighting equipment:
- **Small pool fires < 10 square feet** - Portable PKP extinguisher or AFFF hose reel. You should use CO2 extinguishers ONLY for small pool fires less than 4 square feet.
- **Oil spray fires** – First attempt to secure the source of oil spray. Use portable PKP extinguishers. If the fire runs into bilges, creating combined oil spray and bilge fire, use AFFF Bilge Sprinkling. If you cannot secure the oil spray, you will evacuate the space and activate the Halon and AFFF Bilge Sprinkling system, if installed.

Any major flammable liquid leak, including fuel oil and lube oil, is an immediate hazard, which you must deal with quickly to reduce the threat of fire. An oil leak which forms a spray can ignite when it comes in contact with any hot surface or equipment capable of arcing.
If the leak is minor, you can use a rag to remove the excess oil, and make sure to notify the Space Supervisor. If the leak is major, however, there are some steps that you, and your fellow shipmates, must follow that will help to keep the ship safe:

- Report the leak to the Space Supervisor and the EOOW to allow for concurrent action.
- Repair party personnel will man the machinery space foam proportioning stations upon notification of a major oil leak in the space.
- Stop the leak as quickly as possible, either locally or remotely. This will greatly reduce the fuel source should a fire occur.
- Use AFFF to cover liquid surfaces; this will greatly reduce the risk of fire. Activate the AFFF hose reel to remove oil accumulation on deck-plates or bulkheads and wash the oil into the bilge.

In some situations, the oil leak may discharge directly into the bilge. In other situations, the oil leak may discharge onto the deck plates and then into the bilge. AFFF bilge sprinkling use ensures all bilge surfaces are vapor secured. The use of a rag to reduce the flow of oil and deflect it away from hot surfaces can greatly reduce the severity and consequences of an oil leak.

Re-entry to an evacuated machinery space because of a fire is the most crucial part of the firefighting evolution and potentially the most dangerous. The OSL will direct when a space is re-entered. The primary functions of the re-entry team are to attack and extinguish the fire, ensure the source of oil is secured, and cool the space so ventilation may be started. Prior to re-entry, personnel must don an SCBA and firefighter’s ensemble. The team leader must be equipped with a Talisman K90 thermal imager. The re-entry team uses a charged 1 ½ inch AFFF hose, with vari-nozzle. They have a back-up 1 ½ inch saltwater fire hose. The back-up attack hose has an in-line eductor, used to provide AFFF from 5 gallon cans when backing up the lead attack hose in the space.

Hose advancement within and from a vertical trunk is an extremely hazardous operation. The risk of falling increases when wearing firefighting personnel protection. There is also a risk of the fire extending into the trunk. Additional manning is required to maintain a hose man at the top and the bottom of the vertical trunk. Before entering the trunk, the scene leader will direct the setting of smoke boundaries at the top of the trunk, and the rigging of two charged hoses to the trunk access. Due to the limited space available in a vertical trunk, single hose operation is normally more effective than a two hose configuration. The primary attack hose advances down the trunk, while positioning the secondary attack hose at the top of the trunk, to back-up the primary attack hose as necessary. If a second hose is required at the fire, advance it separately down the vertical trunk using the same procedures as the first.

When the fire is extinguished, a whole other set of responsibilities needs to be taken care of:

- **Withdrawal** - Hose team withdrawal normally consists of backing out the hose in the reverse order of entry.
- **Desmoking** – Desmoking, if necessary, with installed ventilation systems or portable desmoking equipment as directed by the OSL.
- **Atmospheric Testing** – Gas-Free engineers will ascertain whether or not the space has sufficient breathable space, and personnel can re-enter without using a breathing apparatus.
- **Dewatering** – Dewatering, if necessary, will be accomplished with portable dewatering equipment such as directed by the OSL.
- **Remanning** – Only after completion of atmospheric testing and certification that the space is safe. Consider operation of equipment and de-isolation of mechanical and electrical systems only after a careful assessment of damage.

**COMBATING MACHINERY SPACE FIRES**

Considerations necessary in choosing the correct firefighting equipment, and the actions performed inside and outside of the affected space. There are many important considerations and procedures to take into account when operating within main machinery spaces. The effects of a fire in a machinery space can be greatly reduced if the correct actions, in the correct order, are accomplished quickly. Following incorrect procedures, delaying action, or simply not performing certain damage control tasks can lead to loss of life, serious injuries, machinery or equipment damage, or even loss of the entire ship.
Sailors may be assigned to an aviation or air-capable ship. The flight deck is exciting, but it is also the most dangerous place aboard ship. When an aircraft emergency occurs, everyone on the flight deck responds. It is important to become familiar with the people, personal protective equipment (PPE), and procedures involved in flight deck firefighting and rescue efforts.

**Terminal Objective** – Describe flight deck firefighting.

- **Enabling Objective** – Identify the flight deck fire party personnel.
- **Enabling Objective** – Describe the flight deck protective clothing.
- **Enabling Objective** – Describe the steps involved in a firefighting procedure and pilot rescue.

When fighting flight deck fires, skills similar to those of normal firefighting are needed. However, there are distinct differences between the two. First of all, everyone on the flight deck is involved in the firefighting effort, and specific personnel are involved who are not normally part of other firefighting efforts.

**FLIGHT DECK PERSONNEL**

Everyone on the flight deck has a firefighting responsibility. Formal training in flight deck firefighting will be received by all assigned personnel. The fire party personnel described below are common to all aviation and air capable ships. Specific ships and ship classes may have additional fire party personnel.

- **On Scene Leader (OSL)** is a trained individual in the vicinity of an incident who understands the requirements of the emergency and accepts responsibility for directing all available firefighting assets at the scene.
- **Hose Team Leader** is positioned directly beside the Nozzle Man and is responsible under the direction of the OSL for his Hose Team.
- **Hose Team**, consists of one AFFF hose with a minimum of five persons (maximum seven) on each 2-1/2-inch hose and a minimum of three persons (maximum five) on each 1-1/2-inch hose.
- **AFFF Station Operator (Plug Man)** operates the station at the direction of the Hose Team Leader.
- **Rescue personnel**, also known as Hot Suit Men, are specifically designated and specially trained. They must be available for immediate response and properly attired in proximity Fire Fighting Protective Ensembles (PFFPE) and SCBA, while performing firefighting duties. Rescue personnel should always work in pairs as directed by the OSL.
- **Background Assistance Leader** anticipates requirements and organizes and dispatches personnel and equipment to support the OSL. The Background Assistance Leader is positioned so that the entire flight deck or crash scene is in view.
- **Medical personnel** report to the Background Assistance Leader upon sounding of the flight deck crash alarm or announcement of emergency flight quarters. Medical personnel ensure space and equipment is prepared for the collection and treatment of those injured, and provide medical assistance as required.
- **Messengers/phone talkers** are responsible for relaying information from the OSL to flight deck/hangar deck control.
- **Explosive Ordnance Disposal (EOD) and Weapons Personnel** are stationed in proximity to flight operations. They respond to the scene to provide technical assistance, weapons cooling temperature checks, and weapons disposal as required by the OSL.
- **Aviation fuels repair** report to the Background Assistance Leader and are available to provide technical assistance and systems repair. V-4 personnel on larger ships, or Engineering Department Oil Lab personnel on smaller ships, may be dispatched to isolate affected stations/quadrants of the JP-5 system, and notify flight deck control when affected systems are isolated.

**FLIGHT DECK PROTECTION**

Flight deck personnel wear specialized protective clothing designed to enhance their safety on the flight deck and in the water, should they go overboard. This clothing is also worn to fight flight deck fires, unless designated as Rescue Personnel. Flight deck hazards include noise, impact, heat, fire, explosion, and the risk of falling or being blown overboard. For protection from potential dangers, wearing of special protective clothing while on flight deck duty is required. Flight deck clothing is also color-coded, allowing recognition of who is responsible for what on the flight deck.

- **The cranial helmet** has a hard outer shell and a foam rubber lining to protect the head and absorb shock. There is reflective tape on both the front and back of the cranial, to aid visibility. To further aid visibility, a strip of Velcro on the front of the cranial allows attachment of a distress marker light for rescue personnel to find you in the water. The flash function of the distress marker light is either strobe or matrix. Carry the distress marker light in the upper left pocket of the vest, and always ensure the light’s lanyard is securely fastened to the vest.

  - Boots, steel-toed flight deck boots are the only authorized footwear for flight deck operations. Other types of boots, which may be authorized on other parts of the ship, are not to be worn on the flight deck.

  - **MK-1 MOD-0 life preserver vest**, also known as the “float coat,” with the snaps fastened, is designed for prolonged wear, and like the jerseys, they are usually color-coded to identify the wearer's position or duty. The MK-1 MOD-0 has many components and features, any one of which could save lives. All components that are not integral parts of the vest are attached to the vest with lanyards.

  - **The bladder** is inserted into the cover of the vest. To provide flotation, it can be inflated either manually with the oral inflation tube, or automatically with the CO2 inflator assembly.

  - **Oral inflation** tube is used to manually inflate the vest. The tube is about seven inches long and the coupling swivels to aid in manual-inflation.

  - **Distress marker** light provides a beacon for rescue personnel to find you in the water. The flash function of the distress marker light is either strobe or matrix. Carry the distress marker light in the upper left pocket of the vest, and always ensure the light’s lanyard is securely fastened to the vest.
**PROCEDURES AND RESCUE**

Flight deck aircraft firefighting, crash, and rescue techniques are well defined, but no two fire situations are identical. Success depends on training, planning, leadership, and teamwork. All personnel assigned duties incidental to flight operations attend a formal aviation firefighting school. Crash and Salvage team members also attend additional, in-depth training. There are six basic steps in the flight deck firefighting and rescue process:

- **Notification**, mishaps are reported by the most efficient method in accordance with the ship's operating instructions.
- **Initial and Background Response**, the OSL assumes command and directs available personnel in firefighting, ordnance cooling, and personnel rescue. He directs Hose Team Leaders to turn “Nozzles on” and to “Move in.” AFFF Hose Teams attack the fire and cool ordnance as directed by the Hose Team Leaders. The Background Assistance Leader assembles and organizes all additional personnel not actively engaged at the fire scene. This includes Medical Personnel and Messengers or Phone Talkers.
- **Weapons cooling**, due to the danger of detonation, ordnance cooling is conducted simultaneously with firefighting and rescue efforts. AFFF Hose Teams knock down fire and smoke to enable identification of fire-exposed ordnance. Once identified, fire-exposed ordnance is cooled until determined by EOD/Weapons Personnel that it can be safely downloaded and jettisoned/returned to service. While cooling ordnance, the Hose Team locks their agent on that particular weaponry as a weapons cooling team. They remain locked on the weaponry unless hose control devices are installed, or until they are relieved.
- **Rescue**, when the flames are beaten back and a safe rescue path is established, the OSL directs the rescue of personnel. Team members work in pairs to evacuate one incapacitated person at a time. Background Assistance provides immediate first aid to casualties and evacuates them as necessary. Rescue and firefighting are conducted simultaneously once a rescue path is provided. While the rescue is taking place, the Hose Teams continue to cool ordnance and combat the fire until it is extinguished.
- **Residual Fire Overhaul and Re-flash Watch**, the OSL directs two personnel, wearing PFFPE and equipped with a portable fire extinguisher, to locate and extinguish any residual fires. If this Overhaul Team cannot extinguish a residual fire, the Hose Team returns to extinguish it. When the overhaul is complete and there are no residual fires, the OSL may set the Re-flash Watch. A Re-flash Watch is required whenever an aircraft is being moved or jettisoned.
- **Estimated Ready Deck and Salvage**, if aircraft must be removed from the flight deck, the OSL turns command of the scene over to the Crash, Salvage, and Rescue Officer. If salvage is not required, the OSL gives the Air Officer an estimated time to ready deck, when normal flight deck activities can resume. At this time, the Background Assistance Leader directs all hands to conduct a Foreign Object Damage (FOD) walk down to remove any debris from the flight deck that could pose a hazard to aircraft. When the FOD walk down is complete, the OSL reports “ready deck,” and normal operations resume.
Understanding of the firemain system equips Sailors to respond and assist during emergencies. In this lesson, we will explain why the ship needs a fire main system and the basic working principles the system uses to meet these needs. We will learn major components of the system and explain the purpose of each one, the monitoring and safety devices. We will look at the four main fire main systems and the major differences from one to another, procedure on handling the loss of fire main, including rigging a jumper hose.

**Terminal Objective** - Identify the purpose of the Firemain System.
- **Enabling Objective** – Identify the purpose of major components within the Firemain System.
- **Enabling Objective** – Identify the monitoring and safety devices associated with the Firemain System.
- **Enabling Objective** – Identify the types of Firemain System.
- **Enabling Objective** – Identify the procedure for handling a loss of Firemain.

**PURPOSE OF MAJOR COMPONENTS WITHIN THE FIREMAIN SYSTEM**
The firemain is a vital system to the ship because of all of the firefighting systems that it supplies seawater to, like fire hose stations, magazine sprinklers, and AFFF proportioners. It also supplies seawater to other systems on the ship such as the main and secondary drainage, flushing, fuel oil and fuel ballasting, stern tube cooling, and back up for auxiliary machinery cooling water. Pressure for the system is maintained by pumps, while distribution is through pipes and regulated by valves. Valves can be control manually, electrically, hydraulically, or automatically at various stations throughout the ship. Major segregation and firemain supply valves can be operated from the damage control deck, either manually, electrically, hydraulically, or automatically.

The firemain system. When the fire pump discharge pressure exceeds the system pressure, the fire pump discharge check valve is automatically opened by the discharge pressure of the fire pump. Likewise, this valve will automatically close when the system pressure overcomes the pump discharge pressure.

(1) The firemain system originates at the sea chest, which is a cavity or opening in the hull of the ship below the waterline, it remains flooded. It is a cast fitting or build-up structure to which pipes can be welded. Suction sea chests are fitted with gratings that remove large foreign objects, such as large fish and floating debris, from the incoming seawater. Piping carries the flow of seawater from the sea chest to the rest of the firemain system.

(2) The fire pump suction valve controls the flow of seawater from the sea chest to the fire pump. When opened, the valve allows water to enter the pump, and when shut, the valve stops water from entering the pump.

(3) The fire pump is physically located below the waterline and is used to move seawater from the sea chest to the firemain system. It is designed to deliver an adequate volume of water at a sufficient pressure. It is a centrifugal pump that may be driven by electric motors or steam turbines. The standard capacity flow ranges from 750 GPM up to 1000 GPM.

(4) The fire pump discharge check valve prevents water from flowing in the reverse direction through the fire pump and permits the fire pump output to flow to the rest of the firemain system. When the fire pump discharge pressure exceeds the system pressure, the fire pump discharge check valve is automatically opened by the discharge pressure of the fire pump. Likewise, this valve will automatically close when the system pressure overcomes the pump discharge pressure.

(5) The fire pump discharge valve is the last valve open before putting the pump on line and the first valve shut when securing the pump. This valve controls the flow of seawater from the fire pump to the pump riser, which is located on the discharge side of the fire pump leading to the firemain system. Service risers branch off the main and pump risers to various systems or components.

Cutout valves are used to isolate system components, or even the complete system. Gate, ball, globe (pump discharge), or high performance butterfly valves are considered cutout valves. They are installed on the main, on each side of the risers that lead to the services provided by the firemain. Gate valves and butterfly valves are used because they offer very little restriction to flow when they are open. Butterfly valves are fast acting for isolation and are controlled manually, electrically, or by hydraulic remote control. Pressure reducing valves allow you to decrease the pressure of firemain water that is going to be used by other systems that require water with a lower operating pressure. These valves are installed in branch lines of the firemain. They provide seawater for the flushing system, and often back-up to an auxiliary machinery cooling water system. In the open position, cross connect valves are used to connect branches of the firemain system together. In the closed position, the firemain system branches are isolated (or split) from each other. For each section of the firemain that you can isolate by using a cross connect valve, there is at least one available fire pump.

**FIREMAIN SYSTEM MONITORING AND SAFETY DEVICES**
There are a number of instruments, gauges, and controls to monitor the firemain for routine conditions and for emergencies. There are two methods used to monitor the firemain, primary and secondary.

- **Primary** monitoring of the firemain is conducted from DCC, or the damage control console in the Central Control Station.
- **Secondary** or alternate firemain monitoring and control for motor-driven fire pumps, is conducted from the Damage Control Deck or under emergency conditions, it may be conducted locally, at the pump.

On newer ships, the DC console in the Central Control Station provides the watch stander with necessary displays and controls. For all control devices, a monitoring device is located in the vicinity.

- **The local control** method is a hands-on method that uses a hand wheel, push button control, governor, a regulating device, or other manual.
- **The remote control** method uses an electrical push button, mechanical or hydraulic reach rod linkage, or other means that are not close to the valve or pump. In the hydraulic system, a hand-operated pump located on the DC Deck is used to pump hydraulic oil.
- **The automatic control** method is accomplished with self-regulating devices such as pressure regulating valves and transducers, and pressure switches and sensors. DCC and the damage control repair stations are equipped with gauges to indicate firemain pressure in segregated sections. A compound gauge is installed on the suction piping of each fire pump and a simplex pressure gauge is installed on the discharge piping from each fire pump.
Safety devices will protect personnel from injury and help avoid equipment damage.  

**-Relief valves** protect the firemain system from over-pressurization and prevent damage to the system or pump by relieving pressure at approximately 50 psig above the firemain design pressure. They are located throughout the ship at places as the Syntron, or shaft seal, flushing water systems, and on the discharge of fire pumps.  

**-Coupling guard** is a very simple but very important safety device. It protects personnel from accidentally putting a shirtsleeve or hand in to a rotating shaft.  

**TYPES OF FIREMAIN SYSTEM**

The type of firemain configuration used is determined by the function and physical characteristics of the ship. An integral component of all these configurations is the main; the main is a large diameter pipe that runs fore-to-aft of the ship and carries seawater.  

- **The single firemain** system is the least complicated system. It consists of a single main that is located near the centerline of the ship and extends forward and aft on the Damage Control Deck.  

- **The horizontal loop** system consists of two single fore-and-aft, cross connected mains. These two mains are installed in the same horizontal plane but are separated athwart ships, one main in the port side and the other in the starboard side, as far as practical.  

- **The vertical offset loop** firemain system consists of two single fore-and-aft, cross connected mains; however, the two mains are separated both vertically and horizontally. As a rule, the lower main is located below the lowest complete watertight deck, and the upper main is located below the highest complete watertight deck.  

- **The composite firemain** system consists of two mains installed on the Damage Control Deck and separated athwart ships. A bypass main is normally installed at the lower level near the centerline, and cross connections are installed alternately between one service main and the bypass main.
Flooding may be as dangerous as fire aboard ship. Dewatering flooded areas is vital to keeping the ship afloat. All ships have some means for removing liquids from within their hulls. Systems of piping, with or without pumping facilities installed for this purpose, are called drainage systems. Whether the water originates from fighting fires or flooding, it must be removed to maintain the ship's stability. Water and other fluids may have to be shifted or removed in the course of ballasting or housekeeping operations. Additionally they drain floodable voids used in counter flooding after such voids have been flooded. Another use of the drainage system is emptying fuel tanks which have been ballasted with seawater. Drainage systems provide an immediate and effective method to remove flooding water or accumulated bilge waste water.

Terminal Objective – Demonstrate an understanding of Installed Shipboard Drainage Systems.

- Enabling Objective – Identify the types, function, and components of Installed Shipboard Drainage Systems.
- Enabling Objective – Recognize personnel and equipment safety precautions while operating the Installed Shipboard Drainage Systems.
- Enabling Objective – Identify the operation of Installed Shipboard Drainage Systems.
- Enabling Objective – Identify the Installed Shipboard Drainage System Interfaces.

There are three principal types of drainage systems:

**-The Main Drainage System** – Runs throughout the main machinery compartments. However, on some ships it may extend forward or aft of the machinery compartments. For small ships the main drainage consists of a single pipe running fore and aft usually along the centerline of the ship. On larger ships, the main drainage is a loop system extending along both sides of the engineering compartments and joined at the ends. Main drainage systems may be used in many newer ships to drain floodable voids used in counter flooding, after such voids have been flooded, and to empty fuel tanks which have been ballasted with seawater. Branch suction lines leading to valves or manifolds from various bilge wells, tanks or other compartments are of smaller size than the main line.

**-The Secondary Drainage System** – Drains spaces forward and aft of the main machinery compartments. This system is used for the remote machinery spaces. The piping is smaller in size than the main drainage system piping. This secondary drainage system is independent of the main drainage system. It has its own eductors or pumps, piping, and fittings. On some ships the secondary drainage system may be cross-connected with the main drainage systems.

**-The Special Drainage System** – is an installed drainage system used for special purposes and is considered a separate portion of the secondary system. The DC books describe the design, how the system is installed onboard, and the method of operating the system. These systems are used for holding sanitary and waste water. Gravity drainage systems are used for equipment such as ammunition storage spaces located above the weather deck and are ship specific.

There are two methods of removing liquids from a space:

- **Power flow**, liquids, whether at sea or in port, can be discharged by power flow applied either as positive pressure or suction. There are four types of pumps that can be used to create power flow: electrical, steam, internal combustion, and water driven.
- **Gravity flow**, liquids can also be discharged directly over the side into the sea through scuppers or downward in the ship into bilges, tanks, or similar voids from which water is then pumped up and over the side through discharge systems.

The components of the drainage system characteristics and purpose are:

- **Piping** is a length of pipe used to form the main drainage system. It is galvanized or copper-nickel tubing to reduce corrosion. Branches go from the main system and lead into spaces to be dewatered. Normally, the suction pipe is near the lowest point in each space. One or more eductors take the suction from the main drainage system. Discharge piping goes from the pumps to outlets that discharge overboard. In order for the system to operate correctly, branches of valves are placed throughout the system.
- **Pumps** can be used to remove whatever liquid is in the space. Hoses and fittings are used to connect to a particular type of pump being used. The 2½” hose fittings are installed in the main drainage system so that the standard 2 1/2” non-collapsible suction hose may be connected. The following types of pumps are installed in main drainage systems, steam-driven reciprocating pumps (in older type ships), turbine or motor-driven centrifugal pumps, sliding shoe type pumps, and eductors.
- **Holding tanks** may contain waste water or oily water until the liquid can be disposed of properly.
- **Strainers** simply prevent debris from clogging the narrow passages in stop-check valves and eductors.
- **The Specials** – set of valves that can be aligned to allow the transfer of fluids from one or more locations to another simultaneously.
- **Gages**, there are two types of used, the Eductor Pressure/Vacuum gauge which indicates pressure or vacuum on the suction side and the Firemain Actuating Pressure Gauge which measures firemain seawater supply pressure to the eductor. Not having the correct reading could cause a malfunction within the system and not allow the space to be dewatered properly.
- **Eductors** are seawater-actuated pumps from the fire main system. They are aligned and secured to maintain control in removing liquid from bilges and compartments. They take suction on the main drainage system, and can be operated either locally or remotely. Eductors also take suction on the secondary drainage system, and some are portable as well.
- **Valves** control the flow of fluid. Procedure must be followed to ensure the correct valves are opened or shut in the proper sequence, or the system will not work. Drainage systems can consist of the different types of valves ranging from, check valves, stop/check valves, gate valves, butterfly valves, and remote operator valves.

**SHIPBOARD DRAINAGE SYSTEMS SAFETY PRECAUTIONS**

The Navy Safety and Occupational Health Program Manual, OPNAVINST 5100.23 (Series) and the Navy Safety and Occupational Health Program Manual for Forces Afloat, OPNAVINST 5100.19 (Series), and NSTM Chapter 593 (Series), Pollution Control describe the personnel and equipment safety precautions you must observe while operating shipboard drainage systems.
Prior to starting an eductor, you must obtain permission from the EDO while underway, or the Engineering Duty Officer (EDO) while in-port. Maintain communication with personnel while working inside the remote space when the eductor is in operation. Eductors located in remote spaces, can remove all breathing air. Ensure sufficient make-up air is provided and the space has adequate oxygen before entry in all eductor equipped remote spaces.

It is important that bilge suctions are closed at all times when not in use to prevent an open main from flooding a compartment. This situation renders the drainage system inoperative for pumping to other spaces.

When either in-port or underway, the EOSS and ships damage control diagrams must be consulted and followed step by step. Oils and flammable liquids are not normally permitted to be discharged overboard and should be disposed of according to environmental regulations.

Federal law prohibits the discharge of oil into inland or coastal waters, and there are restrictions pertaining to shipboard discharges on the high seas.

**SHIPBOARD DRAINAGE SYSTEM OPERATION**

Once there has been a report of flooding in a space, permission must be granted from the EDO, while in port, or the EDO while underway, before the eductor can be aligned for dewatering purposes. Communications can be conducted over the 2JV sound-powered phone circuit. Remember, only qualified personnel are authorized to perform dewatering procedures in accordance with EOSS. Parameters and operating limits must be monitored according to EOSS when aligning, operating, and securing the main drainage system to ensure that adequate firemain pressure is maintained throughout the ship.

The main drainage system is segregated by bulkhead stop valves. Valves can be remotely from the DC deck. They are classified as X-ray, which in effect, breaks the main into independent systems, each served by an eductor. As long as the piping is intact, any eductor may take suction from any space by opening the proper bulkhead stop and suction valves.

The eductor drainage system alignment is as follows:
- Open the overboard discharge valve, this allows a means for the firemain water to escape.
- Open the firemain valve to create vacuum (or suction) in the eductor. Ensure a vacuum is indicated on the eductor suction gauge.
- Finally, open the suction valve to commence dewatering the affected space.

Secured the eductor as follows:
- Close the suction valve to stop the suction.
- Close the firemain valve to secure vacuum (or suction) to the eductor.
- Finally, close the overboard discharge valve.

The secondary drainage system is for the remote machinery spaces. This system can be operated both locally and remotely. The piping is smaller in size than main drainage system piping. It is independent of the main drainage system, has its own eductors or pumps, piping, and fittings. On some ships the secondary drainage system may be cross-connected with the main drainage system. The secondary drainage system will use the same procedures as in the main drainage system such as aligning, operating, and securing.

All magazines with sprinkler systems have dewatering capability. Magazines which are located above and adjacent to the weather deck drain through a check valve to the weather deck. For magazines not located adjacent to the weather deck, overboard drainage is provided through deck drains in the magazine. These are fittings that penetrate the bulkhead and are approximately 12 inches off the deck. Magazines that are above the waterline use gravity flow for proper drainage. A valve is opened to drain the water from the space.

**MAINTENANCE**

Maintaining drainage systems will play a key role in how effectively the space or compartment is dewatered. The normal drainage system maintenance is assigned to the divisions that are responsible for that individual space. Personnel must check the PMS schedule for required maintenance. Keep up with the PMS for your equipment to reduce down time and a potential hazard. Components such as valves may also require maintenance. However, shipboard welders, Intermediate Maintenance Activities (IMAs), or depots will complete most repairs on installed piping.

There are several outside influences that could affect the efficiency of dewatering. One key factor is the loss of firemain pressure. Proper supply pressure from the firemain must be substantially higher than the pressure against which a particular eductor is required to operate. If the pressure is not high enough to be discharged overboard, it will simply back up through the eductor into the space, actually increasing the rate of flooding into the compartment.

Check firemain pressure and the eductor before beginning the procedure. Loss of electrical power will result in loss of firemain pressure and require eductors to be secured until the fire pumps are restarted. Battle damage could produce a loss of firemain pressure if the firemain system is damaged or could possibly clog the drainage suctions with debris. Also, hull damage could result in flooding that exceeds the capacity of one eductor.
FUNDAMENTALS OF SHIPS STABILITY

Navy ships are designed and operated with stability in mind. A stable ship is a more effective ship, and stability directly affects performance. Understanding the fundamentals and the terminology that defines it is very important to grasp the concept of stability.

Terminal Objective - Demonstrate an understanding of the fundamentals of ship stability.
- Enabling Objective - Identify terminology associated with ship stability.

Many terms define ship stability. Each term describes force acting upon the ship. Balanced forces create a stable ship. Unbalanced forces create an unstable ship.

- **Buoyancy** is an upward force exerted by a fluid that opposes the weight of an immersed object. When an object is immersed in water, it displaces a volume of water equal to the volume of the object. The displaced liquid exerts a pressure on all surfaces of the immersed object trying to force the object back up out of the water while the force of gravity is trying to force the object downward. The buoyancy is equal to the weight of the water the object displaces. This is known as Archimedes’ principle.

- **Displacement** is the weight of the volume of water that is displaced by the portion of the hull below the waterline that is equal to the weight of the ship. It is expressed in Long Tons, or LTs; one LT = 2240 lbs.

- **Stability** is the tendency of a vessel to remain upright and level at sea. Stability is influenced by a number of other factors, and has to be carefully considered as a whole, not individuals parts. Some aspects of ship stability are addressed during the ship’s design and construction while others are acted upon during operations, such as loading and unloading cargo, or ballasting and de-ballasting operations.

- **Moment** is the tendency of a force, such as a hard turn, to produce rotation or to move the ship around a particular axis (leaning). The moment of force can either restore stability to a ship or cause her to overturn or capsize. Wave action, wind, turning forces from extreme rudder swings, recoil of gunfire, and other forces, known as inclining moments, disturb a ship from a stable, resting position, inducing a heeling condition.

- **Center of buoyancy** of an object is the geometric center of the displaced volume of fluid. When the ship is at rest in calm water, it lies on the centerline and usually near the mid-ship section, and its vertical height is usually a little more than half the draft.

- **Center of gravity** (center of mass) is the point at which all the weights of the ship are considered to be concentrated. It is the point at which the entire weight of a body may be considered as concentrated, and if supported at this point, the body would remain in equilibrium in any position.

PRINCIPALS OF BOUYANCY

Two main forces determine buoyancy. When the force of gravity that is pushing the ship down is equal to the buoyancy pushing the ship up and out of the water, it is stable. When Gravity + Buoyancy = 0, the ship has achieved equilibrium.

CONCEPTS OF STABILITY

There are several terms that you need to learn to completely understand ship’s stability and how these concepts interact:

- **Heel** happens when a ship turns sharply, or waves or wind temporarily makes a ship lean to one side. This athwart ship inclination is temporary, and the ship will return to a fully upright inclination as soon as the heeling condition is rectified, such as the rudder returning to amidships after a turn. A heeling moment refers to the disturbing conditions that cause heeling. Hard turns, wind, waves, and other similar forces can cause heeling. A perfect example of this can be seen in a sailboat, when the wind acts on the sail to tilt the boat to one side. When the wind is removed, the boat returns upright.

- **Righting moment** refers to the tendency of a stable ship to right itself after a moment of force.

- **List** is a continuous, uncorrected heeling condition. This can be caused by shifting cargo, flooding, battle damage, or any other condition that changes the relationship between the center of gravity and the center of buoyancy.

- **Roll** is when a ship rocks between port and starboard on its longitudinal axis due to the movement of the ocean or high winds.

- **Draft** is an important measurement of the distance between the waterline and the ship’s keel. Essentially, this is the measure of how much of the ship is in the water. The numbers painted on this ship’s bow are used to measure the draft. Draft is used to calculate trim stability and also to determine the amount of water between the keel and the ocean floor, where known depths are available.

- **Trim** is the difference between the forward draft and the aft draft. Trim indicates whether the ship is level, longitudinally.

- **Pitch** refers to motion of the ship when it rocks between bow and stern due to the movement of the ocean.

Heel, list, and trim are measured using a device called a clinometer. Clinometers are installed at vital stations aboard ship, such as DCC, Chart House, Pilot House, the DCA’s stateroom, Main Engine Control, and on the Bridge. Clinometers consist of an air-tight curved glass tube, which is mounted on a calibrated board. The numbers to the left and right of vertical (or zero) indicates the number of degrees from center. The glass tube contains fluid with a pocket of air, basically a bubble, like a carpenter’s level. To read the clinometers reference the center of the bubble, not the ends. The center of the bubble will determine the number of degrees of heel, list or trim.

MAINTENANCE

Ship stability is maintained through careful monitoring of the material conditions of readiness and proper maintenance of watertight closures. Watertight integrity refers to the way a ship is designed and operated. To keep spaces free from water and the ship buoyant, watertight closures are designed to prevent the entire ship in the case of flooding. These closures and fittings can be secured as a preventative measure, guarding against attack or accident, and can also be secured to isolate flooding. Flooding of spaces can critically affect ship stability. Watertight integrity also aids in fire, blast, and smoke or gas containment. Watertight integrity must be maintained at all times.
BECC 20 Student Workbook

BECC-21

BATTLE AND EMERGENCY PARTY ORGANIZATION

Knowing the importance and principles of the battle and emergency party organization is imperative. This lesson introduces the battle and emergency party organization and the functions of the various repair parties and teams.

Terminal Objective – Identify the battle and emergency party organization and functions of different teams.

- Enabling Objective – Identify the battle and emergency party organization.
- Enabling Objective – Identify the functions of different teams.

The damage control organization establishes standard procedures for handling various types of damage. It also enables the CO and other command personnel, such as the OOD to apply damage control resources in a tiered approach, depending upon the circumstances and severity of the damage. The shipboard damage control organization is divided into two branches:

- **The administrative organization** is under the direction of the Engineering Department. However, every shipboard department has administrative damage control responsibilities. These responsibilities include the planned maintenance of damage control equipment, systems, and fixtures within each department.
- **The battle and emergency organization** varies somewhat from one ship to another, depending on the size, type, and mission of the ship. However, every ship’s battle and emergency organization fits into one basic structure.

Every ship’s battle and emergency organization is structured around decentralized, self-sufficient, but coordinated units. These units must be able to communicate with each other and work together or independently to control damage and quickly restore the ship’s offensive and defensive capabilities.

- **Damage Control Central (DCC)**, at the head of every battle and emergency organization, is the nerve center and directing force for the entire shipboard damage control organization. The DCA supervises DCC and the entire damage control effort.
- **Fast response units** – the Flying Squad and the In-Port Emergency Team (IET). The Flying Squad is the first unit to respond to all emergencies at sea, except when the ship is already at General Quarters (GQ). It may also be known as the At-Sea Fire Party. The IET is the first unit to respond to all emergencies in port, unless the Flying Squad is on duty. The IET may also be known as the In-Port Fire Party.
- **Hull repair party**, most ships have from two to four repair parties assigned to specific hull segments: main deck, forward, aft, and amidships, and designated as repair 1, 2, 3, and 4, respectively. On larger ships, any or all of these parties may be further subdivided, based on the size, type, and manning of the ship.
- **Propulsion Repair Party or Repair 5** is on fire room or engine room takeover capabilities, rather than on damage control qualifications. Repair 5 consists of an engineering officer and various engineering ratings. As an engineer, you will likely be assigned to Repair 5.
- **Specialized Repair Parties**, in addition to hull and propulsion repair parties, a ship may have specialized repair parties and teams, based upon the ship type and mission. These units are made up of officers and ratings with training, skills, and experience in the specialized damage control issues faced by these units.
- **Battle Dressing Stations (BDS)**, most ships have a minimum of two BDS for emergency handling of personnel casualties. Smaller ships, such as minesweepers, may have only one BDS. Few ships have the full battle and emergency organization; the minimum elements common to all ships are DCC, Flying Squad, IET, Repair 2, Repair 3, and Repair 5.

**ORGANIZATION FUNCTIONS**

Every ship is organized into battle and emergency parties, usually associated with specific repair lockers or damage control repair stations (DCRS), with specific capabilities and functions to efficiently accomplish this. Each repair party is established and trained to handle the damage and casualties that occur within its area of responsibility (AOR), whether that is a specific area of the ship, a specific type of equipment, or a specific type of damage. Under the direction of DCC and supported by the BDS, the various repair parties and teams perform most of the damage control work during an emergency.

- **Damage Control Central (DCC)** is the nerve center and headquarters for information and coordination of the damage control effort. It maintains an overview of conditions and activities on a ship-wide basis. It coordinates, directs, and initiates orders to repair parties, while receiving information from them. It receives and implements orders from Command, while keeping Command informed of damage control status.
- **The Flying Squad** is a special fast-response repair party that responds to all casualties while the ship is at sea. Its primary responsibility is to quickly respond to, assess, and control casualties until a regular repair party can respond, if needed. Its goal is to mitigate casualties without disrupting other ship operations.
- **The In-Port Emergency Team (IET)** is a special fast-response team, similar to the Flying Squad but established by the CO when the ship is in port. The IET must be prepared to handle any type of incident, but its primary responsibilities are normally to control and extinguish fires, and to control flooding and its effects.
- **Repair 1** maintains the main deck. Its primary responsibilities are to control and extinguish fires, and to repair any damage. On aircraft carriers, Repair 1 backs up and assists the air department to correct damage in the hangar bay area.
- **Repair 2** maintains forward areas of the ship, generally including the areas forward of the main spaces. Its primary responsibilities are to control and extinguish fires, and to make repairs necessary to maintain the ship’s stability, buoyancy, structural integrity, and maneuverability.
- **Repair 3** maintains aft areas of the ship, generally including the areas aft of the main spaces. Its primary responsibilities are to control and extinguish fires, and to make repairs necessary to maintain the ship’s stability, buoyancy, structural integrity, and maneuverability.
- **Repair 5** is responsible for maintenance of ship’s propulsion. Repair 5 must be able to maintain, repair, and isolate damage to main propulsion machinery and boilers, segregate vital systems, operate and repair steering controls systems, maintain and repair Internal Communication Systems (ICS), relieve propulsion personnel in the event of casualties, and assist other repair parties, as necessary.
- **Crash and salvage** team makes repairs of all types to the flight and hangar decks, and all associated equipment. It also extinguishes aircraft fires, rescues pilots and air crew, and conducts aircraft salvage operations on the flight deck.

**Battle Dressing Stations (BDS)**, manned by medical department personnel, provide advanced emergency treatment to personnel casualties. Stretcher bearers, capable of administering advanced first aid, transport casualties to BDS. On ships with multiple BDS, the BDS are well separated from each other to minimize the risk that one event makes both stations inoperable.

In addition to their specific functions, all repair parties must: repair electrical and phone circuits, give first aid and casualty transport, detect and decontaminate chemical, biological, and radiological agents; control and extinguish fires and evaluate and report the extent of damage.
The shipboard ventilation system controls the air movement within all naval vessels. There is a continuous demand on the shipboard ventilation system to deliver large volumes of air for habitability and equipment operations. Ventilation cooling is essential to maintaining electronic systems, including radars, combat information systems, and many others. Without proper cooling, many of the ship’s electronic systems wouldn’t function and the safety and survivability of the ship and her crew would be in jeopardy. Also, the ventilation system could transport dangerous smoke and fumes or flood water throughout the ship in the case of an emergency. These are the reasons it is important to be familiar with the system, its controls, and the safety precautions associated with the shipboard ventilation system.

Terminal Objective - Identify the types, purpose and safety precautions of Shipboard Ventilation Systems.

- Enabling Objective - Identify the types and purpose of various shipboard ventilation systems found on surface ships.
- Enabling Objective - Identify personnel and equipment safety precautions while operating shipboard ventilation systems.

Shipboard Ventilation Systems help supply and remove air for crew comfort, damage control, and safety. It is vital to understand the types and functions of Shipboard Ventilation Systems so that you can be responsive during normal operations, damage control scenarios, and maintenance. Along with a secondary purpose of equipment cooling, one of the main purposes of the shipboard ventilation system is to keep the crew physically comfortable and mentally alert by providing an atmosphere that enables the body to maintain proper temperature balance. Replacing or replenishing the compartment’s air keeps fresh and cool breathing air available for the crew, and helps cool components.

-Excessive Heat, propulsion and machinery spaces, galley, laundry, and magazine spaces can generate and gather heat that is not only excessive, but dangerous. The ventilation system provides cool, fresh air to reduce the heat in the compartments. Without it, Sailors would not be able to function in these compartments, and the ship’s mission could not be fulfilled.

-Stale air, shipboard compartments such as storerooms and miscellaneous equipment rooms are not normally manned and therefore have a potential for stale air. Without adequate ventilation, these compartments may contain stale, oxygen deficient air and could be hazardous to personnel.

-Explosive and toxic gases, areas where toxic and harmful gases can collect, such as areas where engines are running or around fuel tanks where explosive fuel vapors are present, require ventilation to provide fresh air and remove contaminants and harmful vapors.

VENTILATION SYSTEM CHARACTERISTICS

The many miles of ducts, hundreds of vents, and countless fans aboard ship serve to supply cool, fresh air from outside the ship to the lowest deck, and to remove hot, stale and/or toxic or explosive air from her compartments. Two main characteristics comprise the ship’s ventilation systems: supply (in-bound) and exhaust (out-bound).

-Supply, fresh air is vital for the operation and health of the crew. The supply system brings air from outside the ship and delivers the fresh air into all compartments.

-Exhaust, removes stale, hot air from inside the ship and sends it overboard and back into the atmosphere. This action not only allows for the removal of this hot, stale air, it also facilitates the introduction of cool, fresh air, just like your car needs to get rid of exhaust gases to allow the engine to pull in clean air to operate.

Air moves about the ship via separate ventilation systems. In the event of damage to one of the systems, air must continue to circulate or the crew may face hazardous and uncomfortable conditions. There are three types of separate ventilation systems moving air throughout all ships: forced air system, recirculating system, natural vent system.

-The forced air supply system uses electric motor-driven fans to draw fresh air from the atmosphere and force it through a series of ducts into the various compartments aboard the ship. Hot and stale air is removed from the compartments and the exhaust is discharged overboard. This is the typical system provided in the engineering compartments and engine rooms.

-Recirculating system, the shipboard air conditioning system (AC) is an example of a recirculating system. The AC system is the primary cooling system that circulates air through cooling coils, filters, and heaters. Navy standard air filters are installed in front of the cooling coils to prevent a buildup of dust on the finned elements of the cooling coils. A fan produces the airflow through the system. This system is usually found in berthing, mess decks, medical and electronic spaces.

-Natural vent system requires both a supply of air and the corresponding exhaust of air. The air is supplied by an open pipe or duct between compartments or from the outside atmosphere. The air is exhausted from an air-conditioned compartment for odor control, and for balancing air from compartments not requiring mechanical exhaust.

Air has to reach the lowest compartments. To accomplish this, the ventilation system has various parts that move, direct, and filter the air you breathe. Two of the most important components are screens and closures.

-Screens, ventilation screens, terminals, or diffusers are typically located within each space to distribute the air. Weather or exhaust intakes of ventilation systems are fitted with aluminum or galvanized steel screens based on 1.5 inch wire mesh. When rodent proofing or when the intake diameter is nine inches or less, a screen based on a one half inch wire mesh is fitted.

-Closures, ventilation closures are required for damage control operations; they provide a method to isolate the ventilation system in all compartments in the event of fire or other damage. These hinged covers or fire dampers are rectangular or circular devices, usually with a butterfly valve. Fire dampers may have a gear-operating device; however, there will always be a means of locking them closed. Generally, the locking is accomplished with either a pin or dog. Some ship locations, where watertight closures would not be required to segregate one part of the ship from another, are fitted with these covers.

SAFETY PRECAUTIONS

It is important that you identify personnel and equipment safety precautions involved with the shipboard ventilation system as well. There are two major, inherent dangers with the shipboard ventilation system: the spread of flooding due to unsecured passages that can carry flood waters to other parts of the ship, and the spread of fire, smoke, and fumes in the event of a casualty.
Every Navy ship is subdivided by decks and bulkheads, both above and below the waterline, into as many watertight compartments as possible, without impeding the ship’s mission. The more the ship is subdivided, the greater its resistance to the spread and containment of damage. Ventilation systems are also designed to meet strict requirements regarding watertight and fume-tight integrity, and to prevent flooding of undamaged compartments and halt the spread of fire, smoke, and toxic fumes. During a damage control situation, the decision to secure ventilation must be made on scene. Ventilation is typically left running during the initial attack on the fire with portable extinguishers. This is important for evacuating personnel and for the initial firefighters who may not be fully dressed out with breathing apparatus. Typically, ventilation should be secured when firefighters with breathing apparatus arrive on scene, or the space is abandoned by on-scene, unprotected personnel.

Some of the safety precautions are common sense, such as following procedures stated in the MRCs, but they can’t be ignored or trivialized. The MRCs are going to be your main resource for safety precautions during preventive maintenance. Other precautions can include ensuring a void has been certified gas free before entering or making sure the electrical circuit is tagged out before working on a fan motor.

**PLANNED MAINTENANCE SYSTEM (PMS)**

Preventive maintenance is vital to ensure your comfort and maintaining the shipboard ventilation system. The PMS is utilized to prevent general equipment failure and to increase the performance and longevity of ventilation equipment. The divisional Damage Control Petty Officer (DCPO) performs or supervises the PMS required for the Ventilation System. There are many factors that can adversely affect the ventilation system. For instance, the performance and safety of the system is directly impacted by the cleanliness of the screens and ducts. A large buildup of dust can not only impede the airflow, but is also a serious fire hazard.
The objectives of damage control (DC) includes taking all practical preliminary measures to prevent damage, minimizing and localizing damage as it occurs, accomplishing emergency repairs as quickly as possible, restoring equipment to operation, and caring for injured personnel. Since that is a lot of information to learn, the DC Book was created to consolidate damage control information and to make it as brief and readable as possible; therefore, understanding the parts and locations in the DC Book are so important.

Terminal Objective – Identify the purpose of the Damage Control Book.

Enabling Objective – Identify the parts and locations of the Damage Control Book.

It is important to be familiar with the DC Book and its parts and components. The purpose of the DC Book is to help Sailors learn and understand this important information easily and quickly. DC Books are specifically designed for each ship by the Naval Sea Systems Command (NAVSEA); therefore, no two DC Books are the same.

While the DCA is responsible for the Damage Control indoctrination and training of the crew, there are other resources available for Damage Control information aboard ship. The Repair Party Leader primarily uses the DC Book, as it outlines the repair locker responsibilities for that particular ship. The DC Book outlines everything from the basic components of the ship to the elaborate systems therein. The DC Book is controlled material and in many cases, it is classified as CONFIDENTIAL. A record of all books distributed is maintained by NAVSEA. The DC Book cannot be transferred without authority from NAVSEA.

The number of copies of the DC Book required on board varies from ship to ship. It is determined by the number of repair lockers onboard, the number of books required for lending, and the requirements for a permanent record. As per the NAVEDTRA 14057 Series, Damage Controlman manual, one copy is considered the “master copy” is kept current at all times by the DCA. Copies of the DC Book are available in DC central, main engine control, and each repair party locker. NAVSEA supplies enough books to fill these needs; however, replacement copies are available for books that have become unserviceable due to use. The DC Books are kept in standard stock at the Naval Publication and Forms Center (NPFC) Philadelphia. The Navy Stock Number (NSN) is located on the front cover and in the upper right or left corner. NAVSUP 2002 lists the NSN if your ship does not have a DC Book.

DC BOOK CONTENTS

The DC Book is used as a reference concerning the material features of the ship. Separated into four parts, the Book contains descriptive information, tables, and diagrams: part I - General Information, part II - Damage Control Systems, part III - Miscellaneous Systems and part IV - Electrical Systems.

Part I General Information
- Part I (a) Principal Characteristics
- Part I (b) Steering Gear
- Part I (c) Towing
- Part I (d) Ordnance Handling
- Part I (e) Medical Department
- Part I (f) Ship Damage Control Organization
- Part I (g) Personnel Protection
- Part I (h) Aircraft Launching and Handling
- Part I (i) Nuclear Blast Loading Protection
- Part I (j) Reactor Secondary Containment Boundaries

Part II Damage Control Systems
- Part II (a) Stability and Loading
- Part II (b) Subdivision and Access
- Part II (c) Drainage, Plumbing, Ballasting, and List Control Systems
- Part II (d) Tank Drain System
- Part II (e) Firefighting Systems and Wash-down System
- Part II (f) Ships Fuel System
- Part II (g) Aviation Fuel System
- Part II (h) Automotive Gasoline System
- Part II (i) Ventilation System Including the Collective Protection System
- Part II (j) Air Conditioning Chilled Water Systems
- Part II (k) Compressed Air Systems
- Part II (l) Oxygen and Nitrogen Systems

Part III Miscellaneous Systems
- Part III (a) Fresh Water Systems
- Part III (b) Flushing System
- Part III (c) Voice and Pneumatic Tubes and Message Passing Facilities
- Part III (d) Lubricating Oil Systems

Part IV Electrical Systems
- Power and Lighting Part IV (a)
- Casualty Power Supply System Part IV (c)
- Interior Communication Systems Part IV (b)
BECC 2.0 Student Workbook

BECC-28
SHIPBOARD DRAFT AND SOUND

The draft of the ship is the most important factor in ship’s stability, so measuring draft is extremely important. Once obtained, the draft is used by the Damage Control Assistant to read the Curves of Form to calculate and maintain stability. After the draft is recorded, you then sound a tank.

Terminal Objective – Identify the procedures required for taking shipboard drafts and for shipboard soundings.

- Enabling Objective - Identify procedures related to shipboard drafts.
- Enabling Objective - Identify procedures related to shipboard soundings.

The draft refers to the distance between the ship’s waterline and the lowest point of the ship or the keel. When the ship becomes heavier or lighter, the draft changes, that is why is very important to know this information in order to keep the ship from running aground.

It is important to become familiar with the terms of shipboard draft procedures.

-Roman numeral draft marks, when provided, always indicate the draft of the ship measured from the bottom of the keel. They are used for determining the displacement and other properties of the ship in connection with the Curves of Form. They are three inches in vertical projected height. Whole foot measurements are read at the bottom of the number. At the bottom of the horizontal bar, you read half foot measurements.

-Navigational draft marks are Arabic numerals which indicate the operating draft, including any projections below the keel of the ship. These draft marks are 6 inches in vertical projected height and are read at the bottom of the mark. Navigational draft marks greater than 9 feet are indicated by the last digit only. Thus, for a draft of 28 feet, the water line would be at the bottom of an 8. For a draft of 28 feet 6 inches the water line would be at the top of an 8.

-Limiting draft mark is located near the draft numerals or mid-ship. If the limiting draft mark is exceeded, then the ship's ability to survive damage or heavy weather is jeopardized. The decision to exceed the limiting draft mark rests with the CO of the ship.

-Freeboard, calculated at the mid-ship section, is a rough measure of reserve buoyancy. It is the distance in feet from the waterline to the main deck.

-Ship’s draft is the vertical distance, in feet and inches, from the keel to the waterline.

The draft is taken and logged daily on the 0400 to 0800 watch. The draft is also taken before entering or leaving port, before and after fueling, when taking on supplies, when taking on munitions, when anchoring, when mooring or entering dry dock, and when required by the CO. When in-port, the draft marks are read in feet and inches and then recorded on a form. When at sea the draft is a calculated draft based on the ship’s liquid load by the DCA. Once you have obtained the draft, it must be recorded in the Ship’s Deck Log, Engineering Log, and the DCA’s Draft Log.

Two measurements are required to calculate the mean draft, one taken forward and one aft. If the ship is listing, take the measurements at both port and starboard. If there is no list, take the measurements on one side of the ship. To calculate the mean draft, first add the two measurements, and then divide them in half. A ship’s draft is the vertical distance between the ship's waterline and the lowest section of its keel. The higher the water is on the boat, the closer the keel of the boat is to the sea floor. Measuring the draft of the boat will tell you how much of the boat is under water.

SHIPBOARD SOUNDINGS PROCEDURES

Sounding tape is used to sound tanks and voids to measure the depth of a liquid in the tank or void that the sounding tape provides access to. Soundings are taken while in-port and at sea. When the ship is underway, the Sounding and Security Watch/Rover takes and report soundings of all voids at least once during each four-hour shift. While in-port, void soundings are taken at least once a day.

Sounding tubes are one and a half inch pipes with their lower end fitted in the lowest spot of a compartment, tank, or void. The top of the tube ends in a flush deck plate that is usually located on the DC Deck or second deck. The end of the tube is closed with a threaded plug or cap.

When taking soundings, use an appropriate sounding tape, do not use a sounding tape that has been used in oil or fuel tanks to sound a potable water tank. Follow these steps when taking soundings:

- Ensure the sounding tape is dry
- Remove the cap
- Open the valve
- Lower the sounding tape
- Draw the sounding tape in
- Record the liquid level
- Dry the sounding tape
- Close the valve
- Replace the cap

When the ship is rolling it may be difficult to take an accurate sounding. Lower and raise the sounding rod or tape when the ship passes through even keel to obtain an accurate reading. If sounding a tube with a valve, first remove the cap, then slowly open the valve and listen for the sound of escaping air. Escaping air means the compartment is pressurized and may indicate partial flooding. If heard, immediately close the valve and report it to the EDO or the EOOW, who would then report to the OOD. If the sounding tube leads to a damaged compartment that is open to the sea and flooded completely, the upward rush of water or oil could prevent recapping and may flood the higher compartment. If escaping air is not heard, continue with the sounding.

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Ships are a huge maze with miles of ducts, pipes, and cables that deliver fuel, power, and water to every compartment. Within the first few minutes of an emergency aboard ship, Sailor’s ability to assess and then quickly repair damage may be the difference between life and death of the ship. Damage control (DC) diagrams are imperative when assessing damage and coordinating damage control parties. Aboard each ship are the implements required for ship survival. It is important to be able to identify the purpose of different types of damage control diagrams and the colors, symbols, and markings, which allow damage control parties to save the ship.

Terminal Objective – Recognize DC diagrams and their colors, symbols, and markings.

**Enabling Objective** – Identify the various types of DC diagrams.

**Enabling Objective** – Identify DC diagram colors, symbols, and markings.

### TYPES OF DC DIAGRAMS

Ships consist of a series of rooms called compartments, and hallways are called passageways. When the shipyard constructs a ship, a set of blueprints guide the way, once transformed, these blueprints become the detailed isometric, or equal in measurement, drawings that are issued to every ship. It is important to identify and understand these drawings in order to quickly access damage control operations.

Three-dimensional isometric diagrams show the systems of importance to damage control evolutions. The typical numbering sequence of these diagrams issued to each ship depends on the type of ship and the systems on board. On larger ships, the diagrams, or plates, may be split into two sets: one for forward and one for aft. Damage control diagrams: serve as maps and legends, help access and direct damage control operations and drills, and vary depending on the type of ship and systems on board.

#### DIAGRAM CHARACTERISTICS

There are many types of DC diagrams, but they all share the same basic characteristics. Each deck or platform is shown as a detached separate level on the diagrams or plates. Diagrams also have the following identifying marks:

- **Heavy lines** – Indicate watertight (WT) and oil tight boundaries.
- **Dashed lines** – Indicate flame tight, fume tight and non-tight (NT) boundaries and system runs.
- **Dotted lines and Crosshatched areas** – Indicate hidden boundaries and system runs.
- **Circles** – Indicate where systems pierce bulkheads. Pipes running through decks have no identifying markings.

#### DIAGRAM TYPES

DC diagrams contain information pertaining to the damage control features of the ship’s compartments, piping, ventilation, and wiring systems. Each diagram highlights specific features of the ship. The different types of DC diagrams include:

- Subdivision.
- Drainage System.
- Firemain, Sprinkler, AFFF, and Water Wash-down.
- Flooding Effects and Liquid Loading.
- Casualty Power Supply and Casualty Communications.
- Ventilation, Water, Fuel, and Air Pressure Systems.

- **Subdivision diagrams** are available for the second deck and below and the main deck and above. The main deck and above diagrams divide the ship by decks from the bottom to the upper levels. These diagrams are used to plot the ships damage and designate routes for DC parties. They blueprint the various compartments, trunks, passageways, tanks, and weather decks. Additionally they identify the locations for all doors, hatches, scuttles, and ladders. Through symbols, a subdivision diagram shows if a closure is WT, NT, fume tight, or quick acting. Finally, they show the location of gun mounts, directors, missile launchers, antennas, and platforms.

- **Drainage system diagrams** identify the main and secondary drainage and clean ballasting systems. Additionally, plumbing drains and sounding tubes are shown broken down by compartment or tank. They identify and show the location and type of installed main eductors, deck drains, scuppers, valves, and valve manifolds. They also show pumps and their location, as well as the tank stripping system and piping.

- **Firemain, sprinkler, AFFF, and the water wash-down systems** are graphically represented on individual diagrams. All valves and valve manifolds for each system are identified by type. The diagram shows the location and purpose of each pump and AFFF proportioners.

- **Flooding effects and liquid loading DC diagram** identifies the effects of flooding and liquid loads. It contains positions, type, and holding capacity of storage tanks for storage, service, and ballast for all liquids aboard the ship. It also identifies the tank compartment number, capacity in tons, list degrees, and draft changes forward and aft.

- **Casualty power supply and casualty communications** diagrams are two of the most vital, both are used in conjunction with one another. They are used to locate the panel number and location of automatic and manual bus transfers, and to re-route power for vital equipment such as pumps, guns, directors, electronics, radar, sonar, and 440-volt power supply. They are broken down by deck and compartment, and show the location of permanently installed risers and bulkhead terminals. The communications directory lists all sound powered phone circuits with their location, service to what station, and station number. The ship’s service telephones are listed by location, as well as phone number. Effective communication is restored using the casualty communication system diagram, which shows the location of X40J risers, jack boxes, and the position and number of outlets. The diagram shows the location of switchboards, terminals, and various stowage racks.

The following diagrams contain important information pertaining to the ventilation, water, fuel, and air pressure systems on the ship.

- **Mechanical, recirculating, natural flow ventilation** could transport dangerous smoke or fumes throughout the ship. The system has a series of damage control checkpoints to protect the rest of the ship from an isolated incident. The following are mapped on these diagrams:
  - Mechanical, recirculating, and natural flow ventilation systems.
  - Tightness level.
  - Supply blowers, remote blowers, closures, and dampers.
  - Exhaust ventilation systems.
  - Exhaust blowers, remote blowers, closures, and dampers.

- **Chilled Water System** circulates cold water from the ship’s air conditioning system, not only provides the crew with comfort but also is required for normal shipboard mechanical operations. The diagram maps the location and notes the purpose of cooling coils, potable water, and electronic equipment cooling.

- **Fuel Systems** show filling, transfer, and overflow, the fuel system plates map JP-5 and F-76 Fuel filling, transfer, and service stripping systems.
**Air Pressure Systems** delivers vital Low pressure (LP) and high pressure (HP) compressed air throughout the ship and are imperative to shipboard operations. The compressed air DC plate annotates routes and usages such as blow down systems, laundry equipment, sewage, chilled water expansion tanks, pneumatic tools, radar, stern tube seals, and the ship’s service diesel generator (SSDG) starting air.

**DC Diagram Colors, Symbols, and Markings**

Aboard ships, the damage control diagrams act as maps for damage control. Understanding the legend printed on damage control diagrams is key to deciphering the lines, dashes, circles, colors, and symbols. There are two formats of DC diagrams: laminated and non-laminated. **Laminated** format is used to chart and manage the progress of damage control drills and emergencies. These sets are kept readily available on a foldout hinged display in DC Central and in each repair locker. **Non-laminated** format is used in paper copies for the DCA and record keeping. They are not typically used during emergencies and drills. One complete set is designated as the ship’s master set and is used to record any changes that occurred to the ship’s structures or systems. Another complete clean and unmarked set must be maintained to turn in with the master set when it is time for updating the diagrams after regular overhaul.

Damage control diagrams are color-coded for quick assessment. There are seven primary colors or patterns found on all DC diagrams.

- **Pink** – Hazardous areas (such as JP-5 storage tanks, flammable liquid storage lockers),
- **Blue** – Decontamination stations,
- **Light green** – Battle dressing,
- **Pink striped** – Magazines,
- **Light blue striped** – CBRN-D storerooms.
- **Light green striped** – Medical/Dental.
- **Yellow** – DCRSs/DCC and radiation hazard area.

Damage control diagrams are drawn generally to a 1/16 scale, which means that one inch on the diagram represents 16 feet of actual ship. They are known as isometric drawings, meaning a measurement on the diagram represents a known actual true distance on the ship. In fact, they are so precise that measurements are often taken directly from the diagram. They are drawn in 3-D which tends to distort appearances resulting in inaccurate measurements. Measurements in the vertical direction must be made as close to the centerline as possible and at the same frame as you move up through the decks. Longitudinal measurements are straightforward, but it is still important to measure along the keel at the centerline or as close to the centerline as possible.

Damage control diagrams are full of graphical symbols. These symbols allow damage control parties to read and understand the map or damage control diagram with ease.

Along with the symbols, measurements, and color codes used to decipher a DC diagram, there are different lines.

- **Dotted lines** – Indicate hidden boundaries and system runs.
- **Heavy line** – Indicate watertight and oil tight boundaries.
- **Thin line** – Indicate flame tight, fume tight and non-tight boundaries and system runs.
Damage Control (DC) communications are vital to passing information throughout all areas of the DC organization. This quick information exchange is imperative to the ship’s survival. You will learn the components, circuits and use of the Sound Powered Telephone System. There are several other means of communication aboard ship. You must understand the components and channels for the Damage Control Wire Free Communication System (DC WIFCOM). If neither the Sound Powered Telephone nor DC WIFCOM is available, there are some secondary means of communication that can be used in an emergency. You must know the different alarms you will encounter while aboard ship. Finally, you must also know what to do if your communication methods fail.

Terminal Objective – Identify Damage Control Communications

- Enabling Objective – Identify the major components and the circuits used for the Sound Powered Telephone.
- Enabling Objective – Specify the process of using the Sound Powered Telephone.
- Enabling Objective – Identify the major components and the channels used for the Wire Free Communications (DC WIFCOM).
- Enabling Objective – Identify the function of the secondary systems for DC Communications.
- Enabling Objective – Distinguish the different alarms used in DC Communications.
- Enabling Objective – Provide the causes for malfunctions within DC Communications related equipment and methods to reestablish communications.

While the terminology may sound complicated, it is really quite simple once you get the hang of it. There a lot of information to cover about the major components and the circuits used for the Sound Powered Telephone.

SOUND POWERED TELEPHONE COMPONENTS
The sound powered phone system does not require an external source of power other than the talker's voice. It has of several components.

- Headband – The headband holds the receivers over your ears. It has an adjustable band.
- Receivers – The receivers receive messages. They can be used to send messages if the transmitter fails.
- Transmitter – The operator speaks into the transmitter to send a message.
- Cord – The cord connects the transmitter and receivers to the jack.
- Neck Strap – The neck strap supports the breastplate.
- Transmitter Button – The transmitter button must be depressed to send messages.
- Yoke – The Yoke holds the transmitter in front of your mouth.
- Breastplate – The breastplate supports the yoke.
- Jack – The jack plugs into the jack box to connect your headset to the circuit.

- Headset transmitter-receiver is designed for general use, they are not interchangeable, but you can use the earpiece as your mouthpiece if the mouthpiece should fail. The set has two receiver units in protective shells with ear cushions. Closing the push-to-talk (PTT) button connects the transmitter across the line. The receiver units are connected across the line at all times when the head set-chest set is plugged in. An electrical, alternating current produced by audio energy is impressed on the coil of the receiver unit and causes the diaphragm of the receiver to vibrate in unison with the transmitter diaphragm. In this way, the receiver generates sound waves which correspond to those impressed on the transmitter by the talker’s voice, and the speech is reproduced at the receiver.
- Handset is used primarily for one-to-one talking. The transmitter and receiver units are interchangeable. Sound-powered telephone handsets are designed for general use on a line with other handsets or head set-chest sets. Hold the handset in one hand with the receiver over one ear, the transmitter in front of your mouth, and the handset is powered by the energy of your voice. To talk or listen, push the button that is located between the transmitter and the receiver. Sound powered handsets are hardwired into the sound powered jack boxes, selector switches, and magento call stations.

TYPES OF CIRCUITS
There are three types of sound powered telephone circuits: switchboard, switch box, and string. A switchboard circuit originates from a sound-powered telephone switchboard. A switch box circuit originates from a sound-powered switch box. A string circuit consists of a series of telephone station jack boxes connected to a common line.

Each circuit consists of telephone jack outlets connected by a line or lines. Connection may be direct or may be through intermediate equipment, such as switchboards, switchboxes, or transfer switches. Repair parties must know how to switch from normal to alternate channels when necessary. There are four groups of circuits for DC Communication Sound Powered Telephone: primary, auxiliary, supplementary, and emergency circuits.
- Primary circuits provide communication for primary control and operating functions associated with ship control, weapons control, aircraft control, engineering and damage control. Vital DC primary circuits are designated JA through JZ.
- 2JZ Damage and Stability Control circuit provides vital communication between DCC, engine rooms, repair stations; weapons control center, and other critical stations. It is a two-way circuit; each repair party has its own. An easy way to remember each repair party circuit designation is to add the repair locker number plus the number ‘2’ – the circuit designation for DCC.
- 6JZ forward propulsion repair circuit provides communication with the Damage Control Officer (DCO) for coordinating DC operations in the forward propulsion control area. The Amidships circuit provides communication with the DCA for coordinating DC operations in the amidships repair area.
- 1JZ Open Bridge or Superstructure circuit provides communication for the coordination of DC facilities on the gallery deck and island structure.
- 1A Captain's Battle circuit provides communication between the open bridge, pilot house, captain’s plot, secondary com, combat information center (CIC), gunnery control stations, antiaircraft stations, weapons control center, fire control plotting rooms, DCC, secondary DCC, and flag plotting station.
- Auxiliary circuits provide an alternative means of communication in the event of damage to a primary circuit. The letter “X” that precedes a primary circuit designation identifies an auxiliary circuit. For instance, auxiliary circuit X2I reaches Auxiliary Damage and Stability while corresponding primary circuit 2JZ reaches Damage and Stability.
- Supplementary circuits are primary circuits for their principal functions. They are considered supplementary only in their relationship to DC. Supplementary circuits provide communications between various battle stations and their subordinate stations.
- **1JV maneuvering and docking circuit** provides communication between the pilot house, open bridge, secondary conning, DCC, engine rooms, emergency stations, steering gear rooms, gyro rooms, standard compass, fog watch forward and aft, and each line handling and transfer-at-sea station.

- **2JV circuit** provides communication for the coordination of the propulsion plant, auxiliary machinery, refrigeration machinery, air-conditioning machinery, and catapult control rooms. It is used to report the condition of propulsion shaft bearings and stuffing glands and for other reports to the propulsion repair station.

- **3JV engineering circuit for boilers** provides communication between each boiler operating station, each main feed pump and feed booster pump, smoke watch, DCC, control engine room, auxiliary control engine room, and Repair 5.

- **4JV engineer’s circuit (Fuel and Stability)** provides communication for the coordination of the transfer of fuel and ballast, for reporting soundings of fuel tanks and for fueling at-sea operations. Telephone outlets are provided at central control stations (CCS), DC central, secondary DC stations, propulsion repair 5, pump rooms, fuel oil manifolds, combustion control repair shops and test laboratories, fuel oil fueling stations, fuel oil sounding tubes, fueling-at-sea stations and piston engine aviation lube oil storage tank stations.

- **5JV engineer’s circuit (Electrical Circuit)** provides communication for the coordination of electrical power distribution. Telephone outlets are provided at CCS, switchboard rooms, catapult power panels, deck-edge elevator machinery rooms, missile power rooms, auxiliary machinery rooms, emergency generator rooms, IC and gyro rooms, steering gear rooms, machinery rooms, secondary damage control stations and propulsion repair station 5.

- **Emergency circuits** provide communication for the CHENG and DCA during emergencies. The emergency circuit establishes temporary communication that is required because of damage or for the control of emergency equipment. The letter “X” also precedes the circuit designation for emergency circuit designations, the letter “J” is deleted from the second digit position and added at the end of the designation.

- **X10J circuit** consists of permanent vertical riser cables installed at vital below-deck battle stations and the first weather deck above.

Telephone jack boxes are used at each end of the vertical cable. Four 200-foot lengths of telephone cable, having a telephone plug at each end, are contained on reels and stowed in each repair party locker. The portable cables are used to rig communication lines between the topside jack boxes and from these jack boxes to stations requiring emergency communication.

**CIRCUIT DISCIPLINE**

On the Sound Powered Telephone System, everyone cannot talk and listen at once. For that reason, talkers must maintain strict circuit discipline. Otherwise, the circuit could become clogged with useless conversation just when someone is trying to transmit an important message. If you must interrupt a station on the circuit, use the phrase, “Silence on the line.” There are several rules for circuit discipline:

- Only transmit official messages.
- Press the transmitter button only when you are actually transmitting.
- Use correct nautical terms; slang or profanity is prohibited. Incorrect terminology can lead to misunderstandings and inefficient damage control.
- Never interrupt another station unless you need to pass an emergency message.

When transmitting a message using the Sound Powered Telephone, you can’t just say anything you want. There are guidelines that must be followed within each and every message. In general, all messages between stations are divided into three parts: the name of the station being called, the name of the station calling, and the message that is then given. If the message is correctly received, the reply is “station being called, Aye.” If the message is not understood, the receiving station should say “Say again” after call-up.

**EARPICE AND MOUTHPIECE OPERATIONS**

There may be times when a Sound Powered Telephone becomes damaged, or when parts of it become inoperable. If the wire lead from the mouth piece into the junction box becomes damaged, transmit messages through the Sound Powered Telephone earpiece by hold the earpiece ½ an inch to 1 inch from the mouth and speak clearly into the earpiece. Then move the earpiece into position at your ear to receive the reply. If the earpiece is damaged, use the mouthpiece to communicate by holding the mouthpiece to your ear. Push and hold down the button on the mouthpiece to receive the message.

**DC WIFCOM**

The Sound Powered Telephone is not the only means of communication on the ship. The Damage Control Wire-Free Communications (DC WIFCOM) provides instantaneous communication between the repair lockers, the scene, DCC, the bridge, and the investigators. Each repair locker has a primary channel and a base station with four channels.

- **Channel 1** connects to the Repair 5 area.
- **Channel 2** connects to the Repair 2 area.
- **Channel 3** connects to the Repair 3 area.
- **Channel 4** connects ship-to-ship.

Repair locker base stations can switch between their assigned primary channel and the secondary channel. Each locker can be connected to an independent remote antenna system that enables communications throughout its respective repair zone. WIFCOM may also be used between ship control stations, such as a secondary DCC and the bridge. The DCC base station can also switch to any primary or secondary channel. Each WIFCOM repair locker base station has several major components. Each repair locker is equipped with one base station that has four operable channels. DCC is equipped with two base stations with four operable channels. There is also a base station on the bridge. The WIFCOM has four battery charging units. One battery charging unit can simultaneously charge 12 batteries. Hand held radios and antennas are also a part of the WIFCOM. A remote antenna consists of four antennas for each Repair Locker zone plus one for DCC.

**INTEGRATED VOICE COMMUNICATION SYSTEM (IVCS)**

IVCS is a computer-controlled telephone system. This telephone system consolidates the communications functions and features normally provided by several systems into a single, integrated network. It allows for station-to-station telephone conversations, conference calls, and net communications. IVCS connects with the ship's announcing system, shore telephone lines, radio communications, man-on-the-move communications, and certain battle sound-powered telephone circuits.

**INTERCOM UNITS**

Intercom unit’s circuit 4MC provides fast and dependable two-way transmission between DCC and each repair station. Using extra speakers can provide one-way communication from each repair station to its patrols; however, to do so you will need an external source of power.
SERVICE TELEPHONE
The ship's service telephone is used for day-to-day communication, but may be used as a secondary communication device in the face of an emergency. On some ships, the ship's service telephone is available for DC communications when near or at repair stations. The service telephone is not rugged and may go out of commission early in action. Electrical power is needed for the ship's service telephone to function.

IMC
1MC is the ship’s general announcing system, it is used as a means of transmitting general orders, information, and alarm signals to all areas in the ship and to all topside areas where personnel are stationed or normally located. The system consists of an amplifier-oscillator group located in the interior communications (IC) and Gyro Room, a microphone control station, and several portable microphones. 1MC control stations are located in the pilot house, secondary conning station, and in the OOD stations.

MESSENGER
There are times when many communication options do fail. Repair party personnel are trained as messengers for relaying orders and information during emergencies. Messengers will be used when all electronic methods of communication have failed. Messengers are trained to convey oral orders without errors, when possible, messengers should relay written messages.

DIFFERENT ALARMS USED IN DC COMMUNICATIONS
There are many alarms while in port and underway, these types include the collision, chemical attack and general alarms.
- **Collision alarm** has priority over all other alarms. The DC switch color is yellow.
- **Chemical attack alarm** is overridden by the activation of the collision alarm. The DC switch color is green.
- **General alarm** is simulated single-stroke gong tone. Once activated, the alarm is operated for 15 seconds. It is overridden by the collision or chemical attack alarm. The DC switch is red. The switches are located at the same stations as the 1MC portable microphones.

As with everything aboard ship, DC communication equipment is not always straightforward. At some point in your career, you might find yourself in a situation where some DC Communication equipment is missing; the inventory will not be 100% in accordance with the Allowable Equipage List (AEL). If the discovery occurs during an actual casualty or scenario, report the missing equipment to Repair Party Leader (RPL). If the discovery occurs during normal working hours, report the missing equipment to the DC Leading Petty Officer (LPO) or the Leading Chief Petty Officer (LCPO). When you encounter malfunctioning DC communications equipment, you must restore communications immediately using another phone or headset. If you cannot use your mouthpiece or earpiece for communication, or find another phone, use a messenger.

DCAMS
The Damage Control Action Management Software (DCAMS) is a ship’s visualization tool, providing real-time, tactical damage control information during casualty situations. Increased spatial awareness of casualty locations enhances the CO’s and DCA’s ability to see ship-wide status. The objectives of DCAMS are threefold: to manage casualty information, to manage equipment, and to give procedural assistance.

REESTABLISHING COMMUNICATIONS
To reestablish communications after you have evacuated the DC Repair Station, go to the assigned secondary repair station. Use the auxiliary circuit X2JZ, reestablish communications with DCC. When primary communications, secondary communications, and auxiliary circuits in the surrounding area have failed, you would use an emergency communications kit to reestablish lost communications. This kit, also known as the “Salt and Pepper Lines,” includes the X40J Emergency circuit kit. To use this kit, use the auxiliary circuit assigned to the space to contact DCC and ask to reestablish communications.
BECC-32
DAMAGE CONTROL SYMBOLOGY

During an emergency, the first priority is to secure personal safety to help facilitate arresting the situation. A repair party assembles on scene. The on-scene leader prepares a course of action while maintaining communications with Damage Control Central (DCC). Emergency information must be relayed with accuracy and efficiency to save the ship and the lives of everyone onboard. In this lesson, you will identify the procedures for plotting damage using Damage Control (DC) symbology. You will recognize symbology and apply appropriate plotting procedures.

**Terminal Objective** - Identify the procedures for plotting damage using Damage Control symbology.
- **Enabling Objective** – Recognize Damage Control symbology.
- **Enabling Objective** – Apply Damage Control plotting procedures.
- **Enabling Objective** – Identify Damage Control symbology and demonstrate Damage Control plotting procedures.

Having a reliable means to record and track the progress in combating the fire is very important. If adequate damage control communications is not maintained, the entire damage control organization could break down rapidly and fail to perform its primary functions. This could result in human loss or even loss of the ship; therefore, it is necessary to recognize DC symbology. The Navy has adopted a universal symbology standard of lines, circles, and slashes combined with simplified plotting requirements to assess damage effectively. As a member of the damage control team, it is important to recognize the acronyms and symbols. During an emergency, these acronyms and symbols will be written to report a casualty or read from a report.

Writing detailed information is important. Getting the message across effectively and with a good understanding is imperative. Too much time, though, may be spent spelling out words. In an emergency, the first line of communication is through voice transmissions. Once that has been achieved, documenting the situation using acronyms (and symbols) is the next line of communication.

### DC Acronym Table of Casualties

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
<th>Acronym</th>
<th>Definition</th>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B, C, D</td>
<td>Classes of Fires</td>
<td>FB</td>
<td>Fire Boundaries</td>
<td>OOD</td>
<td>Officer of the Deck</td>
</tr>
<tr>
<td>AFFF</td>
<td>Aqueous Film Forming Foam</td>
<td>FFW</td>
<td>Firefighting Water</td>
<td>P</td>
<td>Personnel</td>
</tr>
<tr>
<td>AMR</td>
<td>Auxiliary Machinery Room</td>
<td>FL</td>
<td>Flooding</td>
<td>PHARS</td>
<td>Portable Hydraulic Access/Rescue System</td>
</tr>
<tr>
<td>BIO</td>
<td>Biological Contamination</td>
<td>FM</td>
<td>Firemain</td>
<td>PKP</td>
<td>Potassium Bicarbonate Powder</td>
</tr>
<tr>
<td>CBR</td>
<td>Chemical, Biological, Radiological</td>
<td>F/O</td>
<td>Fuel Oil</td>
<td>QAWT D</td>
<td>Quick Acting Water Tight Door</td>
</tr>
<tr>
<td>CHM</td>
<td>Chemical Contamination</td>
<td>GQ</td>
<td>General Quarters</td>
<td>R</td>
<td>Ruptured System</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
<td>H</td>
<td>Hole</td>
<td>S</td>
<td>Smoke</td>
</tr>
<tr>
<td>CO2</td>
<td>Carbon Dioxide</td>
<td>HM</td>
<td>Hazardous Material</td>
<td>SCBA</td>
<td>Self-Contained Breathing Apparatus</td>
</tr>
<tr>
<td>CP</td>
<td>Casualty Power</td>
<td>L/O</td>
<td>Lube Oil</td>
<td>STR</td>
<td>Structural Damage</td>
</tr>
<tr>
<td>DC</td>
<td>Damage Control</td>
<td>MER</td>
<td>Main Engine Room</td>
<td>T</td>
<td>Communications</td>
</tr>
<tr>
<td>DCC</td>
<td>Damage Control Central</td>
<td>NAD</td>
<td>No Apparent Damage</td>
<td>WTD</td>
<td>Water Tight Door</td>
</tr>
<tr>
<td>E</td>
<td>Electrical Power</td>
<td>NUC</td>
<td>Radiological Contamination</td>
<td>WTH</td>
<td>Water Tight Hatch</td>
</tr>
<tr>
<td>EDO</td>
<td>Engineering Duty Officer</td>
<td>OBA</td>
<td>Oxygen Breathing Apparatus</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Using acronyms increases the accuracy and speed of communication. Reporting an emergency situation using the correct acronyms assists DCC and the repair party with obtaining an accurate status of the area. Applying lines, circles, and slashes to acronyms is Damage Control or DC symbology. Note the following three symbols using acronym A (FIRE: Class Alpha):
- The A with the line below it means a Class A fire has been engaged.
- The A with the circle around it means the Class A fire has been reported.
- The A with the slash through the circle means the Class A fire has been extinguished.

It is also important to enter critical information in the note area beneath each symbol when every stage of the casualty occurs. These notes will vary from symbol to symbol. When reporting a fire, list the time in the note field.

### DAMAGE CONTROL PLOTTING PROCEDURES

Following proper plotting procedures ensures the effectiveness of DCC. DCC must make quick decisions based on the information reported. Message blanks and DC diagrams are used to plot the area and direct the repair party to the damaged area; therefore, applying DC plotting procedures is very beneficial in addressing shipboard casualties.

When there is a situation that needs to be reported, the first response is usually through verbal communication. The next line of communication is using a message blank. Message blanks are used as a backup method of communication between DCC, DC repair stations, and repair party members. Everyone in the repair party should know how to fill out and read DC message blanks. Some of the damage control control members addressing the casualty are on-scene leaders, repair party leaders, plotters, phone talkers, and investigators.

Message blanks relay orders and information in writing. These are written in print form only to prevent any misunderstanding that can occur with cursive writing or verbal communication. Message blanks are kept as a record of events for later reference and are ship specific. The required information printed in message blanks is concise to ensure an accurate assessment.
DC DIAGRAMS

DC plots the location of the damage reported on DC diagrams. These three-dimensional, isometric diagrams identify the different compartments, decks, and platforms of the ship. They include each compartment, tank, void, and other areas designated by space numbers. A projection of the ship’s deck arrangement shows all compartments labeled and numbered and their damage control features by means of standard symbols. The systems, such as piping and communications, are represented as near to actual installations as practical.

The DC diagrams and plans are generally laminated in special frames. They can be found in the following locations: DCC, repair lockers, unit lockers, and bridge. These diagrams play a vital role in the repair party getting to the scene immediately and allowing DCC to see the location and progress of the damage. Each system is designated by colors, lettering and numerals, as well as symbols: heavy lines are used to indicate watertight and oil tight boundaries, lighter lines identify airtight, fume-tight, and non-tight boundaries; dotted lines and crosshatching are used to indicate hidden boundaries, piping, and valves. Compartments not intersected by decks or platforms are drawn as part of the deck from which they extend. Piping that penetrates a bulkhead has a solid circle showing point of penetration. There is no circle at the point of deck penetration.

Once the event has been documented on the message form and passed on to the repair locker leader, the information is relayed to DCC to plot the location of the event on the ship’s diagram. The DC diagram is the collection point for plotting active damage control situations. Plotting correct information and pointing out the right area of damage decreases the time it takes to control a particular area. The same plotting techniques are also used when filling out the message blank. There are three DC plotting methods; these methods are used to point out the area of damage on the diagram so that the information can be readily seen from DCC:

- **Line Method**, draw a diagonal line from the affected compartment and then connect to a horizontal line. Then write the compartment number along the top of the diagonal line and the compartment name under the diagonal line.

- **Box Method**, draw a diagonal line from the affected compartment. Then write the compartment number along the top of the diagonal line and the compartment name under the diagonal line. Finally, connect the diagonal line to a large box. Plot the damage in the box.

- **Column Method**, off to one side of the DC plate, make a column or series of columns with compartment numbers at the top of each column. Below each compartment number, plot damage vertically.

DAMAGE CLASSIFICATIONS

There are many classifications of damage in order to effectively relay the information. Plotting these classifications correctly is also essential in securing the emergency: electrical fire, ruptured firemain, flooding, and hole damage.
The Damage Control Organization is important because everyone must work together to keep the ship afloat. Damage Control is the responsibility of all hands, but each Sailor has a specific duty within the organization.

Terminal Objective – Distinguish the responsibilities of the Key Damage Control Personnel.
- Enabling Objective – Identify the responsibilities of the Key Damage Control Personnel.

During a damage control scenario, clear direction from the most experienced, trained, and effective leaders is the best way to ensure survival. The three main objectives of shipboard damage control correspond to the three time phases of damage control: before, during, and after your ship sustains damage.

-The first objective is to take preliminary action BEFORE damage occurs. This includes maintenance of watertight and airtight integrity, preservation of reserve buoyancy and stability, removal of fire and missile hazards, preventative maintenance, and testing of emergency equipment and DC fittings.

-The second objective is to minimize, contain, and localize casualty damage by controlling flooding, dewatering, firefighting, and caring for injured and wounded personnel during the casualty.

-The third objective is to accomplish emergency repairs and recover as soon as possible after damage occurs. This is accomplished by segregating the damage, reconfiguring systems, establishing casualty power; regaining a safe margin of stability and buoyancy, reinforcing and shoring damaged structures, and manning essential equipment.

Organization is essential to proper command and control of a shipboard casualty.
- CO has absolute responsibility for his/her command. CO is responsible for maintaining the command in a state of maximum effectiveness for war service and obligated to exert every effort to prepare the command for further service immediately after a battle or emergency action. CO is responsible for the officer’s and crew’s training and exercise in all aspects of survivability, and that they are fully aware of the adequacy and operability of all survivability systems and equipment.
- XO is responsible for carrying out the command requirements regarding survivability training, ship's readiness to manage casualties, and DC and recovery.
- OOD is responsible for acting as the primary assistant to the CO on the bridge. The OOD must be intimately familiar with the ship, its material condition, and the established procedures for emergencies. When underway, the OOD is responsible for the ship in the absence of the CO or XO.
- CDO is responsible for acting as deputy to the XO. The CDO carries out the ship's routine while in-port and takes command in the absence of the CO and XO. CDO is accountable for being intimately familiar with the ship, its material condition, and established procedures.

-DCO, the Chief Engineer (CHENG) is also the DCO. DCO is responsible for the ship's main propulsion and electrical plant, auxiliary machinery, and piping systems. DCO controls damage and supervises firefighting.

-DCa is the assistant to the DCO in damage control and firefighting, and is responsible for coordinating the ship's DC training program. DCA supervises and trains the ship's damage control in-port fire parties in emergency response and maintains the repair locker equipment. DCA conducts periodic inspections (accompanied by the department head) of all DC equipment and fittings. DCA maintains the ship's DC library, and acts as, or supervises, the duties of the ship's Gas-Free Engineer.

-The Fire Marshal is an assistant to the DCO who aids the DCA in the training of personnel and the prevention and fighting of fires. When a fire is reported, the Fire Marshal proceeds directly to the fire scene to direct the efforts of the rapid response team. If the fire is beyond the capabilities of the rapid response team, the Fire Marshal turns his duties over to the Scene Leader of the at-sea fire party and assumes other duties as directed. Fire Marshal then assumes a broader role by directing logistic support to the at-sea fire party. According to the magnitude of the casualty, the Fire Marshal makes recommendations for additional personnel or a recommendation to go to General Quarters (GQ). If GQ is called away the at-sea fire party is relieved, the Fire Marshal may be assigned other duties such as Repair Party Leader.

-The Damage Control Petty Officer (DCPO) is a qualified senior Petty Officer in each division who learns all phases of DC for the ship, firefighting, and Chemical, Biological, and Radiological (CBR) defense procedures. The DCPO assists in training division personnel in damage control, firefighting, and CBR defense procedures. The DCPO prepares and maintains the Compartment Check off List (CCOL) for all division spaces. This listing covers the DC fittings in a space. The DCPO supervises the setting of specified material conditions (X-ray, Yoke, and Zebra, etc., as covered in Material Conditions of Readiness) within division spaces and makes required reports. The DCPO supervises planned maintenance of DC equipment in division spaces and conducts daily inspections of division spaces for fire hazards.

-The Damage Control Repair Station (DCRS) or Repair Locker, and its associated Repair Parties and Teams will perform the majority of the actual work done to save the ship in the event of an emergency. Most sailors will serve as a member of these teams. These teams maintain communication with DCC, other repair stations, and its own subdivisions and patrols. These patrols include teams from the parent repair stations (such as firefighting, desmoking, or dewatering), the unit patrol stations, and the unit lockers. The repair party's equipment and material for affecting repairs and otherwise controlling casualties are stored in the Repair Party Locker and within the DCRS area of responsibility with the following guidelines: Repair party personnel and equipment must not be concentrated; dispersion of personnel and equipment is mandatory to avoid the possibility of destroying entire parties in a single casualty; and label designation is used to identify the team and equipment function area. The number of repair lockers and their locations are provided in each Ship Information Book (SIB). The size of the ship determines which repair lockers are onboard.

-Department heads are held responsible for maintaining optimum material conditions of readiness, as provided by the DCA and prescribed by the CCOL within their department. They ensure that damage control equipment and fittings are operational and maintained in their proper locations, and that any deficiencies in damage control equipment are reported to the DCA. As required by the ship's organization bill, they assign personnel to damage control, repair, and fire parties, while coordinating with the DCA to train personnel in damage control matters.
-Division officers train division personnel and take all practical preliminary measures to avoid damage. To ensure that all DC equipment, closures, and fittings remain in the best possible condition, they conduct periodic inspections of division spaces. For their division, each division officer prepares a Watch, Quarter, and Station Bill that specifies where their personnel fit into the ship’s organizational picture.
WATERTIGHT CLOSURE IDENTIFICATION

Wetartight closures are extremely important to a ship; they have so many different functions. The primary function of the watertight closure is to allow access. The secondary function is to control the spread of fire, toxic vapors, and smoke and to prevent progressive flooding. Containing flooding is one of the most important things we can do on a ship. By using watertight closures we are able to safely maintain the buoyancy of the ship.

Terminal Objective – Identify the types and use of watertight closures.

- Enabling Objective – Identify the different types and characteristics of watertight closures.

The primary need of a watertight closure is to provide access, though there are many other different types of needs across the ship for watertight closures. There are multiple types of watertight closures in order to fit every need. The three main types of watertight closures are doors, hatches, and scuttles.

WATERTIGHT DOORS

Wetartight doors are hinged metal panels on bulkhead openings and are used between various compartments of a ship to provide access in places of routine passage and also in compartments that are not highly used and do not require rapid access. There are four different types of watertight doors on the ship:

- **Individually Dogged Watertight Doors** provide access to compartments that are not high usage spaces and do not require rapid access, for example paint lockers, deck gear lockers, or storerooms. To open or close these types of door manually move each dog individually. Most doors have between four and ten dogs. Steel doors are used for strength, aluminum doors are used to reduce ship displacement, and glass reinforced doors are used to reduce the magnetic signature of the ship.

- **Quick-Acting Watertight Doors** are used for routine passage and access into the superstructure from weather decks, main passageways, or manned spaces. They are usually placed in high traffic areas because they are quicker and easier to open. They have a single lever, which operates all dogs simultaneously.

- **Balastic Doors** are armored closures installed in armored bulkheads, intended to resist the direct impact of projectiles such as splinters, fragments, and machine gun fire. Because they are designed to protect, balastic doors are really thick, same thickness and material as bulkhead plating. They can be quick-acting or individually dogged.

- **Balanced Joiner Doors** are located near watertight doors and hatches, have a metal pipe cast into the hatch cover to allow access. The secondary function is to control the spread of fire, toxic vapors, and smoke and to prevent progressive flooding so many different functions. The primary function of the watertight closure is to allow access. The secondary function is to control the spread of fire, toxic vapors, and smoke and to prevent progressive flooding. Containing flooding is one of the most important things we can do on a ship. By using watertight closures we are able to safely maintain the buoyancy of the ship.

HATCHES

A hatch is an access opening in the deck of a ship that is fitted with a hatch cover for watertight closure; mainly installed in areas where rapid access is not required. In high traffic areas, watertight hatches have scuttles attached to them to allow you to open and close them quickly. They are used for storage on load or offload and also for heavy equipment access.

- **Flush hatch** are installed in areas such as flight decks, hangar decks, cargo decks, passageways or areas of relatively high traffic where a flush deck condition is required to eliminate tripping hazards or to maintain a smooth trucking surface.

- **Raised Quick-Acting Hatch** are equipped with counter-balance torsion springs on the hinge assembly to allow the hatch to be easily opened from below by one person. These hatches are normally installed in machinery space escape trunks.

- **Flush Hatch** is installed in areas such as flight decks, hangar decks, cargo decks, passageways or areas of relatively high traffic where a flush deck condition is required to eliminate tripping hazards or to maintain a smooth trucking surface. Ramped low profile hatches also eliminate the need for trough drains in weather deck areas. Whenever possible, ramped low profile hatches are preferred over flush hatches in weather decks, as they eliminate the problem of corrosion and debris that usually accumulate in the trough area and recessed hinge pockets of flush hatches.

- **Balastic Hatch** is installed in a balastic armored deck. They are spring balance counterweighted or hydraulic operated. An automatic catch assembly holds the hatch open. The hatch and deck are of the same material and thickness.

SCUTTLES

Scuttles are circular watertight closures usually found between decks and often within hatches. They have a single hand-wheel which operates all the dogs at the same time. This allows the scuttle to be secured quickly.

- **Raised Watertight Scuttles** are installed in hatches and decks in interior and exterior areas where rapid access is required. They may be used as an emergency egress or alternate access to berthing, machinery spaces or storerooms.

- **Flush Watertight Scuttles** are installed in areas such as flight decks, cargo decks, hangar decks, passageways, or areas of relatively high traffic where a flush deck condition is required to eliminate tripping hazards or to maintain a smooth trucking surface. Trough drains are required for flush scuttles in weather decks.

- **Ramped Low Profile Scuttles** are installed in areas where a minimum height ramped scuttle would not be detrimental to shipboard vehicular traffic or pose a tripping hazard. Whenever possible, ramped low profile scuttles are preferred over flush scuttles, as they eliminate the problem of corrosion and debris that usually accumulate in the trough area, and also eliminate the need for trough drains.

- **Balanced Armor Balastic Scuttles** are 18-, 21-, and 25-inch diameter clear openings. Balanced armor scuttles are used as secondary or emergency access through a deck, bulkhead, or hatch cover. These scuttles are spring-balanced and are held open by an automatic catch assembly.

MICSELLANEOUS CLOSURES

Other than doors, hatches, and scuttles, there are a few other watertight closures on the ship. These include manhole covers, portholes, air test caps, and deck drain valves.

- **Manhole cover** is a round or oval metal cover secured by bolts or studs to a deck or bulkhead access opening. They may be raised or flush, and may have hinges. They openings into unmanned spaces, usually tanks or voids, for purposes of inspection and maintenance, and are fitted with covers that are designed to maintain watertight integrity and security from hazardous fluid. They have a gasket between the cover and deck or bulkhead to maintain their watertight integrity. Different gasket materials are used depending on what liquids or gases are being contained by the manhole cover.

- **Air-ports or portholes** are round, rectangular, or square closures located in the superstructure. They are used as windows and also for ventilation purposes. Portholes are equipped with a gasket and drop bolts to maintain watertight integrity.

- **Air Test Caps (ATC)** are located near watertight doors and hatches, have a metal pipe cap threaded onto a short pipe nipple. They are used to connect air test equipment to watertight compartments.
Deck drain valves are basically strainers which can be found in galley spaces, sanitary spaces, and even in some working spaces. They are used to drain water. The water may be drained to the ship's Collection, Holding, and Transfer (CHT) system or it may be routed directly overboard. During GQ, they are used as closure devices to prevent the possibility of back-flooding spaces.
The primary function of these closures is to allow access. The secondary function is to control the spread of fire, toxic vapors, and smoke and to prevent progressive flooding. It is important that these doors, hatches, and scuttles are maintained so they will function properly, especially in the event of an emergency.

**Terminal Objective** – Identify the functions of the components of watertight closures.

- **Enabling Objective** – Identify principle parts of watertight/airtight closures.
- **Enabling Objective** – Identify the procedures for operating watertight closures.

It is important to understand the component parts of watertight closures when performing maintenance on them. It is necessary to identify the different principle parts of the watertight closures needed to know when completing a closure inspection, if principle parts are missing or damaged, and how to replace them. There are many types of watertight closures on a ship. The closures we will be focusing on are Quick-Acting Watertight Doors (QAWTD), Individually Dogged Watertight Doors (IWTD), Watertight Hatches, and Scuttles. There are four main parts of an IWTD: the gasket, the knife edge, the dogs, and the hinges.

- **The knife edge** is an inch deep piece of metal that juts out from the door’s frame. It forms a watertight seal with the rubber gasket when contact is made. Some of the things to look out for include rusting, damage, and distortion of the knife edge. Also, there should never be paint on the knife edge, as the paint interferes with the seal.

- **Gaskets** are installed in doors, hatches, and scuttles. When a closure is secured, the gasket and knife edge form a watertight seal. The gasket is very essential to the watertight integrity of the closure. The rubber must be soft and pliable and have no cracks. Deterioration of a gasket occurs when exposed to oil, grease, heat, or paint. Faulty gaskets are a main source of leakage through closures. To check for a successful watertight seal, use a chalk test; which will determine if the gasket is in continuous contact with the knife edge when a closure is dogged. In order to perform a chalk test follow these steps: Clean the knife-edge, clean the gasket, rub chalk on the knife-edge, close and dog the closure tightly, while the closure is dogged down, check for any loose dogs. If any dog is loose, it will need to be adjusted and the chalk test repeated; open the closure and observe the imprint of the chalk on the gasket. The chalk imprint should be in the center of the gasket. If the chalk line is not continuous, the closure is not watertight and requires further adjustment or repair.

- **Dogs** are designed to hold doors, hatches, and scuttles closed while maintaining a watertight seal. They can also be linked together, allowing you to open or close the watertight edge quickly. There are two types of dogs on the ship, quick-acting and individual dogs. There are many parts to a dog.

- **Flanged bushing** is a non-corrosive anchor point that allows spring expansion and compression. It is held in place with a set screw. The flanged bushing also serves as a guide when inserting the dog shaft through the bulkhead.

- **Spring** rests around the dog spindle between the flange bushing and the straight bushing. As a dog spindle is adjusted, the spring compresses, expands, and applies pressure to maintain the adjustment.

- **Straight bushing** is located inside the door penetration, is made of non-corrosive metal. It moves in or out, with pressure from the spring alignment and adjustment, to keep the dog spindle in place.

- **Stick Packing** is made out of greased plastic and cotton. It is inserted through the shaft of the dog and forms a watertight seal.

- **Fucking Plunger** is threaded screws into the dog spindle. It forces the string packing out of a lubrication hole on the spindle, which enables you to lubricate the spindle, bushings, and spring without removing the dog and losing the watertight integrity.

- **Hinges** of watertight closures have a component called the hinge pin. It locates the closure correctly in relation to the knife edge and gasket to form a seal. On a watertight door, the pin holds the door in an upright position, whether it is open or closed. Severely corroded hinge pins and heavily painted hinges make the door difficult to close.

**SAFETY FEATURES**

- **Watertight Door**, a watertight door slamming shut will damage the door’s gasket and could seriously injure a person. To prevent it, a door catch is installed for each shipboard door.

- **Hatch** has perimeter stanchions along with chains to protect personnel. Two hatch stanchions are used to secure the hatch when opened. Raising a hatch is a two person operation. Stanchions are secured using toggle pins. Be sure all toggle pins are correctly in place.

- **Scuttle**, watertight hatches with scuttles also has perimeter stanchions along with chains to protect personnel. To secure the scuttle, a brace link assembly is used when opened. Make sure the brake link assembly is in good operating condition and that it locks in place when the scuttle is opened.

**PROCEDURES FOR OPERATING WATERTIGHT CLOSURES**

There are three types of closures that require specific operating procedures: an individually dogged watertight door, a hatch, and a manhole cover. Each of these closures has different methods of operation. Closures must be secured evenly and correctly to prevent warpage. There are two different types of watertight doors that are used on ships: the Quick-Acting Watertight Door and the Individually Dogged Watertight Door. To dog an individually dogged watertight door, first close one dog that is opposite of the hinged side, then close two dogs that are on the same side as the hinges. Then close the remaining dogs in a crisscross pattern. To undog an individually dogged watertight door, first loosen the dogs on the hinged side of the door, and then loosen the remaining dogs. The last dogs you loosen should be those opposite the hinged side of the door.

To open the Scuttle, grasp the hand-wheel with both hands, the hand-wheel should spin easily when turned. Push the scuttle open and push down the scuttle top. To dog a watertight hatch, you must bolt it down. First, attach all the drop bolts loosely and then tighten them by hand. Next, get the appropriately sized wrench, and tighten the bolts opposite the hinge. Finally, tighten the bolts on the hinge side and then continue to tighten all the remaining bolts evenly. To undog a watertight hatch that is secured, always loosen the dogs on the hinge side first. Then loosen the remaining dogs. Hatches are equipped with counter-balance torsion springs on the hinge assembly to allow the hatch to be easily opened from below by one person. After the hatch has been opened, it must be braced in order to stay open. Brace pipes are attached permanently to the hatch cover. Once the hatch is up, the brace pipes are fastened to the toggle bolt in order to hold the hatch open. To properly secure manhole covers first, we put the nuts on and hand-tighten them. Then, using the appropriately sized wrench, we tighten them evenly in a crisscross pattern. We continue with this pattern until each bolt has been tightened at least three times.
DCPO onboard ships are responsibility for inspecting and maintaining watertight closure integrity throughout the ship, especially when in battle or traveling through heavy seas. Watertight closures help protect the ship from the worst weather or flooding conditions. While performing maintenance assignments, your responsibilities include recognizing common closure discrepancies, proper inspection and maintenance procedures for gaskets, and for balanced joiner doors.

**Terminal Objective** - Demonstrate an understanding of the procedures for inspecting and maintaining watertight closures.

- **Enabling Objective** - Identify common closure discrepancies.
- **Enabling Objective** - Identify the proper inspection and maintenance procedure for gaskets.
- **Enabling Objective** - Identify the proper maintenance procedures for balanced joiner doors.

### COMMON CLOSURE DISCREPANCIES

Inspections identify any discrepancies before they lead to a catastrophic watertight failure. Not properly evaluating watertight integrity could lead to significant maintenance problems. These signs include loose, missing, or damaged parts, parts that have excessive wear, such as hinge pins or dog wedges. Also, distorted or deteriorated metal surfaces and cracked or broken welds, as well as bulkhead penetrations, like stuffing tubes. Ensure the gasket, does not have an indentation made by the knife edge, if so, such indentation should not be more than an eighth of an inch deep. When in freezing conditions, make sure the rubber gasket is still pliable and has not hardened. If so, it will not form a seal. Make sure there is not a lot of dirt or debris on flush deck scuttles, as it will interfere with the watertight seal. Make sure the t-slot wrench is stowed in the bracket located on or near the closure since they are needed to open the scuttle. When inspecting a stuffing tube, make sure the packing gland nut is tight. If it is loose, tighten it. Insert an additional turn of soft packing when tightening the gland nut. You must be careful not to over-tighten the gland nut. Too much packing pressure will cause necking of the electrical cable, and may lower the resistance of the cable’s insulation.

### CLOSURE GASKET INSPECTION AND MAINTENANCE

Gaskets are rubber material that is installed on watertight closures to provide a watertight fit all around by bearing against the knife-edge. It is important to inspect and maintain the gaskets of doors, hatches, and scuttles for watertight integrity according to the PMS schedule throughout the ship’s lifecycle. To replace the gasket in accordance with (IAW) NSM 600, the following tools are needed: small rotary wire brush, rubber gloves, flat-tip screw driver, electric drill, vice grip pliers, hearing protection, razor knife, goggles, paint brush, clean rag, scissors, gasket spool, and chalk.

To inspect a gasket, first ensure that it is soft and pliable, and that it is not cracked, inspect the condition of the joint; it should be on the top of the door and there can be no gap there. The knife edge causes a groove in gaskets; ensure the groove is not greater than an eighth of an inch deep. If any of these discrepancies exist, replace the gasket. If these conditions do not exist, then clean it.

- **To remove the silicone gasket and prepare the surface for the new gasket:**

  1. Locate the gasket joint.
  2. Make a V-shaped cut with a razor knife completely through the gasket on one side of the joint, and remove the wedge of gasket material.
  3. Pull the two ends of the gasket from beneath the channel with a screwdriver, and clamp the ends together with vise grip pliers. Using the vice grips as a handle, stretch the gasket and pull from the channel around the entire door. The wearing of eye protection is recommended prior to performing this action.
  4. Clean all debris and corrosion from the inside of the gasket channel. A small rotary wire brush, chucked in an electric drill, is effective for removing this corrosion. Don’t forget to insert your hearing protection and ensure your eye protection is still secure.
  5. Prime the inside of the gasket channel with Formula 150 epoxy polysamide primer.
  6. When the first coat is dry, apply a topcoat of Formula 151.

- **To install a gasket:**

  1. Unroll enough gasket material to fit around the door using the door as the template. Make sure it is cut long enough so it can go around the door, and have an extra inch of length at the end. Cut the gasket. When cutting the gasket to length, make sure that both ends are cut square to ensure they will mate well.
  2. Apply silicone compound on the gasket. CAUTION: Do not use petroleum-based products on the gasket.
  3. Start at the top of the door and push firmly, so that the gasket is tightly fitted into the channel. Make sure the beveled side faces the inside of the channel.
  4. When you arrive at the gasket joint, force the extra inch of gasket into the channel.
  5. Remove the excess silicone compound from the gasket with a clean rag.

- **After gasket installation check for watertight.** A simple chalk test will tell us if the gasket is in continuous contact with the knife-edge when the closure is dogged.

  1. Wipe the knife-edge clean with a dry rag.
  2. Wipe the gasket clean with a dry rag.
  3. Rub the chalk on the knife-edge.
  4. Close and dog the closure tightly.
  5. Inspect for loose dogs.
  6. Open the closure and observe the imprint of the chalk on the gasket.

### BALANCED JOINER DOOR MAINTENANCE

Balanced Joiner Doors are mainly used between two areas of potentially different air pressures. Identifying the proper maintenance procedures for balanced joiner doors are important for allowing for easy opening in case of severe pressure differential. There are three types of doors: Steel Products manufactured door (steel and aluminum based), Three Ellison Bronze manufactured doors, which are the NAVSEA 129, 139BN and 139CN models, and Puget Sound Naval Shipyard manufactured door.

To perform maintenance on a balanced joiner door, properly identify the manufacturer and model, as well as applicable Allowance Parts Lists (APL) and Maintenance Requirements Cards (MRC).
Dewatering is a very important aspect of the Damage Control (DC) plan. It is important to familiarize yourself with the pumps used in dewatering and their operating procedures. In this lesson, we will discuss the portable AC submersible pump, portable eductors, and the P-100 pump.

Terminal Objective - Identify the use of Portable Dewatering Equipment.
- Enabling Objective - Recognize the operating procedures for the electrical submersible pump (ESP).
- Enabling Objective - Recognize the operating procedures for educators.
- Enabling Objective - Recognize the operating procedures for the P-100 pump.

Electrical Submersible Pump
The portable, alternating current (AC) submersible pump is one of the pumps used to remove unwanted liquids from shipboard compartments. All damage control repair party member have to be familiar with the operating procedures for this type of pump. The ESP is a basic pump used to dewater compartments. It is mainly utilized to remove uncontaminated salt or fresh water. The pump’s motor is cooled using the water that is being pumped through it. Therefore, the water needs to be cool to keep the motor cool. Normally, only water is pumped using the ESP. However, in an emergency, the CO can give permission to use the ESP to remove fuel. The portable ESP has few components: pump handle, Foot Valve Assembly, Suction Hose, Discharge Port, Basket and Star Strainer, and Power Cable and Control Switch.

- Pump handle it attaches to the threads of the discharge port, it provides a means for carrying an inactive pump. It is never installed during operation, because the handle would block the pump’s discharge.
- Foot valve includes a check valve mounted in a threaded housing; it is used to prevent the pump from losing suction when the pump is operating while not submerged. It is connected to a length of suction hose which is, in turn, connected to the pump suction port, but it may also be connected directly to the suction port. The foot valve is always used with the basket strainer mounted on the suction end.
- Discharge port, the fluid is pumped through the discharge port into a 2-1/2-inch diameter standard fire hose and directed to a drain or overboard discharge.
- Basket strainer is installed onto the foot valve assembly, and prevents debris from clogging the impeller when the pump is used but not submerged.
- Star strainer screws onto the suction port and surrounds the entire pump frame. It is used in heavily contaminated waters to screen out debris or foreign matter large enough to clog or damage the pump when the pump is used in a submerged operation.
- Power cable, check for defects where it passes through the case to the motor, into and out of the control box, and the plug. Handle the pump with the fifty foot, two inch round nylon rope, called the handling line.

Safety
There are some very important safety precautions concerning the operation of this pump:
- Always keep the handling line, electric cable, and discharge hose clear so that you can remove the pump quickly.
- Ensure that all hoses are free of kinks and sharp bends.
- Keep the discharge flow unrestricted.
- Use the slip-on basket strainer to prevent debris from clogging the pump.
- Ensure that the suction lift and discharge head are as low as possible.
- Always make sure that the suction end of the pump or the end of the suction hose is in the water while the pump is operating.
- Never use the submersible pump around explosive fumes.
- All personnel need to stay out of the water when you use the submersible pump.
- Wear rubber boots, approved electrical safety rubber gloves, and stand on a rubber mat to prevent the possibility of electrical shock.

Operation
The compartment must have at least 6 inches of water to create enough suction to start pumping. Once suction has been establish and pump started, pump down all the way to 1 inch of water. Keep the strainer clean during its operation. To use the ESP perform the following procedures:
- Ensure the appropriate strainer is attached.
- Unscrew the handle and attach the discharge hose to the pump.
- Lower the pump or the suction hose into the water with the rope handling line.
- Turn the control switch to the ON position when the pump is in position.
- Prime the pump with water, if necessary.
- Keep the suction end of the pump or suction hose in the water while the pump is operating.
- Check the strainer periodically to ensure that it is clean at all times.
- Monitor the pump to ensure that it does not run dry.
- Turn the switch OFF and secure the equipment when pumping is complete.
- Wash the pump in fresh water, wipe it clean, and dry it in accordance with the PMS requirements.

Portable Eductor
Portable eductors are used to remove unwanted liquids from shipboard compartments. Sometimes these pumps are also used in conjunction with other devices. These pumps are very versatile and are operated by themselves, or used in tandem with other dewatering pumps. They remove water when used as portable and as installed devices. They can pass reasonably small particles of material through them as well. Another major advantage of the eductor over the ESP is that they can be used to pump out compartments containing gasoline, oil, or any type of fuel, as there is no danger of combustion, because eductors have no moving parts, and are not powered by electricity, thereby eliminating possible ignition sources.
Eductors are jet-type pumps that have no moving parts. It contains jets, or nozzles, that water flows through, under pressure. The firemain or a P-100 pump supplies the actuation water that enters the eductor through the supply connection. The velocity of the water increases while flowing through these nozzles and creates a vacuum in the suction area of the eductor. Either the suction port of the eductor is connected to a non-collapsible hose or the eductor is completely submerged to remove the water. The eductor discharges approximately double the amount of water it is supplied. There are two types of eductors, one type is the Peri-Jet and the other is the single jet, or S-Type. Both the Peri-Jet and the S type eductors may be present in dewatering operations. They can also be used in engineering compartments to augment the main drainage system or other large compartments with significant flooding. Keep in mind that the eductor discharge is approximately twice the amount as that supplied to the eductor. This particular feature makes it good for dewatering contaminated areas. It has a 2 ½ inch supply fitting, a 4 inch discharge fitting, and a 3 inch suction port. Keep it on a slight angle to prevent the suction opening from becoming stuck to the deck. This eductor has a 4-inch discharge port, it is rated to dewater at a rate of 162 Gallons per Minute (GPM).

To use the Peri-Jet eductor, you need to perform the following procedure:

- Stage the Peri-Jet, hoses, and other major components in an area with a compartment to work, locating the nearest fireplug and removing the wye-gate, locating the nearest overboard drain or path overboard, and estimating the lengths of the hoses that are needed.
- Connect the male end of the 4 inch discharge hose to the 4 inch female connection on the eductor and hand-tighten the fitting.
- Ensure the hoses have no bends, kinks, or obstructions, connect the male end of the 2 ½ inch fire hose to the female supply fitting on the eductor and hand-tighten the fitting.
- With hoses attached, lower the Peri-jet eductor into the compartment to be pumped.
- With the wye-gate removed at the fire station, attach the female end of the 2 ½ inch supply fire hose to the fireplug. Also connect the female end of the 4 inch discharge hose to the overboard fitting, or route it overboard. Hand-tighten the fittings.
- Open the fireplug on the fire station. This allows the firemain water pressure to activate the pump. The liquid in the compartment is now pumped overboard.

The S-Type eductor uses water pressure to create a vacuum, and suction water out of a compartment, however, it uses only one jet and it has a 1 ½ inch firemain supply connection and 2 ½ inch suction and discharge connections. It has a rated dewatering capability of 100 GPM. The carrying handle screws onto the 2 ½ inch threads of the discharge port, and like the AC submersible pump, the handle must be removed for operation. To use the S-Type eductor, perform the same steps you would use to employ the Peri-Jet, with the exception of the hose and connection sizes.

**P-100 PUMP**

The P-100 pump is a commercial, diesel engine-driven, portable pump unit, designed for firefighting and limited dewatering functions aboard ships. It can be fueled with either JP-5 or F-76 fuels; JP-5 is the preferred fuel. It is probably the most versatile firefighting pump you will use. Its primary purpose is to provide you with an emergency firefighting water source and its secondary purpose is for compartment dewatering. It is vital to understand the operating procedure for this highly effective damage control tool.

For firefighting use, the P-100 draws water from the sea and pumps the water through hoses to supply the firemain or individual fire hoses. When used for dewatering, it takes suction on a flooded compartment and discharges it into the sea. It is capable of pumping 100 GPM, which is a little less than the electrical submersible pump; however, you can use a portable eductor in tandem with the P-100 pump to increase the volume and dewatering rate.

The unit contains a diesel engine, a centrifugal pump, an exhaust driven primer valve, a discharge valve, the recoil starter, a discharge pressure gauge, and a one point four five gallon fuel tank.

- **Engine** – air cooled, single cylinder, four cycle diesel engine rated at 10 horsepower.
- **Centrifugal Pump** – single suction, single stage centrifugal pump, rated at 100 GPM.
- **Primer Valve** – jet-type ejector that evacuates air from the pump casing and suction hose.
- **Discharge Valve** – allows for the discharge of pumped water.
- **Recoil Starter** – contains a rope and handle, used to start the unit, and the rope is recoiled into the unit upon each pull.
- **Discharge Pressure Gauge** – displays discharge pressure.
- **Fuel Tank** – 1.45 gallon tank.

**SAFETY**

There are some extremely critical safety precautions concerning the operation of the P-100 pump:

- You need at least two Sailors to carry the P-100 pump since it weighs 164 lbs.
- Use an exhaust hose if you operate the P-100 in confined compartments so that it vents carbon monoxide exhaust gases outside.
- Use the foot valve and strainer on the suction hose and keep them clean at all times.
- Be sure suction is taken from uncontaminated water, clear of mud and trash.
- Keep the discharge flow unrestricted.
- Wear hearing protection at all times while operating the pump.
There are 14 distinctive steps that need to be taken to operate the P-100 pump for dewatering.

- Check the engine oil level before starting the engine. It must be at the proper level, or it cannot be started.
- Connect the suction and discharge hoses. Where required, connect the exhaust hose. A strainer with openings not larger than ¼ inch mesh must always be used on the end of a suction line when pumping water from draft. Check all gaskets and make sure the fittings are tight. Submerge the suction intake.
- Close the pump drain valve and all other openings in the pump casing.
- Close the pump discharge check valve all the way for lifts of 10 feet or more or partially open for lifts of less than 10 feet.
- Set the fuel tank isolation valve, located under the fuel tank, to the open position.
- Set the engine throttle control to the "START" position.
- Open the primer line shut-off valve between the primer jet and the pump suction.
- Slowly pull on the recoil starter checking engine and pump for freedom of movement and priming the engine with lubricating oil. Depress the compression release lever ensuring that it remains depressed. The compression release lever will spring shut when the engine rotates during starting attempts.
- Start the engine by pulling the recoil starter rope.
- Once the engine is running, set the engine throttle control to the "RUN" position.
- Shift the exhaust valve to the prime position blocking the main exhaust opening. The exhaust valve is in the prime position when the handle is horizontal. When a steady stream of water appears at the discharge of the priming jet, close the primer line shut-off valve and return the engine exhaust valve to the normal position. Open the pump discharge valve.
- Repeat the priming operation if the pump fails to hold its prime. If the pump does not deliver water within two minutes, stop the engine and check for air leaks at suction connections and/or the pump packing gland, or failure of the priming jet to produce vacuum.
- Monitor the pump discharge gauge and fuel tank level occasionally while the pump is in operation. For extended operation, refueling may be necessary.
- Reduce engine speed to idle and allow the engine to cool down for two minutes prior to stopping the pump unit. Return the engine throttle control to the STOP position.
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EMERGENCY ACCESS EQUIPMENT

When normal means of access to damaged areas are blocked, forcible entry tools may be required to gain access. Sailors must understand what tools are available and how they operate before a need arises. In this lesson, you will learn about Damage Control Emergency Access Equipment, the components and operating procedures of the Portable Exothermic Cutting Unit (PECU), and the components and operating procedures of the Portable Hydraulic Access Rescue System (PHARS).

Terminal Objective – Identify the procedures to use Damage Control Emergency Access Equipment.

- Enabling Objective – Identify Damage Control Emergency Access Equipment.
- Enabling Objective – Recognize the function of the Portable Exothermic Cutting Unit (PECU) components.
- Enabling Objective – Identify the procedures to use the Portable Exothermic Cutting Unit (PECU).
- Enabling Objective – Recognize the function of the Portable Hydraulic Access Rescue System (PHARS) components.
- Enabling Objective – Identify the procedures to use the Portable Hydraulic Access Rescue System (PHARS).

During a fire emergency, Sailors may be required to enter a compartment to access the seat of the fire, and attack it directly. The access-man is responsible for opening the hatch or door so that firefighters can enter the compartment. The heat from a long burning fire may cause access hatches to compartments to become jammed. Under these circumstances, it may be necessary to use forcible entry equipment, therefore is important to identify damage control emergency access equipment.

Basic forcible entry equipment includes the sledgehammer, axe, crowbar, wrecking bar, claw tool, and Halligan tool. These tools are all located in the repair locker.

- **Sledge hammer** is used for driving in stakes or wedges or for removing objects that are stuck in place such as watertight door dogs.
- **Axe** are used to chip, pierce, gouge, and tear. Axes can also be used as a lever.
- **Crowbar** is used for heavy prying and moving large objects short distances.
- **Wrecking bar** is used to pull large nails or spikes, to open heavy crates, and for wrecking work.
- **Claw tool** is a heavy duty prying tool designed for overhauling.
- **Halligan tool** is designed for forcible entry on bars, doors, outside vents, and used as ladders.

Training is needed before using the hacksaw, bolt cutter, PECU and PHARS. Hacksaws are simple devices designed primarily for cutting light metal. To use a hacksaw effectively, it is important to remember two things.

- **Hacksaw blade** must remain tight or it can break. If the blade breaks, remount a new blade in the hacksaw frame ensuring that the teeth of the blade point away from the handle. Tighten the blade until it hums when plucked with your thumb, similar to plucking a guitar string. The new blade has more set than the old worn out one, so use care to prevent binding or it may break again. Second, when using a hacksaw, apply the downward pressure on the forward stroke, then release the pressure on the return stroke. Cut at a rate of between 40 and 50 strokes per minute. This method is the most effective and will reduce binding and the possibility of breaking the blade.

- **Bolt cutters** are used to cut mild steel rods up to one-half inch in diameter and for cutting away de-energized electrical cables. They are fairly simple to use; however, do not twist the bolt cutters during a cut. This type of action usually breaks the jaws or the blades.

One of the primary pieces of emergency access equipment is the self-contained Portable Exothermic Cutting Unit (PECU). The PECU is used during emergency access to gain entry to secured areas or locations by cutting holes in decks or bulkheads to fight fires, vent smoke or heat, or drain firefighting water overboard from spaces above the damage control (DC) deck.

**PECU** is based on the exothermic principle that combines oxygen with a fuel to produce extremely high temperatures that melt, burn through, or vaporize objects. In this case, the fuel is expendable steel tube cutting rods. The cutting rod ignites when the oxygen, passing through the rod, contacts a spark generated from a battery powered igniter. Once ignited, the fuel rod burns until it is expended, provided the oxygen flow is maintained. Releasing the oxygen lever extinguishes the rod. The exothermic torch can cut through steel, aluminum, laminates, piping, and cable. The PECU also works under water.

**PHARS**, commonly referred to as the Jaws of Life. PHARS supports emergency access or rescue operations that involve spreading, lifting, cutting, pulling, and piercing light plate or sheet metal. It has a portable engine that pumps pressurized hydraulic fluid through one of two hose ports. A valve switch controls the flow of fluid through the hose ports. On entering one port, the fluid forces the rod up, and on entering the other port, the fluid forces the rod down. Toggling the switch then causes the rod to retract, closing the arms or blades. With the exception of the engine, all the tools can be used underwater.

**PECU** is used for rapidly cutting through bulkheads or decks and for the rapid removal of a damaged structure. In order to use the PECU effectively and safely, you must first understand its components.

**PECU**

The PECU components and accessories are provided to ships in a configuration known as a Fleet Pack. This consists of the PECU case, oxygen cylinder, oxygen regulator, battery charger assembly, torch assembly, striker assembly, cutting rods, leather gloves, and goggles.

- **The goggles** use a number five shade lens or darker to protect your eyes. When using the PECU for piercing, wear a shaded face shield or welding helmet.
- **The oxygen cylinder** supplies oxygen to the torch assembly. It is made of shatter-proof spun steel. The oxygen regulator limits the output pressure flow of the oxygen to a preset value of 60 PSI.
- **The torch assembly** consists of the handle, torch shield that protects your hand, oxygen lever that controls oxygen flow to the cutting rod, and spark arrestor that stops sparks from entering the torch handle. It also has a washer, a 1/4 or 3/8 inch size collet chuck and nut assembly, red-disconnect cable lead and green oxygen hose that supplies oxygen to the torch.
- **The 12 Volts DC rechargeable battery** provides power to ignite the cutting rod. The red torch cable attaches to the positive side of the battery. The black striker cable attaches to the negative side of the battery, both attach with quick disconnects. The mode switch is a three position switch that controls the battery charger assembly. The Test position checks the battery condition. The Cut position is the normal cutting setting. The Charge position recharges the battery. A power cord connects the battery charger assembly to a 120 Volts AC source to charge the battery. The condition of the battery is shown with a recharge/good meter reading.
- **The leather welding gloves** protect your hands from flash burns, sparks, molten metal, and the extreme heat of the cutting process.
- **The aluminum case** is carried in a back pack harness. It has a cutting rod stowage compartment and spaces for all of the other components.
- **The striker assembly** ignites the cutting rod. It is rubber coated with a metal strike pad and a black disconnect.
-The cutting rods are made from carbon steel sheet metal rolled into hollow tubes. The rods are stored in cardboard tubes and come in two diameters and four lengths. The 1/4 inch diameter rods are either 22 or 44 inches long. The 3/8 inch diameter rods are either 18 or 36 inches long. The size of the cutting rod determines the amount of cutting power you will have.

In addition to the Fleet Pack, an auxiliary oxygen cylinder case provides two spare oxygen cylinders housed in an aluminum carrying case. These spare cylinders extend the length of time you can use the PECU without having to stop to replenish the oxygen supply. The PECU is designed to be used by damage control personnel for rescue and for providing access to damaged or burning compartments. It can cut access holes for firefighting nozzles through bulkheads, deck plates, and water tight doors in a minimum amount of time.

SAFETY

Before using the PECU, it is important to know how to handle the equipment:

- Keep oil and grease away from oxygen cylinders, valves, regulators, hoses, or fittings.
- Do NOT handle oxygen cylinders, valves or regulators with oily hands or gloves.
- Wear protective clothing, eye, and ear protection when operating the PECU.
- Maintain adequate ventilation at all times.
- Remove all flammable materials from cutting area.
- Keep clear of all moving parts.
- Do NOT operate the power unit in an enclosed area.
- Only approved oil should be used. The PHARS uses fluid which is fire resistant and electrically non-conductive.
- Remove all flammable materials from cutting area.
- Maintain adequate ventilation at all times.
- Wear protective clothing, eye, and ear protection when operating the PECU.
- Do NOT handle oxygen cylinders, valves or regulators with oily hands or gloves.
- Keep oil and grease away from oxygen cylinders, valves, regulators, hoses, or fittings.

Petroleum products mixed with oxygen is violently explosive. Ventilation is mandatory because of the sparks that are produced by the PECU. It is also necessary to station a fire-watch while the PECU is in use. The PECU is a dangerous piece of equipment. It is extremely important to use and handle it properly to avoid injury. In addition to the PECU safety precautions, there are several operating precautions you must follow when the PECU is in use:

- ALWAYS hold the torch at arm’s length.
- NEVER use the torch without the spark arrestor in place. This prevents sparks from entering the torch handle.
- NEVER use the torch without the torch shield in place to protect your hands.
- NEVER connect the slice torch to anything other than oxygen.
- NEVER use air to blow out the oxygen supply line.
- NEVER leave the oxygen valve open when the PECU is not attended.

Keep in mind that repeated attempts to ignite a cutting rod from a discharged battery can result in permanent damage to the battery.

The standard shutoff procedure is to release the oxygen lever on the torch assembly. Perform the standard shutoff when the cutting rod blows out of the torch, the cutting rod sticks to the work piece, or the side of the cutting rod blows out. These are normal occurrences. If the oxygen lever fails or there is a fire in the oxygen hose, you need to shut off the oxygen at the cylinder valve to remove the oxygen at the source. Remain calm, but be quick.

PHARS

The PHARS are used to spread, lift, cut, pull, and pierce light plate or sheet metal during emergency access or rescue operations. When in use, the engine pumps pressurized hydraulic fluid into the piston cylinder through one of two hose ports. A valve switch controls which port the fluid enters. One port forces the rod up and opens the arms of the spreader or blades of the cutter. The other port causes the rod to retract, closing the arms or blades. Except for the engine, all PHARS tools can be used underwater. The PHARS is comprised of four components: engine, cutter, spreader (Jaws of Life), and extension ram.

-The cutter has curved claw-like extensions that come to a point. Like in the spreader, hydraulic fluid flows into a cylinder, placing pressure on a piston. The three components of the cutter are: cutting blades, connector with quick disconnect, and control valve (trigger).

-The spreader or Jaws of Life is designed for opening, pulling, and lifting. It is hydraulically operated by a power piston. The components of the spreader are: aluminum alloy arms with tips made of heat-treated steel, jaw retainer pin, control valve (trigger).

-Extension rams are used for spreading or pulling. The ram uses hydraulic fluid to extend or retract a piston rod inside a cylinder. The components of the extension ram are: feet, connectors with quick disconnect, control valve. The PHARS has three accessories: multi-tool manifold block, hose reel, attachment set.

SAFETY

When operating the PHARS, it is important to have a safety observer and an operator present, as well as the person operating the hydraulic equipment, and have good communication between team members.

- Wear proper PPE when operating the PHARS.
- Hold the blades perpendicular to the material being cut.
- The material being cut must be secured so that it won’t twist.
- Only approved oil should be used. The PHARS uses fluid which is fire resistant and electrically non-conductive.
- Do NOT operate the power unit in an enclosed area.
- Keep clear of all moving parts.
BECC-24
DAMAGE INVESTIGATION

When a casualty first occurs, preliminary information is not always conclusive. There may be obvious signs of damage – such as a loss of power, a wisp of smoke, a dropping pressure gauge, a hot bulkhead, or a leaking seam. These are symptoms of a dangerous condition; they must be investigated thoroughly to identify and correct the casualty. Trained damage investigators are assigned to repair lockers and operate in pairs. They travel assigned routes to identify the casualty, establish and maintain damage control boundaries around the casualty, and ensure no further damage occurs. They must have an in-depth knowledge of the ship’s layout and the systems in their assigned area. They investigators must become qualified through the PQS program. The prompt actions and accurate assessments of well-trained investigators can make the difference that saves your ship.

Terminal Objective – Identify the responsibilities, procedures, and equipment used by the Damage Control Investigator.

- Enabling Objective – Identify the general responsibilities of a Damage Control Investigator.
- Enabling Objective – Distinguish primary and secondary boundaries.
- Enabling Objective – Identify investigation procedures.

Without adequate investigation, no one knows what materials are needed on scene, which circuits and pipes to isolate, and which flooded compartments can be secured and pumped dry. One role of investigators is to provide precise reports to the repair locker, allowing key damage control personnel to form a concise, accurate picture of the damage. As a result, repair parties can more efficiently and effectively localize and overcome the casualty. How well investigators fulfill their responsibilities can mean the difference between saving and abandoning the ship.

Investigators are experienced Sailors and must be PQS-qualified, physically-fit, and well trained. They must intimately know the vital systems, equipment, and spaces assigned to their repair locker, and become familiar with those throughout the rest of the ship. Because their reports validate sensor data, investigators have an important bearing on the actions taken to localize and control damage.

FOUR PRINCIPLE RESPONSIBILITIES

Damage control investigators have four principle responsibilities: investigate cautiously, investigate thoroughly, report clearly and quickly, repeat the investigation.

- Investigate cautiously, damage investigation is highly dangerous, to increase safety, investigators must always: stay alert, work in pairs, use SCBA, control watertight fittings, and re-secure compartments.
- Investigate thoroughly, investigators must systematically search for: structural damage, flooding damage, hidden damage. Investigation of structural damage must cover a considerable area surrounding the immediate scene of damage, not only on the same level but also on decks above and below the principal casualty. Investigators must look for damage such as fragment holes, ruptured pipe lines, warped or fractured frames and stanchions, cracks, open seams, leaky stuffing tubes, bent shafts, improperly closed fittings, severed electric cables, and any damaged bulkheads that need shoring. In addition to searching for structural and flooding damage, investigators must inspect controls, gauges, meters, and equipment. Open circuit breakers or the failure of operating equipment may indicate hidden damage, such as shorted electrical wiring, which could be as hazardous as the primary damage.
- Report clearly and quickly: investigators report the facts and their assessment of damage based on those facts to their Repair Locker Leader. Depending on the ship and the situation, they may deliver their reports by messenger, interior communications circuits, or handheld radios. Clear, complete reporting by investigators lets Repair Locker Leaders effectively assign damage control resources.
- Repeat the investigation, the first investigation is considered preliminary. Even though a compartment appears to be free of fires and flooding, investigators cannot assume that damage does not exist. A fire may be ignited from undetected damage to an electric circuit. Flooding may be caused by open or partly opened valves. Events and conditions can change rapidly, so investigators must continue investigating and reporting observations.

PRIMARY AND SECONDARY BOUNDARIES

Even if heavily damaged, most ships can be saved through effective damage control. Allowing damage to spread increases repair time and risk of personnel injury. When damage occurs, boundaries are set to limit or control its spread. Investigators are vital in ensuring the integrity of these boundaries or setting new ones. Whether dealing with flooding, fire or smoke, there are always two designated sets of boundaries, a primary and a secondary.

- Primary boundaries are the innermost watertight border surrounding a confined space, above, below, and on all sides, such as the outside bulkheads of a fuel tank.
- The secondary boundary is established as a backup in case of primary boundary failure.

Investigators must take immediate action to reestablish boundaries if one become lost. If primary boundaries cannot be established, the Investigator will start a new boundary at the next watertight frame. Investigators conduct rapid compartment by compartment surveys of damage, concentrating on unmanned compartments. Their objective is to quickly cover their assigned areas and report to the repair party leader. They report findings as they progress through the ship. Repair party leaders dispatch attack teams as reports are received. They continue their search for damage while the initial response teams proceed to the scene. After investigating their assigned areas and reporting conditions, investigators may be directed to continue to monitor their areas or to return to the repair party staging area for recuperation or other duties.

Ship system damage reports must pinpoint the system affected and damage location by frame. This ensures that the required sections of the system are isolated with a minimal impact on the rest of the ship. Investigators must use extreme caution when investigating for underwater hull damage and flooding. When underwater hull damage is found or suspected, all tanks and voids should be sounded and compared with pre-damage soundings. The closest tanks and voids to the suspected damage should be sounded first, but underwater structural damage may not necessarily be confined to the area adjacent to the damage.
Large holes at or below the waterline of the ship can be caused by torpedoes, mines, or even from the concussion of near-miss bomb explosions. In addition to the breaching the hull, damage to critical operating systems and the resulting flooding may require extensive time in a dry dock to make all the necessary repairs, even small holes about 5-6 inches or smaller at or above the waterline can be just as catastrophic even though it may not appear to be of immediate consequence. Should the ship roll in heavy seas or lose buoyancy, then damaged areas will become submerged and admit flooding waters above the ship's center of gravity. This extra weight reduces stability and becomes increasingly dangerous for the ship. If there were multiple holes, the priority would be given to the lower portions of the ship.

Terminal Objective – Recognize when to patch, plug, or shore shipboard damage and safely complete these tasks.

- **Enabling Objective** – Identify plugging procedures and equipment.
- **Enabling Objective** – Identify patching procedures and equipment.
- **Enabling Objective** – Identify equipment and personnel safety precautions during the operation and the use of the pipe patching procedures.
- **Enabling Objective** – Identify shoring procedures and equipment.

**PLUGGING**

Several factors such as access, flooding, or wreckage determine whether to insert a plug from the inside or outside of the ship. Holes that protrude inward and outward will be plugged differently. The type of damage and the availability of material onboard can determine the plug type to be used. The two plug types we will discuss today include wood and other plugs.

- **Wooden Damage Control (DC) plugs and wedges** are inexpensive. They are prefabricated from soft wood, such as yellow pine and fir, and come in assorted sizes. The plugs are conical, square ended, and wedge shaped. For larger holes, 4 x 4 x 12-inch wooden blocks can be combined with plugs and wedges to better conform to the shape of the hole. As you can see, these plugs and wedges are not painted. The plugs and wedges will absorb more water and grip better when left unpainted. Wooden plugs, when covered with cloth or oakum, will plug jagged holes. Wrapped plugs and wedges will provide better grip and help fill in some of the gaps between other plugs. Plugs and wedges may not always create a watertight fit, but with cloth, oakum and smaller wedges, the flooding can be significantly reduced. To properly insert a plug or wedge: wrap wooden plugs and wedges with materials such as cloth or oakum prior to insertion, forcibly insert the wrapped plug or wedge into the crack or hole, caulk the remaining leaky areas with rags, oakum, and smaller wedges.

- **Other Plugs** are generally blanket strips that are rolled into a cone shape. Any materials, such as pillows or mattresses, rolled or wadded into a damaged area can be used as plugs. These items can also be wrapped around wood plugs to assist in plugging the protruding edges of the holes. In order to apply a patch or a plug, some special tools and pieces are required. Hook bolts (to include L, T, and J) clinches (wood and metal), caulking tools and materials, and banding tools and equipment are just a few. Blankets, tables, mattresses, pillows, plywood sheets, and other miscellaneous material may also be required to assist in plugging a hole.

Confining the flooding damage can be accomplished by setting the flooding boundaries and sealing off the adjacent compartments. The underlying reason is to preserve buoyancy and stability. No temporary patch will be 100% watertight; but if it reduces the entrance of liquid, the ship’s dewatering equipment and installed eductor systems have a better chance of saving the ship.

**PATCHING**

Any type of patch requires a gasket. Gasket materials can be rubber sheets (generally preferred), usually 1/8 inch thick, canvas, rags, or oakum. Be careful; oakum is an extremely flammable material. It is also important to realize that one type of patch will not be correct for all types of leaks.

- **Box patch**, holes with jagged edges protruding inward less than six inches, or the depth of the box patch, can be fixed with a box patch. If the protrusions exceed six inches, then cut, hammer, or bend to get the protrusions to less than six inches. Box patches come in various types. The box is open on one end and has a gasket along the facing edges. While they may be manufactured when needed, prefabricated steel box patches up to 18 inches square and six inches deep, can be found onboard most ships. If a steel box patch isn’t available, a wooden box patch can be made from wooden planks. An advantage of the wooden box patch is that its edges can be shaped for a closer fit on uneven surfaces. Both of these patches can be shored or welded in place using metal clips. Larger ships should make and carry large box patches in sizes up to four feet square and one foot deep.

- **Bucket patch** is similar to a box patch with gasket material. An ordinary galvanized bucket can be used as a bucket patch. The bucket patch can be held in place by shoring or by using a hook bolt. A hinged plate patch passes through the hole in a folded position and is tightened with a line. This patch is recommended for holes up to 18 inches in diameter. To apply a hinged plate patch, fit the line of the plate through the mattress or the gasket. Fold the plate and push it through the hole from inside the ship. Secure the line to the ship.

- **Plate patch**, up to five square feet, can be made from mess deck tables and mattresses or steel plates. On steel plates, eyes can be welded onto the plate to attach handling and supporting lines for heavy patches, making it easier for the patch to be lowered from outside of the ship. For holes at or just above the waterline, a Sailor inside the ship could then reach through the hole and grab the handling line and pull the plate tight against the ship’s hull by securing it to a supporting stanchion.

- **Folding "T" patches** are for small inward or outward holes. Almost any pliable or moveable material can be used as a patch. Pillows or mattresses can be rolled up and shoved into a hole to slow the flow of water. Patches can be used for cracks and split seams, not just holes. Prior to patching a crack or split seam, a ¾-inch hole at each end of a crack should be drilled. A pneumatic air drill or cutting torch can be used. This prevents further splitting. Apply a gasket over the complete length of the crack and at least 2 inches beyond the hole on all surfaces and sides. To hold the gasket tightly against the crack, shore with sholes or strongbacks. Use caulking, oakum, cloth, marlin, and canvas for split seams or cracks under a welded frame.

Pipe patching minimizes casualties due to a leaking pipe. A pipe patching kit contains tools and materials needed for emergency pipe patching. The kit is small enough to go through scuttles and small openings. The tools and materials are stowed in canvas bags with a carrying strap and located in repair lockers and in main machinery spaces.

- **Soft patch**, small holes or cracks in low-pressure piping can often be repaired by applying a soft patch that will hold up to 150 PSI.
SHORING

The water that entered through a hole in the hull will put a lot of pressure on the surrounding metal structure. Battle damage, collision, or rough seas can place a ship in jeopardy, putting holes in the skin of the ship, rupturing bulkheads, bending beams and frames, and causing equipment to shift or break loose. This damage, if neglected, can seriously affect the stability, buoyancy, and mission of your ship. Shoring may have to be erected to minimize damage until proper repairs can be made.

The purpose of shoring is to place support against a structure to prevent metal fatigue, sagging, and bulging. A shore can be used to: Support ruptured deck, build temporary bulkheads, support hatches, support equipment, and hold cofferdams.

-Wooden shores are made from soft woods such as Douglas fir and yellow pine. Although hardwood shores would be stronger, they are difficult to cut, are less absorbent, and harder to nail, so they are unsatisfactory for Navy use. All wooden shores should be straight grained with few knots and cracks. Douglas fir is the strongest and best of the two softwoods. All wood shores received as purchased stock are treated with a fire resistant chemical. Do not paint the shores because the paint will not allow the shores to absorb the water and swell to form a tighter fit. Shores are usually 16 to 18 feet in length and stowed in designated rack locations above the waterline. A shore length must not exceed 30 times the minimum thickness.

-Steel shores have several advantages. They are much stronger than wood, and they are fireproof, and save space. Welded members of a steel shore will not slide or jump out of position. They allow repairs to be semi-permanent, allowing the ship to continue in operation. Welded steel permits a greater number of repairs than wood. They are telescoping tubular sections fitted with adjustable swivel head and base plates, and a screw jack, and are available in two models: 3 to 5 feet with a vertical load of 20,000 pounds when closed, but extended 1 inch on the screw jack. However, it has a vertical load of only 12,000 pounds when extended to its maximum height. 6 to 11 feet carries a vertical load of 20,000 pounds when closed, but extended 1 inch on screw jack. However, it has a vertical load of only 6,000 pounds when extended to its maximum height.

Shores alone are not enough to strengthen weak bulkheads. Wedges, sholes, and strongbacks are used to assist in keeping the shoring in place.

-Wedges are triangular blocks with rectangular butts. They should be cut with a coarse saw and left unpainted so that they will absorb water, which causes the wood to swell, and better grip the area into which they are wedged. Wedge length is 6 times its minimum butt thickness and the width must be the same as the shore. Most wedges are made of softwoods, like Douglas Fir or Yellow Pine.

-Strongbacks are bars or beams of metal or wood and are always shorter than shores and are used to distribute pressure or to serve as an anchor for a patch.

-A shole is a plate placed under a shore to distribute the weight or pressure. Softwood is preferred for a shole, but any material at hand may be used. The thickness should be 1 inch or more and 8 to 12 inches wide.

There are three types of shoring methods “I” type, “H” type, and “K” type. Any one of these methods will take a handful of Sailors to construct. A carpenter’s square is used to measure angles on a shore, when measuring the length and angle of a shore using a batten.

-K or triangulation shoring has both shores under direct compression. The ends are cut at a 90 degree angle or less and are installed at angles no greater than 90º.

-H or cross-axial stress shoring is not for deck anchorage. The pressure acts parallel to the axis and it is used only when necessary. It is not as strong as the direct compression shoring.

-I or direct compression shoring has the pressure acting on an axis. It supports the greatest weight and load and is normally used to strengthen buckled bulkheads in compartments.
Mass conflagration is any fire or explosion that is of such a size as to be beyond the control of the repair parties and may be a threat to the survival of the ship. Being a firefighter requires high flexibility and common sense when combating fires. In this lesson we will cover current lessons learned, special cases of conflagration, and the procedures and techniques required to combat them. We will discuss lessons learned, planning methods, training ideas, and generic procedures to enable commanders to effectively restore the mechanical and human fighting capabilities of their ships during a mass conflagration.

**Terminal Objective** - Demonstrate the procedures and techniques required to combat mass conflagrations.

- **Enabling Objective** - Identify the procedures and techniques required to combat mass conflagrations.
- **Enabling Objective** - Demonstrate proper firefighting techniques while using the SCBA.

A mass conflagration is damage of a magnitude that cannot be readily handled by the conventional DC organization; therefore, all hands participation is required to save the ship. A conflagration may involve mass casualties. It is imperative that command, control, and communication be established and maintained to effectively coordinate DC actions over a prolonged period of time. This can be achieved by the effective leadership of well-trained officers and crew from all departments aboard each ship.

Planning for mass conflagration responses must include an assessment of all potential threats. The particular types of threats to be expected in the ship’s area of operations will vary from minefields to small crafts to a full combatant force, and may include oceanographic and meteorological factors. Threats to most surface warships can be classified by two weapons systems: air or underwater delivered weapons. A mass conflagration may also involve mass personnel casualties. It is imperative that command, control, and communications be established and maintained to effectively coordinate DC actions over a prolonged period of time. This can be achieved by the effective leadership of well-trained officers and crew from all departments aboard each ship.

Cross training sailors to perform DC functions not related to their normal training will increase the adaptability, survivability, and readiness of the ship includes:

- **Primary air-delivered weapons** include anti-ship missiles of various sizes, projectiles, and air-delivered bombs.
- **Primary underwater weapons** include torpedoes and mines.

In addition to normal survivability responsibilities, there are specific additional duties that must be performed in preparation for a mass conflagration, involving the following personnel:

- **Master at arms** must establish crowd control procedures, and assist the Officer in Charge (OIC) in the reorganization site.
- **Medical Personnel** must be able to implement the Mass Casualty Bill, if required.
- **Supply officer** shall provide access to locked spaces; coordinate logistics support, staging, and issue of DC and Firefighting assets; provide clothing as available; provide fluids and food for rotating DC teams.
- **Operations/Combat systems officer** must coordinate restoration of combat systems with the engineer officer. Also coordinate assistance from other ships as needed.
- **Master at arms** shall establish crowd control procedures, and assist the Officer in Charge (OIC) in the reorganization site.

Cross training sailors to perform DC functions not related to their normal training will increase the adaptability, survivability, and readiness of the crew. It is impossible to know when, where, and what will happen when you are dealing with a mass conflagration. Each scenario has a diverse and different set of variables and factors. Due to the size and intensity of the mass conflagration, it can spread rapidly and the threat can change dynamically. A mass conflagration may also involve mass personnel casualties. It is imperative that command, control, and communications be established and maintained to effectively coordinate DC actions over a prolonged period of time. The inflicted damage must be brought under control immediately and simultaneously; combat systems must be kept in or returned to a state of battle readiness. Training that will increase the survivability and readiness of the ship includes:

1. Ensuring that all embarked personnel immediately fulfill shipboard DC requirements in accordance with Type Commander (TYCOM) directives.
2. Study and planning for worst-case scenarios, to include:
   - Type or number of weapons that may inflict the worst damage, including interruption of engineering, propulsion, and services.
   - The propensity of damage to spread horizontally and vertically.
   - Adding shipboard fuels to a fire.
   - Awareness of the design stability and buoyancy of the ship and maximum extent of sustainable damage.
3. Review and learn to integrate engineering operational sequence systems and combat systems operational sequencing system casualty control and restoration procedures.
4. Locations, methods, and techniques for cutting emergency accesses in bulkheads and overheads for heat and smoke venting and for application of cooling water.
5. Repositioning personnel at GQ stations based on threat assessment (e.g., removing personnel low in the ship when in minefield).
6. Development of a plan to provide drinking water, food, and rest to personnel involved in casualty restoration or firefighting.
7. Please select the images below to find out what type of training is necessary for each scenario.
8. Training that will increase the survivability and readiness during a fire would be
   - Emergency egress training to include damage to normal escape routes.
   - Ability to contain casualties by quickly setting boundaries for fires, smoke, and toxic gases.
   - Awareness of the propensity for major fires to spread vertically.
   - Containment procedures for vertical fires.
9. Training that will increase the survivability and readiness during a flood would be
   - Ability to contain casualties by quickly setting boundaries for flooding.
   - Awareness of the adverse effects of firefighting water to ship’s stability.
   - Development of plans for water removal during firefighting operations.
10. Training that will increase the survivability and readiness with the loss of a key personnel would be
    - Cross-training of personnel to perform DC functions beyond their normal rate training.
11. Training that will increase the survivability and readiness during electrical or power outages would be
    - Awareness of electrical shock hazards due to damaged circuits and cableways.
12. Training that will increase the survivability and readiness during loss of communication would be
    - Designation of all available primary, secondary, and emergency communications circuits.
    - Practice of lost communications procedures.
13. Training that will increase the survivability and readiness during mass casualty would be First Aid for
- burns
- shock
- smoke asphyxiation
- major wounds
- heat illness
- cardiopulmonary resuscitation
- electrical shock

Assume the ship will become dark, hot, and that propulsion and electric power may be lost. Firemain and communication may also be lost in key areas. Firemain ruptures may occur, fire hoses may rupture, and the use of firefighting water while combating a fire can cause flooding problems, severe list, and slippery decks. Fire and smoke may cause abandonment of DCC and other vital spaces. Smoke can deny access to portions of the DC deck, and one or more repair stations may not be accessible.

The condition of the ship may provide many different circumstances; some of which may require the use of a SCBA. Any crewmember discovering a fire, or indication of a fire, must sound the alarm immediately. Once the word has been relayed, the decision must be made to immediately start attacking the fire or start containment and isolation actions. If the fire is too large to attack with a portable extinguisher, take action towards isolation and containment. Where installed, sprinkler systems should actuate to extinguish fires that are large enough to force space abandonment.

Ideally, if additional personnel are available, firefighting and fire containment can proceed together. With the fire party on scene, the fire must be sized up and re-evaluated. A fire in progress can change incredibly fast from the very first report. Investigators on scene, dressed out in personal protective equipment, verify the fire’s location with the aid of thermal imagers if the smoke is already thick. Location and size is necessary to figure out where to establish fire and smoke boundaries, and to resolve what systems should be isolated, along with whether or not any other combustibles are at risk. When attacking a fire, speed is essential. The attack on the fire should begin as soon as possible to gain immediate control and prevent its spread. After evaluation by the OSL and Attack Team Leader, the decision to attack the fire directly or indirectly is made.
Pumps are used to move liquids, such as water, oil, and gases. They use an external source of power to move fluids from one place to another. Identifying the terms, operating principles and components of basic pump types helps Sailors to understand how fluids are moved around the ship. Because pumps are so vital to the ship’s safety and its mission, they are a part of many systems.

**Terminal Objective** – Demonstrate an understanding of the operating principles and components of basic pump types.

- **Enabling Objective** – Identify the terms, operating principles, and components of basic pump types.

**PUMP TERMS, OPERATING PRINCIPLES, AND COMPONENTS**

Pumps are vital to the ship’s operation; therefore, there are many different kinds of pumps that operate in many different systems. Ships would be vulnerable to fires, floods, and sinking without pumps. The major types of pumps found aboard ship are: centrifugal, rotary, reciprocating, and jet. There are a few concepts specific to pumps that need to be understood: pressure and pumping process, fluid and mechanical friction, bearings and lubrication, and prime movers.

Friction is the resistance that one surface offers to its movement over another surface. Fluid friction opposes the flow of fluid. A higher flow rate through piping will cause an increase in fluid friction and will cause the pump to work harder or be less efficient. In addition to fluid friction, mechanical friction is also a factor to consider in pumps. Wherever there are moving parts that encounter each other, friction is created. Bearings and lubrication help offset mechanical friction. Bearings support the rotating shafts in pumps and reduce the friction caused by their movement. The outside of the bearing is normally stationary, allowing the inside, where the shaft makes contact, to rotate freely. Bearings and other pump components must be lubricated to reduce friction. Pumps utilize many different bearing types and lubrication methods, so you must follow the appropriate maintenance procedures for each type to ensure pump longevity and efficiency.

The prime mover is simply a motor or an engine that drives the pump. They are coupled to the input shaft of the pump, and provide the torque necessary to move the liquids. These prime movers can be: electric motors, internal combustion engines, and steam turbines.

**CENTRIFUGAL PUMP**

One of the most common pumps found aboard ships is the centrifugal pump. Highly efficient, these pumps are used for pumping water, fuel, coolant, and many other non-viscous liquids. The term viscosity refers to the thickness of a liquid. Non-viscous liquids are easy to pump, while thick, viscous liquids are not. Centrifugal pumps can be classified in many different ways, such as their service application, number of stages, shaft position, impeller type, casing type, construction, and drive type. However centrifugal pumps are classified, the same basic components are present. While centrifugal pumps may come in a wide variety of styles, many of the basic components are essentially the same. The major components of the centrifugal pump are: casing, impeller, check valve and recirculation line, wearing rings, and mechanical seal and stuffing box packing.

- **The centrifugal pump casing** not only houses the other components, it is also an integral part in how the compressor functions. It is constructed so that the liquid travels from the suction port, through the pump, and along the volute, ultimately exiting the pump at the discharge port.
- **The impeller** is the component of the pump that creates the pressure required to move the liquid. It is connected by a shaft to the prime mover, and its rotation forces the fluid that enters near the center of the impeller outward, against the casing. This fluid follows the path of the volute, and out of the pump. As this fluid moves out, more fluid is pulled into the pump to replace it creating the pumping action.
- **Recirculating lines** are installed on centrifugal pumps to prevent the pump from overheating or becoming air bound. A recirculation line is a small line connecting the discharge side with the suction side of the pump. This allows water to recirculate, thus maintaining a flow of liquid through the pump.
- **A check valve** prevents reverse fluid flow through the pump by only allowing fluid to flow away from the pump’s discharge.
- **Wearing rings**, most pumps are designed with replaceable wearing rings to eliminate the need to replace the entire impeller or pump casing due to wear. The impeller wearing ring is attached to the hub and rotates with the impeller. The casing wearing ring is attached to the pump casing and is stationary.
- **Mechanical seals** are the preferred method of sealing the rotating shafts in a centrifugal pump. The stuffing box packing is used in some existing applications and can also be used in an emergency in the case of a seal failure. They are located in the pump’s stuffing box, consists of a stationary element and a rotating element, each with a flat, smooth sealing face that prevents the flow of liquid into or out of the pump casing.
- **Stuffing Box Packing** a pliable lubricated material used to seal around the portion of the shaft located in the stuffing box.

The centrifugal pump works on a simple principle. Liquid enters the suction side of the casing and then flows into the eye of the impeller. The rotating impeller throws the liquid against the casing using centrifugal force. When this happens, a region of low pressure is created at the eye of the impeller, which causes more liquid to move into the empty space to replace the liquid being removed. The liquid moving between the blades of the impeller spreads out causing it to lose velocity and increase in pressure.
**ROTOR PUMP**
Rotary pumps are positive displacement pumps. A fixed volume of fluid is discharged by the pump with each revolution, regardless of the head pressure. Rotary pumps are useful for pumping oil and other viscous or thick fluids. They are self-priming because the tight clearance between the rotating element and the casing allows air to be pumped and expelled. This creates a low-pressure area on the suction side of the pump, similar to the centrifugal pump. They are generally classified by the rotor type, such as gear, screw, or vane. While there are several different types, their basic operation is the same. Rotary pumps are often classified by the type of rotor they contain: gear pump, screw pump, and vane pump. Rotary pumps consist of a casing containing rotors running in close clearances. Fluid is trapped in between the rotors as they spin, and the fluid is carried to the discharge side of the pump where it is pushed from the pumping chamber to the discharge port. The rotor assembly may consist of pairs of intermeshing gears, screws, lobes, cams or sliding pistons, vanes, blocks, or other rotor types.

**GEAR PUMP**
The operating principles of the gear pump are also very simple. The simple gear pump has two spur gears that mesh together and revolve in opposite directions; one gear is called the driving gear while the other is the driven gear. The liquid is trapped and carried along in the pockets formed by the gear teeth and the pump casing. Because of the meshing of the gears, the liquid does not have any place to go but through the discharge side of the pump.

**SCREW PUMP**
In the screw pump, the liquid is trapped and forced through the pump by the action of the rotating screws. As the rotor turns, the liquid flows between the threads of each pair of screws. The threads carry the liquid along within the housing to the center of the pump where it is discharged. In the double-screw low pitch pump, one rotor is driven by the drive shaft while the other is driven by a set of timing gears. In the triple-screw, high pitch pump, a central rotor meshes with two idler rotors. Most screw pumps are equipped with mechanical seals. In case of mechanical seal failure, the stuffing box may accept rings of conventional packing for emergency use.

**VANE PUMP**
In the sliding vane pump, the liquid is trapped in the pocket formed by the rotor, sliding vane, and cylinder wall. The sliding vanes come in and out of the rotor as it rotates. The rotor is eccentrically located in relation to the casing. The vane comes out as it passes through the suction side, trapping the liquid as it rotates. The vane is pushed in as it passes through the discharge side to expel the fluid.

**RECIPIROCATING PUMP**
Now that we have discussed the centrifugal and rotary pumps, it is time to talk about the operating principles and parts of a reciprocating pump. It moves water or other liquid with the use of a plunger or piston that travels back and forth inside a cylinder. Reciprocating pumps are self-priming, positive displacement pumps. Each stroke of the pump displaces a definite quantity of liquid regardless of the resistance against which the pump is operating. A single-acting reciprocating pump draws liquid into its cylinder on the suction stroke and forces the liquid out on the discharge stroke. A double-acting reciprocating pump draws or discharges liquid on both ends of the piston.

**JET PUMP**
Has no moving parts and is often used for pumping large quantities of liquid. It is a self-priming, non-positive displacement pump that can pump air. The volume of its discharge depends on the head pressure. The kind most often used is the eductor, which is used to pump bilges and dewater compartments. The principle behind the operation of these pumps is a high-velocity jet of seawater to lower the pressure in the chamber around the converging nozzle. Seawater exits the converging nozzle at a high velocity. As the seawater passes through the chamber, the air becomes entrained in the jet stream and is pumped out of the chamber. Pressure in the chamber decreases, which creates a vacuum, and draws water from the suction line. The diverging nozzle allows the velocity of the fluid to decrease and the pressure to increase.
Oil/Water Separator equipment separates oil from oily waste drawn from the Oily Waste Holding Tank (OWHT) or the bilges. Sailors need to understand the purpose and operational function of the Oily Water Separator System. Proper usage ensures sanitary onboard conditions and safety for all the crewmembers, while satisfying the regulatory requirements put in effect by federal laws.

**Terminal Objective** - Identify the operational characteristics of the Oily Water Separator System.

- **Enabling Objective** - Identify the operational characteristics of the Oily Water Separator System.
- **Enabling Objective** - Identify the function and components of the Oily Water Separator System.

In the past, regulations only required maintaining a log book that detailed the vessel’s position when pumping fluids overboard. Unfortunately, this practice resulted in unacceptable levels of pollution. In order to achieve the discharge qualification required by new regulations, an efficient Oil/Water Separator and monitoring system has been upgraded to ensure the quality of overboard discharged water by all ships. There are three distinct steps in the oily water separation process.

- **First**, the OWHT stores oily waste prior to processing by the Oil/Water Separator (OWS).
- **Second**, the OWS processes the oily waste by separating the oil and water. Then it discharges the oil to the WOT.
- **Finally**, the OWS discharges the acceptable processed water overboard via the Oil Content Monitor (OCM) system.

The OWS is designed for processing all oily wastes except for the following: fuel ballast, gas turbine water wash, and synthetic oily waste generated by the ship, both in port and at sea. This system cannot effectively process oily waste containing synthetic oils having neutral or negative buoyancy or high concentrations of detergents to include: fuel ballast, gas turbine water wash, synthetic oil waste, AFFF, solvents, detergents.

**PRINCIPLES OF OIL WATER SYSTEM OPERATION**

The OWS works on the principle of gravity separation and coalescence. It is provided with a dedicated suction from the OWHT. The OWHT functions as a pre-settling tank and processes the oily waste waters by separating the bulk oil from the oily waste water. It then discharges the processed water overboard, within three feet above the waterline, and sends the separated oil to the WOT for eventual pier side disposal. The three separate pressure vessels for stages are vertically mounted and arranged in a series for processing the fluids flow. These stages are known as the First Stage Gravity and Coalescence Separator, the Second Stage Coalescence, and the Third Stage Coalescence.

- **First stage gravity separator** operates under a method similar to a vacuum and is designed to significantly reduce the fluid velocity of the incoming oily water mixture. The resulting decrease in velocity permits oil/water separation to occur naturally from the effect of gravity. The first stage contains the following components:
  - **Oil level float switch**, mounted in the First Stage, senses the oil and electronically signals to activate the oil pump. When discharged oil covers the float switch with water, the system returns to its previous condition.
  - **Shutdown flow switch**, should there be a loss of suction or should the fluid level in the first stage become too low, the internal shutdown float switch automatically shuts down the pumps.
  - **Oil separation**, oil droplets in the influent accumulate at the top of the vessel, while solids settle to the bottom. Oil droplets that do not rise to the top of the vessel are removed through coalescence by the 19 inclined absorption plates on the bottom of the vessel.
  - **Water discharge**, near the bottom of the gravity separator, the processed water enters the suction port of an electric motor-driven water pump and discharges into the Second Stage Coalescer.
  - **Second stage coalescer** contains a filter element that performs the dual function of removing particles and oil that were not separated in the first stage. The replaceable filter element is designed for the inside to outside fluid flow. As fluid flows, oil droplets grow to sufficient size, and are forced off the surface by fluid flow. The detached oil droplets rise and accumulate at the top of the vessel. When sufficient oil collects in this stage, to reach the level of the second stage flow switch, the oil is automatically discharged in the same manner as in the first stage.
  - **Third stage** works identical to the second stage in its function and operation, except that it is equipped with a manually operated oil discharge valve instead of a solenoid controlled. There is very little oil in this stage. This stage serves primarily as a backup to the second stage.

**COMPONENTS**

The key components of the OWS system are: Oil Content Monitor (OCM), Oily Waste Transfer Pump (OWTP), Oily Waste Holding Tank (OWHT), Waste Oil Tank (WOT), Synthetic Waste Oil Tank, Contaminated Fuel Settling Tank (CFST), and Oil Water Drain Collecting Tank (OWDCT).

- **OCM** monitors the effluent water quality before discharging overboard; measures the oil content of the water being discharged by the OWS. It ensures federal compliance with oil discharge regulations. When the oil content exceeds the limit, a signal is generated and then sent to a diverter valve, redirecting the flow back to the OWHT to process again and a visual indicator activates. A separate enclosure is mounted at the rear of the unit to house a time relay. This relay provides contacts, which can be set to close after a predetermined period of time. It is adjustable to close at any time between 4 and 25 minutes after the separator unit starts.
- **OWTP** transfers oily waste within the ship and from ship to shore facilities through pipe risers and standard deck connections. It has the ability and capacity to completely off-load waste oil and oily waste water from the WOT and the OWHT.
- **OWHT** stores oily waste prior to processing by the OWS or before discharge to shore facilities.
- **WOT** receives separated oil from the OWS for later discharge to shore receiving facilities. Synthetic oils, or oily waste water, are not collected or held in the WOT.
- **Synthetic waste oil tank** is normally installed on aircraft carriers and ships with gas turbine engines, receives synthetic oils from drip pans or machinery pumps. Synthetic oil is stored until it can be discharged or transferred to shore receiving facilities.
- **CFST** reclaims contaminated fuel; receives bottom sediment, water, and fuels stripped from fuel storage and service tanks during normal fuel stripping operations. The water and sediment are allowed to separate from the fuel, and then stripped to the OWHT. The usable fuel then returns to the fuel storage tanks.
- **OWDCT** receives oily waste from equipment funnel drains. The collected oily waste is transferred to the OWHT via the OWTP and processed by the OWS.
A heat exchanger is designed to exchange the heat in one medium for the heat in another. They exist all around us in everyday items, for example a car’s radiator. The engine heat is absorbed by the coolant in the engine, and that coolant is then routed to the radiator, which exchanges the heat in the coolant with the cool air running over the radiator. Heat exchangers are used for controlling the heat produced from friction and other processes inside equipment, while keeping the equipment warm enough to operate at the most efficient temperature. They are also used to remove heat from a vapor to condense it to a liquid, allowing the reuse of water in the basic steam cycle, or the refrigerant in air conditioning and refrigeration systems. In this lesson, you will identify the methods of heat transfer and the functions, construction, and operation of heat exchangers.

Terminal Objective – Identify parts and functions of various heat exchangers.

- Enabling Objective – Identify the methods of heat transfer.
- Enabling Objective – Identify heat exchanger functions.
- Enabling Objective – Identify the construction and operation of heat exchangers.

A heat exchanger is any device that facilitates the transfer of heat from one fluid (liquid or gas) to another fluid. For the heat to transfer from one fluid to another there must be a difference in temperature between the two fluids. When these two substances are placed in contact with, or near each other, heat will then flow from the warmer to the cooler substance until both fluids are the same temperature. Heat transfer occurs at a faster rate when there is a large temperature difference between the two objects.

The transfer of heat occurs in three different methods. They are conduction, convection, and radiation.

- **Conduction** is a method of heat transfer from one body to another when the two bodies are in physical contact.
- **Convection** refers to the transfer of heat through the motion of circulating gases or liquids. There are two types of convection heat transfer:
  - **Natural convection:** The natural movement of the fluid as the warmer region rises and the colder region falls to replace the rising warmer region.
  - **Forced convection:** A mechanical device, such as a pump or fan, produces fluid movement.
- **Radiation** is a method of heat transfer in the form of waves, similar to those of light or radio, without physical contact between the emitting and receiving substances.

There are different types of heat exchangers and they each have different functions, each change the temperature of fluid in different ways.

- **Heaters** raise the temperature of fluid.
- **Coolers** lower the temperature of fluid.
- **Condensers** change the state of a fluid from a gas to a liquid, and can be classified into two categories, main and auxiliary. Steam condensers change exhaust turbine steam into water by allowing the steam to flow over the outside of tubes filled with cool seawater. The condensed steam, now changed to water, is then returned to the system for reuse. The main difference between the main and auxiliary condensers is the location from which the exhaust steam is retrieved. Main condensers retrieve exhaust steam from steam propulsion turbines, and auxiliary condensers retrieve exhaust steam from turbine generators, or any non-main propulsion source.

All heat exchangers operate on the principles of heat transfer between fluids, changing the temperature of fluids as they pass through them. However, their characteristics and construction dictate how they work and the purpose they serve. They are constructed and installed according to their intended purpose. There are several different characteristics that determine the class of heat exchangers: path of the heat flow, the direction of the fluid flow, the internal surface of the heat exchanger, the number of fluid passes, and the construction of these devices.

- **The path of the heat flow** refers to how the fluids interact with each other. There are two basic paths for heat flow, direct-contact and indirect-contact.
- **Indirect-contact** or surface type heat exchangers direct heat flow from one fluid to the other fluid through the use of a tube, plate, or other surface. There is no direct contact between the two fluids. They are also classified by the number of passes one fluid makes past the other: a single-pass or multi-pass unit. A single-pass unit allows one fluid to pass the other fluid only once. A multi-pass unit allows one fluid to pass the other fluid more than once.
- **Direct-contact** heat exchangers transfer the heat flow from one fluid to another by mixing the two fluids together.

- **The direction of fluid flow** within them is Parallel, Counter, and Cross flow type heat exchangers.

  - **The Parallel flow** type allows both fluids to flow in the same direction. A large temperature difference at the inlet initially results in a high rate of heat transfer, but as the flow continues through the heat exchanger, the rate of heat transfer will decrease.
  - **The Counter flow** type is constructed so the two fluids to flow in opposite directions. They are used in applications that require large temperature changes in the cooled or heated fluids.
  - **The Cross flow** type allows one fluid to flow at right angles from the other fluid. This type is most commonly used in condensers.
- The tubes or plates inside a heat exchanger may vary. They are either plain surface or extended surface. A heat exchanger tube or plate is considered to be a plain surface if they are smooth on the outside, with no protrusions. A tube or plate is considered to be an extended surface if the surface is fitted with rings, fins, studs, or some other kind of extension. The advantage of this kind of extension is the increase in surface area available for heat transfer, without a substantial increase in overall size or weight.

- Their construction, indirect heat exchangers are classified by and they are designed for specific applications. Most surface heat exchangers are of a shell-and-tube construction. This is defined as a large pressure vessel with a bundle of tubes contained inside of it. Basic shell-and-tube types include: Straight tube, U-Bend tube, Helical or spiral tube, Double tube, and Plate tube.

- Straight tube are held in tube sheets at each end of the heat exchanger, they may be welded to or expanded into a tube sheet at each end for non-removable bundle types, while others are removable to facilitate maintenance.

- Helical or spiral tube has one or more coils of tubing installed inside a shell. The tubes may be joined with headers at each end of the shell or case.

- Double tubes are usually of a U-bend construction with one tube inside another. This allows for expansion and contraction and is commonly used as air coolers for generators to prevent extensive damage in the event of tube leakage. The shells or outer tubes are usually arranged in what is called banks. These outer tubes are connected at one end by a common tube sheet with a partitioned cover that serves to direct the flow. The smooth-surfaced inner tube carries the cooling fluid. The outer tube has internal ribs that make contact with the outer surface of the inner tube. Failure of an inner tube can be detected from telltale drains.

- U-bend tubes, also known as a return bend heat exchanger, are constructed with a bundle of U-shaped tubes inside a shell. This construction has a hot fluid entering into the inlet and flowing outside the tubes. The fluid releases heat to the cooling liquid, usually water, as it flows through the U-bend tube. The cooled fluid exits through the outlet. Since the tubes are U-shaped, there is only one tube sheet which allows for thermal expansion and contraction.

- The plate tube is noticeably different in design from other shell-and-tube heat exchangers. It consists of a stacked array of parallel plates, with gaskets to contain and direct the fluids. Hot and cold fluids flow in the spaces between alternate plates, with heat transfer through the plates.
Engineers operate and conduct maintenance on equipment that has various types of gear combinations. Engineers must be able to identify and understand the functions and uses of gears and gear combinations. In this lesson, you will learn to identify the purpose, types, and characteristics of gears.

**Terminal Objective** – Demonstrate an understanding of the purpose, types, and characteristics of gears.

**Enabling Objective** – Identify the purpose, types, and characteristics of gears.

Gears are toothed machine parts, that come in many shapes and sizes, which mesh with another toothed part to transmit motion or to change speed or direction. Gear teeth are always in mesh so there is no creep and slippage; this is referred to as positive drive. The purpose of gears is to change the direction of motion, speed, and or torque from a driving unit to a driven unit. The gear arrangement determines if gears change direction and what type of motion it produces. The typical gear arrangements include: Two gear arrangements and three gear arrangements.

-Two gear arrangements are used to change direction.

Three-gear arrangement, an idler gear is fastened to a shaft that is free to turn in either direction and is located between an input and output gear. The job of the idler -gear is to enable the input and output gears to move in the same direction.

An important application of gears is providing a gear reduction or multiplication. When gears of the same diameter size are used, then the speed and torque are equal. If a change in speed or torque is needed, then gears of different diameters are used. When a small gear drives a larger gear, the output has an increase in torque and a decrease in speed. There are five main types of gears and each type has advantages and disadvantages. The main gear types include: Spur, Worm and Worm Wheel, Rack and Pinion, Helical, and Bevel.

-Spur Gear, there are two types:
-External Spur gears have teeth that are cut straight across the outside of the rim and is often called a pinion gear. This type of gear is used to increase speed and decrease torque, or decrease speed and increase torque. It may also be used to change the direction of motion. External Spur gears are used in deck winches.

Internal Spur gears have teeth that are cut straight across the inside of the rim. They are often used to change the speed between the input shaft and the output shaft, without changing the rotation (direction). In this type of arrangement, either gear could be fastened to the input shaft. A pinion and internal Spur gear arrangement are used on hose reels.

-Worm Wheel is a single helical gear usually fastened to the driven or output shaft. Worm gear has threads like a screw and is usually attached to the driving or input shaft, and the output shaft is driven at right angles to the input shaft in a Worm gear arrangement. The advantages of the worm wheel include a large speed reduction or increase in a compact unit that produces very little noise because of the single helical gear. However, the disadvantage is that it produces thrust. It is usually used to operate valves, auxiliary steam turbines such as Main Fuel Oil Service Pump and Main Lube Oil Pump, and lube oil purifiers.

-Rack and Pinion is actually two types of gears that work together to change rotary motion to linear motion. The external Spur gear is called a pinion gear, which meshes with the teeth of the rack, so that as the pinion rotates it causes the rack to move. This gear arrangement is used for shipboard steering units, aircraft elevators, and drill presses.

-Single Helical gears have teeth on the rim of the wheel that are cut at an angle. The advantage of using this gear is that it runs quietly due to its design. One disadvantage of a helical gear is the tendency to thrust or push axially on its shaft. It is necessary to put a special thrust bearing at the end of the shaft to counteract this effect. To overcome the disadvantage of a single helical gear arrangement, a double helical gear arrangement can be used.

-Double Helical gears look like two single helical gears joined in a "V" pattern. Since the teeth on each half of the gear are cut in opposite directions, each half of the gear develops a thrust that counterbalances the other half. Single helical gears are widely used in auxiliary equipment such as auxiliary reduction gears and forced draft blowers. Double Helical gears are used in Main Reduction Gears.

-Bevel gears are used to drive an output shaft at an angle to the input shaft. They are usually mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. They are commonly used in remote operating valve hand wheels and in the drive linkage to the attached Main Lube Oil Pump.
Couplings are used to couple or connect a driving shaft to a driven shaft. It is important to know the different types of couplings and their uses to eliminate the need for constant repair on the pumps around the ship. This lesson will identify the purpose, function, safety precautions, and components for various types of couplings.

**Terminal Objective** – Identify the types of couplings used in the U.S. Navy.

**Enabling Objective** – Identify the purpose, function, and safety precautions for various types of couplings.

The general purpose of couplings is to couple or connect a driving shaft to a driven shaft. The driving unit is known as the prime mover, which can include the following: Electric motors, Steam or gas turbines, and Internal combustion engines. Couplings play an important part in propulsion systems for Navy ships. Couplings are the mechanical connection between the driving unit and the driven unit. The principal function of a coupling is to transmit rotary motion and torque from one component to another. It allows the driven unit to be uncoupled or disconnected from the prime mover should maintenance need to be performed.

**MISALIGNMENTS**

Excessive misalignment is not tolerated, because it adds strain and causes abnormal wear to the components. The three types of misalignment include:

- **Offset** – shafts are out of line, or not centered with each other.
- **Angular** – shafts are at an angle to each other.
- **Offset and Angular** – shafts are out of alignment and at an angle to each other.

Shaft alignment is checked whenever the coupling is disassembled as dictated by the Planned Maintenance System (PMS) or whenever a noticeable vibration is observed. If the shafts are found to be misaligned, alignment of the unit must be undertaken to avoid shaft coupling breakage or damage to the equipment. The appropriate Maintenance Requirements Card (MRC) or technical manual must be consulted when aligning the components.

**COUPLING TYPES**

Many types of couplings are used throughout a ship. Couplings are used to allow for maintenance and account for misalignments. Types of couplings include: Rigid Flange, Gear, Grid, Pin, Rubber Jaw, and Universal Joint (Hooke).

- **Rigid Flange coupling** does not accommodate misalignment. Use only when the shaft of the driving unit lines up perfectly with the shaft of the driven unit. It is used on main shafts, and lubrication is not required. The rigid flange coupling parts include: flange, nuts and bolts, key and screw set.

- **Pin coupling** is flexible and is used for medium torque and is not lubricated. The pin coupling components include: flange, pins and nuts, bushings and gasket. The bushings give this coupling its flexibility. They are made of soft metal, such as lead or copper, or of hard rubber.

- **Gear coupling** is a rugged flexible coupling used for heavy torque and compensates for slight misalignment. Heavy weight oil is used to prevent metal to metal contact as the gear teeth mesh. The component parts for the Gear coupling include the following: hub, flange, nuts and bolts, gasket, O-ring, and lubrication plug.

- **Rubber Jaw coupling** is flexible and is used for medium torque for a low horsepower drive system. It is not lubricated, it allows for slight misalignments; the component parts include: hubs, jaws, and a rubber bushing. It does not have a connecting link as in previous couplings. It provide for smooth transmission of rotary motion.

- **Grid coupling** is flexible and is used for heavy torque and compensates for slight misalignment. Grease is used to lubricate the spring and to reduce sliding friction. The component parts for the grid coupling include the following: hub, grid spring, cover, gasket, lubrication plug, and cover nuts and bolts.

- **Universal Joint coupling** is flexible and is used to connect two shafts that are not in the same plane. It consists of two “U” shaped yokes with one end connected to a shaft. The two yokes are connected through a cross shaped part with pivot pins, which allows both yokes to bend. With this arrangement, one shaft drives the other shaft with as much as 25 degrees of angular misalignment. It is mainly used in propulsion plant spaces as valve reach rod connections.

The following are safety precautions to take when working with couplings:

- Never place any part of your body into moving machinery.
- Do not wear jewelry, a necktie, or any loose fitting clothing while operating this or any other equipment.
- Ensure that equipment is de-energized and properly tagged out of service before attempting to perform repairs or preventative maintenance.
- Properly reinstall shaft or coupling guards after the completion of maintenance, and ensure that all guards and other safety devices are in place.
Bearing allow the wheels and axles to turn. It is important to know the purpose, types, components, and functions of bearings. In this lesson you will demonstrate an understanding of the purpose, types, components, and function of bearings.

Terminal Objective – Demonstrate an understanding of the purpose, types, components, and function of bearings.

• Enabling Objective – Identify the purpose, types, components, and function of bearings.

Machinery in engineering spaces is equipped with many types and sizes of bearings. Bearings give the machines the support they need to function and keep the ship running at its utmost potential. The purpose of bearings is to support and maintain alignment of shafts, allowing shafts to rotate. A shaft is a solid or hollow metal rod that can support other mechanical devices, such as gears, pulleys, cam wheels, and propellers.

A bearing’s main function is to support and guide moving parts of a machine. The bearings in a pump support its rotating shafts and reduce the friction caused by their movement. They maintain a relationship between the moving part or parts and the non-moving part. They also transmit loads from one engine part to another. Some bearings remain stationary in performing their functions, while others move. Some bearings provide a bearing surface on which an object slides back and forth. Rolling friction is always less than sliding friction. Lubrication helps to reduce the friction within bearings. They also carry away the heat produced by unavoidable friction.

- Sliding friction is the friction between an object that is sliding against or on another object. The amount is determined by several factors. In addition, speed and force determine the amount of heat produced by sliding friction.
- Rolling friction, one way to reduce the friction between two objects is to separate them with balls and rollers. This changes sliding friction into rolling friction. By using balls and rollers, the amount of contact area between them is decreased; thus friction is decreased.
- Fluid friction occurs between two objects separated by a fluid. This develops the least amount of friction because the only friction developed is the internal friction of the fluid separating the surfaces. Liquids, with oil being the most common lubricant, are normally used as the fluid because they are not compressible. When a shaft is rotating in a journal bearing, the oil separates the surfaces. The only friction in the bearing is the fluid friction between the shaft and the layers of oil; thus, fluid friction develops the least amount of friction of the three types of friction.

**Types of Bearings**

- **Split journal bearings** are used to support and limit radial movement of shafts. They are constructed in two parts that are clamped into support blocks or housings. The inner surface of the bearing shells is lined with a soft anti-friction metal called BABBIT, which normally consists of lead, tin, copper, or antimony. The main advantage of split journal bearings is that they are easy to remove and replace. Split journal combination radial thrust bearings are used to support and limit both radial and axial movements of shafts. They are constructed in two halves with a thrust surface located on the end of the bearing. A shoulder machined on the shaft rides against the thrust surface of the bearing. Contact between these two surfaces limit axial movement.

- **The Kingsbury thrust bearings**, the rotation of the ship’s propeller pushes a column of water that causes an opposite reaction called thrust; this thrust causes axial movement of the shaft. It used to limit axial movement of the propeller shaft and to transfer thrust to the ship’s hull. It is placed at the end of the thrust shaft and is attached to the ship’s hull. The double-sided Kingsbury thrust bearing is used to absorb axial thrust in both the ahead and astern directions. The Kingsbury Thrust Bearing is rather intricate with several components.
  - The thrust collar is keyed on and rotates with the shaft transferring thrust.
  - The shoes pivot and have a beveled edge on the BABBIT surface. Clearance between the shoes and the thrust collar limits the axial movement of the shaft.
  - The upper leveling plates support the shoes and allow the shoes to pivot.
  - The lower leveling plates support the upper leveling plates. The action between the upper and lower leveling plates serve to equalize the thrust load on the shoes.
  - The base ring supports the lower leveling plates and is held stationary in the housing. The housing is attached to the ship’s hull.
  - The Kingsbury Thrust Bearing transfers the thrust from the shaft to the bearing housing in the following order: Thrust Collar, Oil Wedge, Shoes, Upper Leveling Plates, Lower Leveling Plates, Base Ring and Housing.

- **Ball and roller bearings** change sliding friction to rolling friction and limit radial and axial movement. They are called anti-friction bearings because they decrease the contact area between the surfaces. There are several varieties of ball and roller bearings that you need to know when you are working aboard ship.

- **Radial ball bearings** consist of inner and outer groove rings that are separated by balls. The inner ring is pressed or expanded on the journal of the shaft and rotates with the shaft. The outer ring is press fitted into a support block and does not rotate. Ball thrust bearing limits axial movement of a shaft. The inner ring is expanded or pressed onto and against a shoulder that is machined on the shaft. This ring rotates with the shaft. The outer ring is fitted into the housing and does not rotate. Combination radial thrust ball bearings limit radial and axial movement of a shaft. Cylindrical roller bearings are used to limit radial movement of a shaft. The inner ring is pressed on the shaft and the outer ring is pressed in the housing. Rollers are used to change the sliding friction to rolling friction. The tapered roller bearings limit both radial and axial movements of a shaft. The taper of the inner and outer rings and the rollers allow the bearing to limit both radial and axial movements.
Needle bearings limit radial movement of a shaft. Needle bearings contain a large number of small cylindrical rollers that may ride directly on the shaft or on an inner ring. If the bearing has an inner ring, the inner ring will be pressed on the shaft and the outer ring will be pressed into the housing with rollers between the two rings.
The Main Reduction Gears (MRG) and propulsion shafting are essential components of a ship’s propulsion system. All components must work properly and efficiently to propel the ship through the water. As an engineer aboard your ship, it is important to understand the purpose, terminology, associated components, and functions of the main reduction gears. You must also understand the safety precautions, associated components, and functions of the main propulsion shaft and their effects on the movement of the ship.

**Terminal Objective** – Demonstrate an understanding of the components, functions, and safety precautions of the main reduction gear and the main propulsion shaft.

- **Enabling Objective** – Identify the associated components, functions, and safety precautions of the main reduction gear.
- **Enabling Objective** – Identify the associated components, functions, and safety precautions of the main propulsion shaft.

Main reduction gears and engines are located in the engine room. It connects the prime mover to the shaft, the gear element arrangement transfers power and rotation from the prime movers to the propeller at a reduced speed. The main propulsion shaft transmits the output of the reduction gears to the main propeller. The propeller rotates, producing a counter-force on the ship propelling it through the water. The purpose of the main reduction gears is to reduce high engine RPM to a useful low propeller RPM. If the ship’s propellers were to operate at that high of speed, the ship would make little progress through the water.

There are three major components of the main reduction gears:

- **The high speed flexible coupling** connects the main turbines to the high speed pinions of the main reduction gear. The couplings allow for expansion of the turbine shafts. This takes care of any slight misalignment between the main turbines and the reduction gears. These couplings are lubricated from the main lube oil system.

- **The casing** is made of welded steel construction which supports and houses the reduction gear components. The casing is separated into three sections, each bolted to the other: the lower casing, upper casing, and the casing cover. The lower casing provides a base foundation, contains the lube oil sump, and the second reduction gear (bull gear) bearing housings. The upper casing supports and houses the first and second reduction gears and their respective pinions and bearings. The casing cover is split into quarter panels containing inspection ports and supports the piping and oil spray nozzles.

- **Gears**, there are many gears within the casings that provide the overall reduction of speed to the propeller.

- **The first reduction pinion** is coupled to the high speed flexible coupling and driven from the engine rotor and drives the two first reduction gears. Locked train means that the two first-reduction pinions are locked between the two first-reduction gears and transmit the power from the turbines equally to the two gears.

- **The first reduction gear** is attached to one end of the quill shaft and is connected to the shaft through steel webs.

- **The second reduction pinion** is driven by the quill shaft. They drive the bull gear. The second reduction pinions will make poor tooth contact with the bull gear, whenever the second reduction gear is misaligned in its bearings.

- **The second reduction gear**, also called the bull gear, has its hub keyed onto the main thrust shaft. It is located forward of the main thrust bearing and rotates at the same speed as the main shaft.

- **The quill shaft** connects the first reduction gear to the second reduction pinion, also transmits torque between the two. It consists of a gear coupling having two shaft rings with internal teeth and a shaft having external teeth.

- **Journal bearings** are used to support the weight of gears and pinions, and maintain radial alignment. They are babbitted, hard seated, rigid mounted bearings. Rigid mounted bearings are used to ensure no misalignment of gears. There are two bearings for every gear, and each bearing is lubricated from the main lube oil system.

- **The spray nozzles** are a piping extrusion, shaped to form a wide-angle spray pattern at its discharge, similar to the discharge spray of a portable spray bottle. They provide cooling and lubrication for the gears.

These components allow the engine to operate efficiently with minimal vibration and at a low RPM.

To maximize thrust, the main reduction gears (MRGs) aboard U.S. Navy ships are commonly arranged in one of two ways:

- **Double reduction** has two stages of reduction between the input, high-speed pinion, and the output shaft.
- **Double helical** refers to the gear cut used to reduce the axial thrust and produce a smoother action and reduce gear tooth stress.

The MRG assembly includes the following components:

- **Turning gear/propeller shaft locking device** provides a means to lock the engine and shaft or is used to slowly turn over or jack the reduction gears utilizing an electric motor to include warming up of the engines and cooling down while securing the engines. The turning gear is also used to perform PMS and other types of inspections where slow movement of the main reduction gear is desired.

- **Vent fog precipitator** is used to prevent oil vapors from escaping into the engine room from the reduction gear casing during operation by ionizing the vaporized oil, collecting it and then draining it back to the sump. Vent fog precipitator fittings are attached to the main reduction gear casing. There is a pilot light on the vent fog precipitator power pack that indicates the operating condition. Failure of the pilot light to glow or a flickering pilot light indicates faulty operation.

- **Lube oil pump**, is attached to and driven by the reduction gears, the amount of fluid delivered by it is directly related to the ship's speed.
Mechanical counter is a speed sensing device mounted on the forward end of the second reduction gear, and is driven by the thrust shaft. It indicates the number of times the shaft has turned over by means of a shaft revolution indicator. It transmits the RPM to the engine room control station and other places on the ship.

**-Bull gear** is keyed to the thrust shaft, and the thrust collar for the main thrust bearing as an integral part of the reduction gear. Thrust developed by the shaft is absorbed by the thrust bearing, preventing shaft thrust from affecting the reduction gears. The bull gear is the largest gear.

**MAIN PROPULSION SHAFT**

The main propulsion shaft is an important part of the ship’s propulsion system. Without the main propulsion shaft, the ship would be dead in the water (DIW). That’s why as an engineer it is important to identify the safety precautions, associated components, and functions of the main propulsion shaft. The main propulsion shaft and components receive the power transmitted from the MRG, which rotates the shaft and propeller. The main propulsion shaft and components receive the power transmitted from the MRG, which rotates the shaft and propeller.

The propeller is mounted to the tail shaft. The tail shaft is totally exterior to the hull of the ship. It is joined to the stern tube shafting by means of a coupling and supported by the strut bearing contained within the strut which is attached to the ship. It imparts velocity to a column of water and moves it in a direction opposite to the direction in which the ship is intended to move. The propeller is the of the screw type. Propeller blades are placed at such an angle as to advance the ship with each revolution; this angle is called the propeller pitch angle.

The stern tube shaft is where the shaft penetrates through the hull of the ship. It is used to prevent seawater from entering the ship. It is sealed by means of a stern tube syntron seal and is supported by a water cooled stern tube bearing.

**-Fair water sleeves** are circular steel or composition shields secured to the after end of the stern tube and to the struts. This fairing is accomplished by a gradual reduction in diameter from that of the stern tube or strut to that of the shaft.

**-After Stern Tube Bearing, Forward Stern Tube Bearing**, the shaft is supported inside the stern tube by two stern tube bearings. There is one bearing on the inner side and one on the outer side of the hull. They are made of rubber or phenolic resin mounted on bronze shells and lubricated by seawater. The construction is basically the same as that of the stern tube bearing. The purpose of the strut bearing is to support the weight of the Propeller.

There are three types of seals that are associated with the stern tube shaft seal assembly: the rubber-lip-type face seal (Syntron Seal), mechanical type face seal (Crane MX-9 Seal) and the emergency inflatable seal ring.

- **The emergency inflatable seal ring** is located aft of the primary seal. It is made up of two sections and prevents water from entering the shaft alley while conducting repairs to the primary seal. It is inflated using low pressure air, CO₂, or nitrogen. The shaft shall be locked and all sources which could cause the rotation of the shafting shall be danger tagged and locked.

- **The mechanical type face seal** (Crane MX-9 Seal) consists of a single seal assembly in which a nonmetallic ring wears against a bronze ring. Primary sealing occurs between the rotating seal and the stationary face. Secondary sealing occurs at the face sealing strip and between the two O-rings and the shaft.

- **The rubber-lip-type face seal** (Syntron Seal) assembly consists of two identical tandem rubber seals and is held in contact with the shaft by encircling garter springs. It uses cooling water provided from the firemain through a 150/25 PSI reduction. This provides the face of the seal with cooling and lubrication. The seal area also has a gland which is designed to accommodate rings of emergency flax packing, usually 1”, for situations where the seals are unable to be repaired.

**MAIN AND LINE SHAFT**

- **The line shaft** consists of two components, the line shaft itself and its bearings. It consists of all shafting from the thrust shaft to the stern tube shaft. It is supported by bearings, which help maintain shaft radial alignment. The line shaft is sealed at the bulkhead by means of packing and stuffing boxes to maintain water tight integrity between spaces during flooding. Line shaft bearings are lubricated by oiler rings. The oil sump is located beneath the bearing.

  - **Main line shaft** bearings are bearings that support the weight of the shaft within the hull of the ship. The bearings are Babbitt-faced, spherically seated, shell type journal bearings.

**BULKHEAD STUFFING BOXES**

The stuffing boxes, which are also a part of the main propulsion shaft, allow the shaft to pass through one compartment to another and prevent progressive flooding, thus maintaining watertight integrity. A packing is installed in the outside diameter of the seal to provide a limited or controlled clearance with the shaft during normal operation. It is used only in the event of compartment flooding or compartment air testing. Grease is never applied to the packing area under normal operation and shall be used only during compartment flooding to better seal the packing to the shaft.
CC-20
TANKS AND VOIDS

It is very important to become familiar with the types of tanks onboard, these tanks play an essential part in the daily operations and containment of liquids. They are used to hold fluids vital for the ships’ operation, such as fuel, oil, water, and gases. Voids (enclosed spaces) are usually empty, watertight compartments separating other compartments. Safety precautions must be taken with the utmost importance in these spaces.

Terminal Objective – Demonstrate an understanding of the purpose, functions, and components of tanks and voids.
- Enabling Objective – Identify the functions of tanks and voids components.
- Enabling Objective – Identify types of tanks and voids and the safety precautions to follow prior to entering a void (enclosed space).

Tanks and voids play an essential part in operations and containment of liquids. Daily life onboard ship is dependent on well-maintained and functioning tanks. Different tanks have different components such as baffles, gauges, hose valve connections, piping, pumping systems, relief valves, sight glasses, sounding tubes, tailpipes, tank covers, tank-level-indicating systems, and vents. Enclosed voids help provide a sealed bulkhead to prevent cross-contamination between the different tanks.

FUNCTION AND COMPONENTS
Tanks are used to hold fluids such as, potable water, fuel oil, lubricating oil, sewage, and gases. Voids on the other hand are used to provide unventilated, sealed spaces between different types of tanks such as a potable water tank and a fuel tank preventing cross contamination due to leakages between the tanks. Not all tanks are the same, so their components may vary. The following are common components of tanks:
- **Baffles** are metal plates in the lower part of a tank that reduce the surging of fluid with the motion of the ship.
- **Vents** are installed at the topmost points of tanks and in some instances may vent to the weather decks. The primary purpose of the vent is to permit air to escape as well as allow air to enter and exit while the tanks are filled and emptied.
- **Sounding tubes** are used for determining the liquid level in the tanks and for taking samples. Avoid the use of sounding tubes to take samples of potable water, it can easily introduce possible contaminates. Sounding tubes extend a few inches from the bottom of the tank, through its top, and up to a space where it is convenient to access the tube. Sounding tubes are not installed in pressurized tanks.
- **Tank access cover** allows tank entry. Tanks are not considered safe to enter until the tank has been emptied, cleaned, ventilated, and certified as “Safe for Personnel” by the Gas Free Engineer (GFE).
- **Tank level indicators** measure liquid level. These indicators work like the gas gauge in a car with a float and a receiver device. Float-actuated indicators can be direct reading (float gage) or indirect reading (magnetic float). Tank level measurement is used to determine how much of a given liquid has been removed from or remains in a tank. In rectangular shaped tanks, level and volume are linearly related. In odd-shaped tanks (most common) volume must be determined at given increments as a function of level. The initial calibration of tank capacity gauges or development of capacity tables and curves depends upon tank geometry.
- **Sight glasses** are used on smaller tanks for direct or indirect reading. The direct reading sight glass characteristics include a vertical pipe with a magnetized float, and cutout valves that remain closed and are opened only when taking readings to prevent fluid leakage. Indirect reading sight glass characteristics include a vertical pipe with a magnetic float, and small flags outside the pipe that indicate fluid level.
- **The tank gauge** is used to measure fluids in tanks for record keeping purposes. Fluids in tanks are measured by a remote sensor tank gauge, a sounding tape, or a graduated sounding rod. It is also possible to use a top sounding tape with the appropriate tank tables. The method of measuring fluids in tanks depends on the type of tank, size of the tank, and what type of ship the tank is on.

TYPES OF TANKS AND VOIDS

Voids are usually empty, watertight compartments separating other compartments. They are not passageways, spaces that crewmembers would be accessing on a daily basis, or useful spaces due to their placement, size, and shape. Tanks are used for storing and transferring different liquids, including fuel oil, lube oil, potable water, feed-water and many others.

There are five types of fuel oil tanks onboard a ship: storage tanks, service tanks, contaminated oil tanks, oily water drain collecting tanks, and overflow tanks.
- **Storage tank** holds fuel as it is loaded onto the ship before it is filtered for use.
- **Service tank** holds fuel oil for immediate use by propulsion equipment such as boilers, diesel engines, and gas turbines.
- **Contaminated oil tank** holds oil that is contaminated with water or other impurities.
- **Oily Water Drain Collecting Tank** collects contaminated oil/fuel with water for transferring to the contaminated oil tank. All fuel vents and drains, including those in the stripping system, are directed to it through a funnel.
- **Overflow tank** receives the overflow from a storage tank.

There are various types of tanks used to hold lube oil:
- **Storage tanks** are used to store new or renovated oil.
- **Settling tanks** allow water and other impurities to settle out of the oil. They are used to temporarily store used oil.
- **Sumps or oil pans** are used to collect oil as it drains from the engines, gears, and bearings.
- **Stripping tanks** permit used oil to stand while water and other impurities settle out.

Some tanks are used to store water:
- **Potable Water Tanks** store fresh, drinkable water onboard ship. Potable Water Tanks are located low in the ship and are constructed and situated to prevent contamination. They are marked “POTABLE WATER ONLY” and are set-up with connections at least 18 inches off the deck. They are provided with relief valves to protect tanks from over pressurization. The hoses for the Potable Water Tanks are kept in marked, padlocked, lockers. Tank-sounding tubes include padlocked valves or caps, which are only unlocked when in use.
- **Feed Water Tanks** hold water for use by the boilers for production of steam.
- **Ballast tanks** can be filled with seawater or fuel to maintain ship stability, in some instances to lower the ship into the water and flood well-decks which will permit amphibious craft to enter and exit the ship.
There are tanks used for collection:

- **Collection, Holding, and Transfer or CHT Tanks** are designed to hold shipboard sewage generated over a 12-hour period while in restricted waters. The collected sewage is held until it is transferred or discharged from the ship. CHT Tanks accept soil discharge from the following: water closets, urinals, showers, laundries and galleys.

- **Freshwater Drain Collecting Tanks** collect water condensed from steam drains for reuse in the boiler or drainage from various piping systems and equipment, which include turbine gland seal and exhaust piping, warmup drains from noncondensing turbines, and air ejector condenser drains. The drainage is discharged into the collecting tanks via funnels which must be kept covered to prevent entrance of contaminants.

**SAFETY**

Voids and tanks are considered Immediately Dangerous to Life and Health (IDLH) spaces, and access to them is prohibited. In an emergency, such as rescue efforts or emergency repairs, the CO, must grant permission to enter. Prior to entering a void or empty tank, a GFE must certify that the following dangers have been eliminated: possible poisonous gases, lack of sufficient oxygen, possible flammable gases. Personal protective equipment; respiratory protection; fire extinguishing equipment; emergency rescue provisions; tools and equipment, and ventilation must be used. While personnel are in the void or space, an attendant must be stationed outside, tending the safety line.
Stability is fundamental to a ship’s operation. Weight is constantly added, removed, or shifted as a ship burns fuel and as ammunition and other stores are loaded, unloaded, or consumed. The Ballasting System provides a way to compensate for these stability changes. In addition, the Navy’s amphibious warfare ships require Ballasting and Deballasting Systems to raise and lower their hulls in the water. Lowering the hull in the water partially floods their well decks, permitting the launch and recovery of landing craft and other amphibious vehicles for shore landings.

**Terminal Objective** - Demonstrate an understanding of the functions and operation of the Ballasting System components.
- **Enabling Objective** - Identify the functions and safety/protective precautions of the Ballasting System.
- **Enabling Objective** - Identify the location and operational characteristics of the Ballasting System.

Ballast refers to weight, solid or liquid, that is loaded into a ship to increase stability. The systems that control the level of seawater in ballast tanks have two main functions. One is to control the ship’s stability, and the other is to allow for amphibious operation by raising or lowering the hull in the water, to partially flood their well decks.

**SHIP’S STABILITY AND CLINOMETERS**
The factors that determine a ship’s stability are: Draft, List and Trim. To determine your ship’s stability, use draft marks and a clinometer. Draft marks are located on the hull, and clinometers are installed at vital stations such as the Chart House, DCA Stateroom, Damage Control Central, Main Engine Control Navigating Bridge, and Pilot House. Clinometers use a pendulum or an air bubble in a fluid, similar to a carpenter’s level, and measure the angle of the ship, either port to starboard (list and heel), or fore and aft (trim).

There are three main functions of the Ballasting System. One function is that in surface ships it maintains a ship’s stability as fuel, ammunition, or other cargo is loaded, unloaded, or consumed. Another one is in an emergency; it is used to correct a ship’s stability as a result of damage, such as flooding caused by firefighting water or a hull breach. For amphibious assault ships, it also provides a means of controlling the ship’s draft, list, and trim in order to launch or retrieve Landing Craft. Air Cushion (LCAC) or conventional landing craft during assault operations.

Ballasting refers to the filling of ballast tanks with seawater to correct list and trim for normal ship operations. This increases the ship’s draft. These tanks can be filled with seawater from the ship’s firemain system or flooded with water directly from the sea. Deballasting decreases a ship’s draft and corrects the ship’s stability. Deballasting utilizes many different methods to remove the seawater from these ballast tanks: Main and Secondary Drainage System, Eductors, Fire Pumps, Bilge Pumps, Gravity, and Compressed Air.

**CHARACTERISTICS**
The characteristics and physical arrangements of the ballasting system and its components are fundamentally the same for all amphibious ships. The Ballasting System consists of a series of dedicated ballast tanks both above and below the ship’s normal water line, a ballast tank valve control system, a Ballast Control Console (BCC), a deballast air system, and a communications system. There are, however, variations in the size and number of tanks, the number of hydraulic stations, and the number of deballast air compressors. In addition, other surface ships use ballasting systems, and these systems differ from ship to ship.

Ballasting system tanks are located both above and below the waterline and are filled or drained of seawater to affect the ship’s stability. The upper set of ballast tanks consist of various sized wing tanks located below the main deck but above the normal water line. The normal water line is typically the second, third, or fourth decks depending on the ship class along the port and starboard sides of the well deck. This group of tanks is filled from the firemain system through hydraulically operated fill valves and emptied by gravity through hydraulically operated drain valves either individually or simultaneously as desired from the BCC.

Ballast tanks located below the ship’s normal water line are filled from the sea by opening the hydraulically operated sea valves located in the bottom of the tanks and the electrically operated tank vent valves located on the second deck. Tanks are emptied by forcing the seawater out of the tank through the same sea valves with air pressure from the air deballast system with the tank vent valves closed. Tanks under the waterline are equipped with electrically operated vent and blow valves to allow the tanks to be vented when filling and to admit low pressure air to the tanks when emptying.

The ballast tank valve hydraulic control system is arranged for two modes of operation: Primary mode - Hydraulically controlled valves are operated remotely from the BCC. Secondary mode - Valves operated manually from each hydraulic station.

The ballast tank valve hydraulic control system is divided into a series of hydraulic control stations, the number of which is dependent upon the quantity of ballast tanks and the size of the hydraulic control stations. Each station consists of a motor driven hydraulic pump to supply hydraulic pressure to a group of hydraulically operated valves.

The hydraulic control stations control: Firemain fill, drain, and sea valve operation. To allow for system flexibility, the control stations can be cross connected to allow any station to provide hydraulic power to operate the hydraulic valves of any other station. The BCC is located in the ballast control room and remotely controls ballasting and deballasting operations by controlling and monitoring: Hydraulic control stations, air deballast system, tank levels, well depth, and ship draft. Normally during ballasting operations, the ballast control room is manned by the DCA, one or two operators, and a phone talker.

**AIR BLOW DEBALLASTING SYSTEM**
A typical air blow deballasting system consists of an air main loop from which branch lines supply air to ballast tank and remote operated blow valves. Cross connection and isolating valves are provided in the loop main to enhance reliability of the system.

The system is comprised of the: Air Main, compressor and air blow valve. The air main is supplied by several rotary-type air compressors to ensure reliability of the air supply. At each ballast tank fitted for air blow deballasting, compressed air is supplied by way of a motor-operated air blow valve. A motor-operated tank vent valve discharging to a vent line is provided. The vent and air blow valves are usually interlocked mechanically acting as a unit so that the vent valve is closed when the air blow valve is open and vice-versa. While deballasting uses air, it is important for the engine room to control the vents on all condensers and pumps that are taking suction directly from the sea. If not, air may blow out of the bottom of the ballast tanks and render these condensers and pumps air bound.
WELL DECK
The well deck drainage system is designed to assist in efficient flooding and draining the well deck when conducting ballasting operations. The well deck drain system consists of: Drain wells, piping, valves and remote, manual valve operating gear. The well deck drains are manually opened when preparing to ballast the ship to aid in even flooding of the well deck. As the ship is deballasted, these drains permit the complete drainage of the well deck, the water barrier recess, and the ramp stowage space.

COMMUNICATION
All normal communications for safe and effective control of ballasting operations are made by the following sound powered telephone circuits: 1JV and 6JV (primary) and 21MC (secondary). Messengers and the dial telephone system are used as supplemental and backup methods of communication.

OTHER SHIPS
Non-amphibious ships also have the ability to ballast and deballast in order to maintain or correct stability. There are two distinct systems: Automatic Fuel Oil Compensating System and Manual Fuel Oil Ballasting System. On ships such as the Arleigh Burke class destroyers, automatic fuel oil compensating systems provide automatic ballasting for all fuel oil storage tanks. By constantly supplying firemain water to the tanks through a reducer, the tanks are kept full of fuel, water, or a combination of the two. Even with the automatic ballasting system, there are still some tanks and voids that must be manually ballasted. Oilers can typically ballast cargo fuel tanks from the sea to avoid improper attitude and draft when low on cargo fuel.

Manual fuel oil tank ballasting is accomplished by using several systems that are interconnected by a manifold. Ballasting water is supplied to the tanks from the firemain system. Tanks can be dewatered by either the bilge stripping pumps or eductors to the main drainage system.
Navy ships contain numerous piping and tubing systems spanning from the bow to the stern. As an engineer, you are required to maintain and repair piping and tubing systems. Therefore, it is important to be familiar with the components associated with each of the systems. In this lesson, you will learn to identify the components of piping systems, tubing systems, and hose assemblies in accordance with specific instructions.

Terminal Objective – Demonstrate an understanding of the characteristics of tubing systems, piping systems, and hose assemblies

- Enabling Objective – Identify the components of piping systems
- Enabling Objective – Identify the components of tubing systems and hose assemblies in accordance with NSTM 505, Piping System.

Pipes are the main structures that allow fluid to be transferred from one location to another aboard ship. They are usually rigid and made of one of many different materials, including steel, copper, brass, aluminum, and stainless steel, and each serve a different function, including transferring water, fuel, and sewage. Be sure to use extreme caution when working in the vicinity of operating equipment, especially pressurized piping systems. Before disassembling piping, ensure the system is tagged out of service, depressurized.

A pipe’s dimension is determined by inside diameter (ID), outside diameter (OD), and length. To determine pipe size, use the iron pipe size (IPS) scale when the OD is less than twelve inches. The IPS scale measures ID to determine the pipe size. A pipe’s wall thickness is used to determine the pipe’s pressure rating. The wall thickness of a pipe can be determined by measuring the inside and outside diameters by using this equation:

\[
\text{wall thickness} = \frac{\text{OD} - \text{ID}}{2}
\]

To determine pipe size, use the IPS scale when the OD is less than twelve inches. When the OD is more than twelve inches, the ID is used to measure the pipe size.

**PIPE FITTINGS**

- **Pipe nipples** connect pipes or fittings and have male threads.
- **Straight couplings** are used to join two straight sections of pipe with male threads; straight couplings have female threads at each end.
- **Pipe elbows** change the direction of a piping run. The most common elbows are 45º and 90º with internal threads in both ends, and may be welded or brazed depending on the application.
- **Street elbows** connect pipes to machinery. They have male threads on one end and female threads on the other.
- **Pipe tee** consists of three sections of pipe. Tees have female threads to connect to male threads of pipe. They may be welded or brazed depending on the application.
- **Reducer couplings** change the size of a piping run and have internal threads on both ends.
- **Pipe caps** have female threads and are used to close the end of a section of pipe.
- **Pipe plugs** are solid fittings with male threads, are used to close the end of a fitting with internal threads.

**PIPE FLANGES**

Pipe flanges are used to connect pipes to valves, machinery, or other pipes. They are connected by welding, threads, or by a combination of these methods.
- **Flat face flanges** connect low pressure piping systems. This type of flange requires a gasket between the flange faces. The proper type of material required can be determined by using the packing and gasket chart in your work center.
- **Raised face flanges** connect high pressure piping systems by using a spiral wound gasket (semi-metallic) with a retainer.

Temperature can have an adverse effect on piping systems. Extreme heat or cold can cause piping to expand or contract, creating undue stress on the pipe. Expansion joints allow flexing when the piping system is heated or cooled. Bellows and corrugated are two types of expansion joints. Bellows type expansion joints are installed between flanges, while corrugated expansion joints have corrugations similar to a cardboard box.

**COMPONENTS OF TUBING SYSTEMS AND HOSE ASSEMBLIES**

Tubing and hoses allow fluid to be transferred from one location to another aboard ship. Tubing and hoses are flexible, usually have a thinner wall, and are less rigid than piping. Tubing is most commonly made of metal, copper, or stainless steel, while hoses are most commonly made of rubber. Tubing size is determined by measuring the outside diameter, or OD, and the wall thickness.
Be sure to use extreme caution when working in the vicinity of operating equipment, especially pressurized piping systems or hose assemblies. Before disassembling piping, ensure the system is: tagged out of service and depressurized. It is also important to remember NOT to: remove asbestos lagging, make unauthorized alterations to equipment or components, paint over or put sealant on hose identification labels or install a hose with a rated working pressure that is less than the design pressure of the system in which it is installed.

**FITTINGS**

Flare and flareless fittings provide safe, strong, dependable connections to tubing without the necessity of threading, welding, or soldering.

- A flare is a bell-shaped opening at the end of tubing made with a flaring tool. Flare nuts connect tubing to the fittings. They draw the inside of the flare on the tubing against the outside of the taper of the fitting, forming a metal-to-metal seal. The taper is located on the outside to form a seal inside of the tubing flare as the flare nut is tightened.

- Flareless nuts also connect tubing to the fittings to form a seal. When a flareless nut is tightened, it compresses the sleeve, which fits around the tubing and forms a seal between the tubing and the fitting; the taper is located on the inside of flareless fittings.

There are six types of tube fittings: union, elbow, tee, reducer, tubing cap, and adapter. Tube fittings are made of steel, aluminum alloy, or bronze and should be used with tubing of the same material. Adaptors work a bit differently, they connect a tubing run to a pipe run, and have male pipe threads on one end and a connection for tubing with male machine threads on the other.

**HOSES**

Hoses are flexible tubing for transferring fluids. They are used to absorb motion between resiliently mounted machinery and fixed or resiliently mounted piping systems. It uses reinforced rubber hose and metal end fittings. There are several terms associated with hoses:

- **Abrasion** is the wearing away by friction.
- **Blister** is a raised spot on the surface, cover, or tube, indicating a separation between the layers, usually forming a void or air pocket.
- **Collapse** is a condition in which the hose caves or falls in on itself.
- **Kink** is a temporary deformation of a hose.
- **Shelf life** is the period of time dating from the time of manufacture to the time of installation.
- **Service life** is the period of time in which a rubber hose is installed and in use.

There are two types of non-rubber hose construction: Polytetrafluoroethylene (PTFE) and metal. PTFE hoses are constructed with material that is reinforced externally, with one or more layers of braided stainless steel wire, while metal hoses have corrugated metal tubes overlaid with several layers of wire braid reinforcement. Precaution should be taken when storing hoses to eliminate damage. The temperature should not exceed 125°F. Storing hoses in straight lengths is preferred, but if hoses must be coiled, ensure the diameter of the bend is not less than three feet.

A hose can be identified by the manufacturer’s part number, size, or dash number. A hose built to Military Specification (MILSPEC) requirements has the number of the specification and, where applicable, the class of hose, the quarter, year of manufacturer, and the manufacturer’s trademark.

Hose and hose assembly inspections are mandatory and should be conducted in accordance with the prescribed PMS requirements. In addition to PMS requirements, visual inspections should be conducted at least once a quarter. The following should be noted during visual inspections: evidence of leakage at fitting ends, discoloration of fittings, slippage of hose out of fitting, large areas of hose covered by paint, soft spots or bulges on hose body, presence of identification tag, and twisting or other distortions. If there is any indication of weakening hoses or fittings, notify your Work Center Supervisor.
Drinking water or potable water is water safe enough to be consumed by humans whether the water is used for drinking or not. The potable water system on ship supplies scuttlebutts, sinks, showers, sculleries, and galleys. It provides water for various freshwater cooling systems. Only by ensuring acceptable potable water quality can the health of the crew be protected; therefore, this lesson covers the Potable Water Service and Transfer system for receiving, sampling, and treating potable water including safety precautions for calcium hypochlorite.

**Terminal Objective** - Demonstrate an understanding of the purposes and components of the Potable Water Service and Transfer System as well as the safety precautions.

- **Enabling Objective** – Identify the purpose and major components of the Potable Water Service and Transfer System
- **Enabling Objective** – Identify the operation of the Potable Water Service and Transfer System for receiving, treating, and sampling potable water, and the safety precautions for calcium hypochlorite.

**SERVICE AND TRANSFER**

Potable water for shipboard use comes from one of several sources: shore-to-ship delivery, ship-to-ship transfer, or the ship’s distillation plant. The purpose of the Potable Water System is to create, hold, and distribute “Potable Water” that is suitable for human consumption. It varies greatly from ship-to-ship with respect to size, arrangement, and operation of components. The system provides storage capabilities and a method of distributing water to the various outlets on the ship. It allows for the capability of distilling seawater to make freshwater and then the treatment of freshwater to make it potable.

When in port, fresh water hoses are run from the shore to the ship through connections painted dark blue. At sea, distillation or desalination is used to replenish the fresh water tanks. A nightly report is made to the OOD when underway as to the percent of potable water onboard the ship.

- **The potable water tanks** store potable water for use onboard ship. The number and size of potable water tanks onboard depends on the class or size of ship.
- **The fill and suction manifold** is an arrangement of valves located at a common distribution point within the system. The function of the manifold is to allow the transfer of potable water to and from the various tanks within the system.
- **The piping** provides a flow path for the potable water to flow through the Potable Water System.
- **Valves** are used to start, stop, and control the flow of potable water. Each valve hand wheel shall be color-coded dark blue. Relief valves ensure tanks are not over-pressurized while filling or transferring is in progress. These valves are located on top of each tank.

The fill and transfer main connection is used to fill or transfer potable water to or from another ship or shore installation, or between the ship’s own potable water tanks. When not in use, the fill connections will be closed with screw caps attached with a chain. These connections will be at least 18 inches above the deck with the receiving connection turned down to protect it from contamination, and labeled POTABLE WATER ONLY in 1-inch letters.

Brominators disinfect the water by chemically treating it to prevent the growth of bacteria. Mounted on the ship's bulkhead the Brominator recirculates water in the potable water tanks using its own pumps for disinfecting the water. It also contains a bromine cartridge that releases bromine resin into the water passing through the cartridge. This release rate is proportional to the water flow rate, temperature, and water quality. The Navy uses two types of Bromine Feeders: automatic proportioning and recirculating.

- **The Automatic proportioning bromine feeder** is installed between the distilling plants and the potable water tanks to provide the initial treatment of distillate before entering the potable water storage tanks.
  
- **The Recirculating bromine feeder**, which is the most common type, is designed to treat water in potable water storage tanks. The water is treated by the recirculation of potable water from a potable water storage tank, through the brominator, and back to the same tank.

Bromine cartridges are installed upside down and thread into the cylinder with a shelf capability of 24 months from the date the cartridge is filled. This date is stamped on each cartridge and should be stocked and rotated to ensure they are expended before the expiration date. A Time Totalizer Meter provides a visual indication of the time remaining before the next scheduled bromine cartridge change.

**OPERATION**

Potable water for shipboard use comes from one of several sources: the ship’s distillation plant, shore to ship delivery, or ship to ship transfer. There are certain precautions to keep in mind to prevent the contamination of the system. Water sampling by use of the sounding tube subjects the tank to possible contamination by the person sampling. Cross connections between potable and seawater systems, or connections to other systems that could contaminate are not permitted. The piping, piping components, and plumbing fixtures shall be kept in good condition. The installation of an air gap is the best method of preventing contamination.
TREATMENT
Potable water may be contaminated during production, handling, storage, or distribution. Therefore, it must be disinfected before consumption to kill disease carrying microorganisms called pathogens. Treatment with a halogen, such as chlorine or bromine, is the only approved method of disinfecting potable water.

The bromine disinfection method uses brominators in system to disinfect the water. Bromine presents less of a safety problem during handling, has a longer life, and requires less maintenance than the chlorine disinfection method. This method of disinfection involves adding bromine to water to destroy unwanted organic species. Bromination has been proven effective in controlling most disease producing bacteria, even with relatively short contact time.

The chlorine batch method uses chlorine in the form of calcium hypochlorite. It is considered the least desirable method because it may result in over chlorination and because it exposes the potable water to potential contamination. The calculated amount of chemical is dissolved in warm water and any suspended matter is allowed to settle out. The solution is then poured into a filled tank via sounding tube or vent. One gallon or more of potable water must be poured into the sounding tube after adding the chlorinated solution to ensure that the entire solution is flushed into the potable water tank. A chlorinator may be installed in either the distilling plant distillate line or in the shore fill line or one chlorinator may serve both the distillate line and the fill line. When handling or using calcium hypochlorite, do NOT mix with anything except water and dispense only with clean dry utensils and amounts required for immediate use. Avoid contact with the skin and eyes by wearing rubber gloves and a face shield.

RECEIVING SHORE SOURCE POTABLE WATER
When in port, fresh water hoses are run from the shore to the ship filling tanks designated to hold potable water. There are certain precautions to keep in mind to prevent the contamination of the system. Before making a shore to the ship connection, the shore outlet connection must be flushed until the water is clear, free of rust or dirt. Once clear, flush the outlet connection for an additional 15 to 30 seconds. Disinfect the outlet connection by swabbing it with chlorine. Let the chlorine stand for two minutes and then re-flush. Medical Department personnel sample and test the water before the final hose connection is conducted and test the potable water in tanks at least once daily.

Representatives from both the ship’s Medical and Engineering Departments routinely perform sampling and testing of the Potable Water System. The ship’s medical department is responsible for determining the quality of the water. The engineering section determines the quantity stored or produced, and performs the actual chlorination or bromination.
Machinery becomes very hot from continuous movement and keeping it cool ensures efficiency and longevity. The Auxiliary Machinery Cooling Water (AMCW) system draws seawater into the system and is channeled through various components before entering the heat exchanger for cooling. A back-up system is used to support the AMCW system when the pumps are not in use or if they malfunction. In this lesson, you will identify the purpose, function, and major components of the AMCW.

Terminal Objective – Identify the operational characteristics of the Auxiliary Machinery Cooling Water System.

- Enabling Objective – Identify the purpose, function, and components of the Auxiliary Machinery Cooling Water (AMCW) System.

The purpose of the AMCW system is to provide cooling water to auxiliary machinery. This system is vital to ensure that the machinery operates efficiently. The system can maintain various pieces of equipment; these include the lube oil coolers for turbine driven auxiliaries, such as the main feed pump, forced draft blower, fuel oil service pump or lube oil service pump, air compressors, and the air condition and refrigeration equipment.

**SYSTEM FLOW**

The flow of sea water follows a path prior to accomplishing its job through the system:
- **Seachest** is a cavity or opening in the hull of the ship below the waterline where seawater enters or exits. Cooling water piping directs water flow from the seachest to the auxiliary equipment in the AMCW System.
- **The suction valve** isolates the pump from the sea-chest and allows the pump to take suction.
- **The pump** is a single-stage centrifugal component used to pump seawater from the seachest to the system.
- **The vent valve** is located at the top of the pump casing. It removes air and ensures that the pump is primed.

- **The recirculation line** prevents the pump from overheating by allowing seawater to flow through the pump during low load conditions.
- **The recirculating inlet valve** allows water to enter the recirculation line.
- **The Y-strainer** prevents the orifice from being clogged by debris.
- **The recirculating line orifice** limits the flow of water through the orifice.
- **The recirculating outlet valve** directs seawater to the suction side of the pump.
- **The AMCW pump discharge check valve** prevents water from going in direction through the AMCW pump.
- **The pump discharge valve** isolates the AMCW pump from the system.
- **The duplex strainer** removes debris and prevents clogging of small in the auxiliary machinery and orifices serviced by the AMCW system. A to alternate between the baskets so the idle basket can be removed for cleaning.
- **The strainer outlet valve** allows the seawater from the strainer to go to the equipment for cooling purposes.
- **The heat exchanger** is where the actual cooling process begins. Heat is transferred from a hot fluid (oil or water) coming from the auxiliary equipment to the cooler water of the AMCW system in the equipment’s heat exchanger. There are two cooling valves, one on each side of the heat exchanger. The cooler inlet valve controls the release of seawater into the heat exchanger. This valve is fully open when in operation to allow maximum water flow into the heat exchanger. The cooler outlet valve throttle the seawater through the heat exchanger. The output temperature from the heat exchanger can be adjusted for proper operation by throttling the outlet valve.
- **The Y-strainer** is installed before the strainer. It contains single body housing and a wire mesh basket. A drain connection is provided at the bottom of the body to remove accumulated debris. The basket is periodically removed for cleaning.
- **The flow limiting orifice** consists of a thin metal plate inserted between two flanges in the pipe. The diameter of the hole drilled through the plate, and the associated pressure drop, determine the flow rate of water.
- **The overboard discharge valve** allow seawater to be discharged from the system back to the sea. A back-up system is also used for cooling, depending on your ship’s configuration. The reducing station will reduce firemain pressure to a usable pressure for a back-up supply for the AMCW system. The output of the reducer will go to the same places as the output of the AMCW pump.

Firemain pressure is always maintained above 125 PSIG. Most ships’ AMCW system operating pressures are between 45 to 55 PSIG. The reducing station may be the primary source of cooling water if the ship does not have an AMCW pump. If the ship does, the reducing station becomes a back-up system for cooling water. If the reducing valve fails, the operator can take manual control through the reducing station bypass to maintain the desired pressure.
Monitoring devices provide the operator with remote warning and monitoring of cooling system operation and impending faults.

- A pressure gauge at the discharge side of the pump indicates the pump’s performance.
- A differential pressure gauge indicates differential pressure between the strainer inlet and outlet. A high differential pressure would be an indication of a clogged strainer.
- Thermometers show the temperature of the water.
- Reducing station pressure gauge indicates the performance of the reducing valve and is used when taking manual control through the reducing station bypass.
High pressure (HP) and low pressure (LP) air systems compress atmospheric air to desired pressures for various shipboard applications. Understanding these systems provides Sailors with the capability to operate and maintain them. In this lesson, you will identify the major components, locations, functions and operational procedures of the HP and LP air systems, as well as the safety precautions, indications, and alarms.

**Terminal Objective** - Demonstrate an understanding of the safety precautions, components, functions, and operational procedures of Compressed Air Systems.

- **Enabling Objective** - Identify major components, location, function, and operational modes of the Low Pressure Compressed Air System.
- **Enabling Objective** - Identify major components, location, function, monitoring, and operational principles of the High Pressure Compressed Air System.
- **Enabling Objective** - Identify the safety precautions, operational procedures, indications, and alarms when operating Compressed Air Systems.

**LP AIR SYSTEM**

The LP air system supplies compressed air at an operating pressure of 150 PSIG or less and it is located at various locations throughout the ship. There are several components that make up the system:

**COMPRESSORS**

LP air compressors supply from 80 to 150 PSIG for the LP air system. The Navy uses different types of LP compressors: centrifugal, reciprocating, and rotary.

- **The centrifugal type** LP air compressor operates at pressure of up to 125 PSIG. It meets the high capacity, oil free demands of new, large ships. In order to operate properly, it needs several components:
  - **Prime mover** - An electric motor connected to a speed increasing gear assembly to achieve the impeller speeds necessary for operation.
  - **Compressor** - Houses the multi-stage impellers that compress the air.
  - **Cooling system** – Comprised of an intercooler, after-cooler, and a chiller to condense and remove some of the moisture from the air.
  - **Lubricating system** – Contains a main lube oil pump and an auxiliary electric motor used to run the pump during start up and shut down.
  - **Unloading control valve** – Allows for the release of pressure to the atmosphere during times of low demand. This prevents compressor surge.

- **Reciprocating compressors** range from two to six stages and supplies compressed air ranging from 80-5000 PSIG. LP compressors of this type normally have two stages, while the HP compressors contain four to six stages. LP compressors have pressures from 80-150 PSIG. Medium pressure compressors range from 151-1000 PSIG, and HP compressors provide 1000 PSIG or higher.
  - **Prime mover** is usually an electric motor that drives the compressor crankshaft and pistons.
  - **Pistons** - The pistons move up and down in the cylinders. In one cycle of operation, there are two strokes: the intake stroke draws air into the cylinder, and then the compression stroke compresses and discharges the air.
  - **Valves** control the intake and discharge airflow. They open and close due to differential air pressure between the inlet and outlet of the valve.
  - **Cooling system** is required for cooling of the compressed air and the compressor. An intercooler cools air after a compression stage, and an after-cooler removes heat from the final stage of compression.
  - **Monitoring devices** give the operator valuable information about performance and include the lube oil sump dipstick, pressure gauges, and thermometers.

- **The rotary, water flooded, helical screw type** LP air compressor produces compressed air at an operating pressure of 125 PSIG. The prime mover, an electric motor, drives the rotary compressor. It contains two rotors: the male rotor has four lobes, and is directly connected to the prime mover through a flexible coupling. The female rotor is driven through timing gears from the male rotor, and has six lobes. Air compresses between the lobes of the screws and the casing. The injection water system utilizes recirculated freshwater, injected into the air inlet and maintained by differential air pressure, to reduce clearances and minimize air leakage, therefore, no water pump is needed. The freshwater entrains in the compressed air and is heated by the compressing action of the lobes. Upon discharge, the entrained water separates and cools. It is stored in the separator holding tank and then recirculated back to the compressor inlet for reinjection.

**DEHYDRATORS**

Dehydrators remove water vapor from compressed air. LP air system dehydrators are located between the compressor and the air receiver/accumulator. There are two types of dehydrators:

- **The Type I dehydrator** is a self-contained, fully automatic, refrigerant type unit. It is designed to remove vaporous water, oil, and other solid contaminants from LP air systems. Moisture removal is achieved by cooling the air in the system with a low-temperature coolant, which condenses the water vapor to liquid water. It contains a high temperature alarm to indicate an improper refrigerant temperature.

- **The Type II dehydrator** is self-contained unit designed to remove vaporous water, oil, and other solid contaminants. In the Type II dehydrator, air moves through desiccant chambers, which absorb the moisture directly from the air. To allow continuous, automatic operation, the dehydrator is constructed with two desiccant chambers, plumbed in parallel. This means that when one chamber is dehydrating the airstream, the other is being reactivating. Interlocks prevent both chambers from operating at one time. There is also a high dew-point alarm, which warns the operator of excessive moisture in the airstream.
SYSTEM COMPONENTS
There are other components that are part of the system:
- **The priority valve** is located between the non-vital and the vital headers in the LP air system. It ensures pressure is maintained in the vital air system by isolating the non-vital air system when air pressure in the system falls below a set point, usually 80 PSIG. In this manner, air is only provided to vital systems required for the basic operation of the ship’s propulsion systems.
- **The controller** permits the operator to control the compressor in either the manual or the automatic modes. In the manual mode, the compressor operates in an on or off manner. When placed to automatic, however, the compressor turns on and off based on pressure limit switches, control switches, receiver air pressure, and timer. Each automatic mode of operation represents specific cut-in and cut-out pressure set points. The controller is located on or near the compressor.
- **The air reducing station** reduces air pressure from the HP air system from 3000 to 80 PSIG as an emergency backup for the LP air system.
- **The freshwater expansion tank**, located on the LPAC, provides fresh water for sealing, heat absorption, and compression.
- **Moisture separators** remove water and impurities from fully saturated, moisture-laden compressed air. Moisture separators are typically installed downstream of the compressor discharge and have low point drains installed at suitable locations throughout the ship’s compressed air piping.

MODES OF OPERATION
The LP air system’s three modes of operation, lead, lag, and emergency standby, allow for different operating air pressures.
- **Lead** - The compressor starts when the air receiver/accumulator pressure drops to 110 PSIG. The compressor then unloads when the pressure reaches 125 PSIG.
- **Lag** - The compressor starts when the air receiver/accumulator pressure falls to 105 PSIG and unloads when the pressure reaches 120 PSIG.
- **Emergency standby** - When the operator selects the emergency standby mode, the LP air system compressor starts when the air receiver/accumulator pressure drops to 100 PSIG. The compressor unloads at 115 PSIG.

HIGH PRESSURE AIR SYSTEM (HP)
The HP air system provides operating pressures of more than 1000 and often 3000-5000 PSIG. It provides compressed air for augmentation of the LP air system, charging and ejecting torpedoes, starting and cooling aircraft, starting gas turbine engines, and starting diesel engines. Loss of HP air directly affects the ship’s ability to meet operational requirements so it is very important to understand the major components, locations, functions, monitoring, and operational principles of the HP air system. The air system has several components. These include the high pressure air compressor (HPAC), instrumentation and control, pressure relief valve, moisture separator flask, oil-particulate filter, check valve, and dehydrator.

- **HPAC** provides air for the ship’s HP air system. It is a multi-stage reciprocating compressor with an operating pressure of above 1000 PSIG. Its valve hand-wheels are color-coded dark grey and operate in two modes, automatic and manual. In the automatic mode, the compressor is controlled by cut-in and cut-out pressure switches. The compressor starts when system pressure falls below the preset low cut-in pressure switch threshold. In the manual mode, the compressor starts by pushing the start button. The compressor runs if the system pressure has fallen below the preset low cut-in pressure, between 2500 to 2800 PSIG, and it stops automatically when the system pressure reaches 3000 PSIG. The compressor stops in the manual mode just as in the automatic mode, as sensed by the preset high cut-in pressure switch. The compressor will not start automatically, however, when the system pressure falls below the cut-in pressure.
- **Monitor system**, the HP air system is remotely monitored in the CCS, DCC or the Enclosed Operating Station (EOS), as well as local monitoring provided at the compressor. Audible and visual fault indications are present for each compressor. Temperature indications are provided for the inlet and outlet air of each stage, final air discharge, lube oil in the reservoir, cylinder cooling water, and seawater outlet temperatures.
- **Pressure relief valves** are installed in systems in which an excessive pressure may cause damage to the system or equipment or may injure personnel. It is an automatic device, which upon sensing excessive pressure, actuates a release, safely discharging the pressure from the system in a controlled manner. Upon sensing a drop in pressure below the excessive pressure point, the release closes, thus returning the valve to normal operation.
- **Moisture separator flasks** collect and remove the moisture that precipitates out as water from compressed air during cooling. They are located downstream of the compressor discharge and remove the excess moisture laden air where it is collected in the flask and removed through the low point drains. They are blown down hourly whenever the compressor is in operation.
- **The oil-particulate filter** removes oil and other particulate matter from the HP air system.
- **Safety-stop check valves** are installed in hose supply lines to prevent injury to personnel due to whipping hose in the event of a hose rupture. This is accomplished by quickly and automatically shutting off the flow under certain excess flow conditions. If downstream pressure is removed, as in a hose rupture, the pressurized dome forces the valve closed. The valve remains closed until the downstream casualty is repaired and the reset needle valve bypass is opened and re-pressurizing downstream of the control valve.
- **Dehydrator** is a semi-automatic, operator-controlled, self-activating, heat-reactivated, dual-tower, desiccant-type unit. HP air system dehydrators are semi-automatic while LP desiccant dehydrator components are fully automatic.
- **Piping distribution system** delivers compress air to various locations on the ship.

MEDIUM PRESSURE AIR COMPRESSOR (MPAC)
Although not very common, some ships may be outfitted with a MPAC, which supplies compressed air at pressures ranging from 151 to 1000 PSIG and are used for: diesel engine starting, diesel engine speed control, propulsion control, and LP air system augmentation.
SAFETY

It is extremely important to understand the operating procedures, alarms, and indications of compressed air systems. Compressed air systems hold pressures up to 5000 PSIG and can be hazardous to personnel and equipment if not operated in a safe manner. Compressed air represents stored energy. As compressors produce this energy for shipboard use, they also produce heat. You must ensure that compressed air is always free of dirt, oil, and moisture. A vital procedure for maintaining the compressed air system is the blowdown. Regardless of air pressures, all air receivers/accumulators, separators, filters, and air flasks are blown down, or purged, to remove water and oil. There are many safety considerations when working with air compressors and compressed air. Safety and protective devices are installed on the component’s control panel to monitor and maintain the systems in peak operational condition. There are temperature, humidity, pressure alarms, and indicators that alert the operator to possible system failure. There are safety devices to protect you from harm when operating air compressors. Belt guards, fan guards, and coupling guards protect you from rotating elements of the compressor. There are also relief valve tail pipes, which protect you from the pressurized air discharged by a relief valve.
Sustained operations require Navy ships to be self-sufficient in producing distilled water since space limitations permit only enough storage tanks for a few days’ supply. The ship, therefore, depends on distilling plants to produce high-quality distilled water from seawater. In this lesson, you will demonstrate an understanding of the types, components, and operation of distilling plants.

**Terminal Objective** - Demonstrate an understanding of the types, components, and operation of distilling plants.

- **Enabling Objective** – Identify the purpose and types of distilling plants.
- **Enabling Objective** – Identify the major components and the theory of operation of the low-pressure flash-type distilling plant.
- **Enabling Objective** – Identify the major components and the theory of operation of the reverse osmosis distilling plant.

The primary purpose of distillation is to create potable water for ships. There are various distilling units and distillation methods for performing this process. The purpose of the onboard **distilling plant** is to convert seawater into fresh water. Fresh water is needed for drinking, cooking, and showering; boilers, diesel engine jacket water, and potable water systems, require fresh water also.

There are common terms associated with changing seawater into fresh water:

- **Effect** is the part of a unit where a distilling process occurs. It is also known as a shell.
- **Distillation** is process of evaporating seawater, then cooling and condensing of the resulting vapor to produce fresh water.
- **Feed Seawater** is the raw material of the distilling unit, also called seawater feed or evaporator feed.
- **Evaporation** is the action that takes place when a liquid changes into a vapor or gas and is the first half of the process of distillation.
- **Saturated Steam** is water in a gaseous state that is in contact with the liquid from which it was boiled at a given pressure or temperature.
- **Vapor** is the product of evaporation of seawater feed.
- **Superheated Steam** is vapor that is not adjacent or next to its liquid source and that has been heated to a temperature above its saturation temperature.
- **Condensation** is the process of cooling vapor to revert it back to a liquid and is the second half of the process of distillation.
- **Distillate** is the product (fresh water) that result from the condensation of the steam (vapor) produced by the evaporation of seawater.
- **Potable Water** is water that is safe for human consumption. It is fresh water that has been treated with a chemical disinfectant to kill harmful bacteria while in the storage tanks.
- **Brine** is any water in which the concentration of chemical salts is higher than what it is in seawater.
- **Salinity** is the concentration of chemical salts in water that increases the ability of water to conduct electrical current. Salinity cells measure this conductivity indicated in units of equivalents per million (EPM), parts per million (PPM) or micromhos per centimeter (µmhos/cm).

### TYPE OF DISTILLING PLANTS

The two types of distilling plants used onboard ship are the low-pressure flash-type distilling unit and the reverse osmosis distilling unit.

- **Low-pressure flash-type distilling units** use low-pressure steam from either the auxiliary exhaust systems or the auxiliary steam systems as the heat source to evaporate seawater. For this unit, the operating shell pressure is less than the atmospheric pressure; in other words, it is a vacuum.
- **The reverse osmosis distilling units** do not heat seawater. The centrifugal pumps force the seawater at high pressure against a membrane, where the liquid is permitted to pass but the salts are not. The salts are pumped back to the sea as brine.

### LOW-PRESSURE FLASH-TYPE DISTILLING PLANT

The low-pressure flash-type distilling units, auxiliary exhaust systems or auxiliary steam systems provide low-pressure steam to evaporate seawater. The operating shell operates in a vacuum process to lower the boiling temperature. The operation reduces the formation of harmful scale, or mineral deposits, on heat transfer surfaces, and less energy is required to run the unit and produce fresh water. The low-pressure flash-type distilling unit consists of several major components:

- **The seawater feed pump** takes suction from the sea and delivers seawater to the evaporator for conversion into steam, and, ultimately, into usable fresh water.
- **First and second stage evaporator shells**, referred to as flash chambers because seawater “flashes” to steam as it enters these chambers.
- **Air ejectors** are jet pumps that use auxiliary steam as the driving force to help maintain a vacuum inside the evaporator shell by removing air and non-condensable gasses. An air ejector condenser uses auxiliary steam from the air ejectors that help heat the seawater before the seawater enters the first stage shell.
- **The seawater heater** uses auxiliary exhaust steam or auxiliary steam to heat seawater prior to its injection in the first stage shell.
- **Condensers** are a set of cooling tubes located at the upper part inside the evaporator shells, used to condense steam vapor into distillate. Distillate troughs collect the water condensed from the steam. The distillate pump takes suction from the distillate trough and delivers the water to either a potable water tank for later use by the crew or to a feed water tank for use by the boilers.
- **The brine pump** removes brine that accumulates at the bottom of the evaporator shells and discharges it to the sea.
- **Demisters** (moisture separators) are used to remove entrained water droplets from the steam in the evaporator shell. These water droplets then drain back to the bottom of the shells. These water droplets may contain salt particles.
- **A three-way solenoid trip valve** is controlled by a salinity cell. It diverts the contaminated water overboard or to the bilge when tripped.
REVERSE OSMOSIS PLAN

Navy reverse osmosis (RO) desalination units are designed for service where low pressure steam or waste heat is unavailable or the quantities are insufficient to operate distillers. Osmosis is defined as the movement of a liquid solution through a semi-permeable membrane. The use of a semi-permeable membrane that allows water to pass through it while it is closed to dissolved salts is critical to the normal osmosis process. If this membrane is placed between two compartments in a container, as one half holds a salt solution and the other half is pure water, a fundamental scientific principle comes into play. The two different concentrations of liquids within the same system will try to reach equilibrium, such as the same concentration of salt, on both sides of the membrane. The only way for this to happen is for the pure water to pass through the membrane to the saltwater side in an attempt to dilute the solution. As the pure water passes through the membrane, pressure, called osmotic pressure, begins to build. This attempt to reach equilibrium is called osmosis.

RO is the reversal of the natural flow of osmosis. In a water purification system, the goal is not to dilute the salt solution, but to separate the pure water from the salt and other contaminants. When natural osmotic flow is reversed by the application of pressure on the saltwater side, water from the salt solution is forced through the membrane in the opposite direction; this process is called reverse osmosis. Through this process, we are able to produce pure water by screening out the salts and other contaminants. In the RO process, permeate is the term applied to the portion of the liquid that passes through the membrane.

The reverse osmosis distilling unit contains various components:
- **The duplex strainer** removes large debris from the seawater.
- **Centrifugal separator** removes heavily suspended particles by centrifugal force.
- **The heater** prevents freezing on the fresh water side of the membrane when operating in cold weather. The heating element turns on when the water temperature drops below 35º.
- **20-micron and 3-micron filter elements** are utilized to filtrates seawater to prevent fouling of the membrane.
- **Activated carbon filter** removes bromine or chlorine which can damage the membrane.
- **High Pressure Pump (HP)** is a positive displacement, reciprocating type pump.
- **Accumulator** dampens the pulsation from the reciprocating motion of the HP pump.
- **Flow meters** monitor both the brine and permeate leaving the reverse osmosis unit.

The RO unit is divided into three modules (skids) that house the different components:

- **Filter Skid**, also known as the Pretreatment System, it removes particulate matter that would otherwise foul the reverse osmosis elements. For the pretreatment process, feed water goes through a centrifugal separator, then through an electric heater followed by a 20 micron and a 3 micron cartridge filter elements.

- **HP Pump Skid** contains the HP pump, drive motor, V-belt drive, and an accumulator. It increases the pressure differential across the reverse osmosis membrane required for reverse osmosis to take place.

- **RO Skid** is where the actual distilling process takes place. It contains the RO membrane elements inside a pressure vessel, a dump valve, and flowmeters. It fits into a cylindrical pressure vessel with piping connections to feed water, brine, and distillate collection. As pressurized seawater flows across the membrane surface, fresh water passes through while dissolved salts are rejected. Since the RO modules are connected in series on the seawater side, the seawater becomes more concentrated as it flows from one membrane to another. The more highly concentrated seawater is discharged as brine. Fresh water is collected in the centerline of the module and is discharged to the potable water or feed water tanks.
Hydraulic systems use liquids to transmit and increase force from one point to another. Pumps are used to produce the force that is transmitted through the fluid inside of a pipe which is converted to mechanical work.

**Terminal Objective** – Demonstrate an understanding of hydraulic systems.

- **Enabling Objective** – Identify the purpose, terms, principles, components, and safety precautions for hydraulic systems.

Hydraulic systems make every day lifting and moving easier and faster than doing the same activities by hand. Tasks that would have taken hours or even days can be done in minutes or hours. The purpose is to supply power to machinery to complete tasks that used to be done by individuals. It include: Anchor windlass, Cranes, Flight deck elevators, Rocket launchers, Steering gear, and Weapons elevators. Different types of hydraulic systems require different types of hydraulic fluid. Hydraulic system functions determine which of the following fluids is used: Petroleum oil, Synthetic fluids, Blends and mixtures.

**TERMS**

The following are important terms to know when working with hydraulic systems:

- **Fluid** is anything which flows or can be made to flow. Both liquids and gases are considered fluids.
- **Fluid power** is the power transmitted and controlled through the use of a pressurized fluid. It is the general term used for both hydraulics and pneumatics.
- **Hydraulics** is the branch of physics pertaining to the practical applications of liquids that are in motion.
- **Load** is any device or set of devices that use the power from power producing equipment.

**PROPERTIES OF LIQUIDS**

Fluids are used in hydraulics because they have a molecular structure with characteristics that are similar to solids and gases. Like solids, liquid molecules are more closely packed than gases. Due to their density, liquids cannot be compressed; therefore, transmit force quickly. Like gases, liquids transmit force in all directions, unlike solids, which transit force in a single direction. Liquids are unique because they are subjected only to the force of gravity and seek their own level regardless of the shape of the container. This property allows hydraulic fluid to fill all cavities in a system. According to Pascal’s Law, Pressure exerted on a confined fluid is transmitted in all directions and acts with equal force on all areas. A force applied to one unit area of a confined fluid will be transmitted equally and undiminished to each unit area of its confining container.

The basis of hydraulic systems is rooted in Pascal’s Law. Force output is the formula used to determine the amount of force generated by different combinations of hydraulic pistons. Force output is the amount of force that is transferred between hydraulic pistons. The formula that demonstrates this concept is: Pressure equals Force divided by Area, or Force equals Pressure times Area ($P = F / A$ or $F = P \times A$). Now, if the second piston was twice the size of the first piston and the same force is applied, then twice the force is applied to the second piston.

**FLUID FLOW**

Hydraulic systems depend on the flow of fluids. The way fluids flow is classified into two categories.

- **Laminar** is a streamlined flow where the liquid particles flow smoothly in even layers. Friction losses in this type of flow are minimal.
- **Turbulent** is a random or erratic pattern of flow of liquid. Friction losses in this random or erratic pattern result in inefficient operation, increased friction losses, and increased pressure drops. Hydraulic systems require the most efficient use of fluid flow.

**COMPONENTS**

Actuators convert fluid power energy to mechanical motion and force. They are used when a large amount of force is required to operate a valve.

- **Cylinders** convert fluid power into linear mechanical force and motion. There are two types of cylinders: a single cylinder and a telescoping cylinder. A single cylinder is a single piston that can work in either a single direction or in both directions. A telescoping cylinder is made for long work strokes. Fluid power motors convert fluid power into rotary force and motion. The fluid enters the motor, rotates the gears, and then fluid exits through another port.

- **The driver** is the prime mover in the hydraulic system. It is the energy input source; it can be either an electric motor or any type of engine.

- **Fluid storage** holds excess hydraulic fluid to accommodate volume changes from cylinder extension and contraction, temperature driven expansion and contraction, and leaks. Hydraulic systems have either a reservoir or sump for fluid storage depending on the size of the system. Reservoirs are located in small hydraulic systems and are designed to aid in separation of air from the fluid. Sumps are located in large hydraulic systems and should be large enough to hold all of the system’s hydraulic fluid during shut down.

- **Heat exchangers** remove heat generated by the equipment to maintain the optimum operating temperatures of the hydraulic fluid. Overheating causes thermal breakdown, while expansion and contraction may adversely affect the operation of the equipment.

Hydraulic power controller’s guide and control hydraulic fluid by the use of the following valves:

- **Relief valves** protect the system from over pressurization.
- **Sequence valves** are pressure actuated valves that direct the fluid flow in a predetermined sequence.

- **Unloading valves** maintain system pressure by diverting fluid back to the sump or reservoir.
- **Pressure reducing valves** help maintained a set pressure for a system or sub-system.
- Direction control valves direct or prevent the flow of fluid through selected passages.
- Flow control valves control a specific rate of fluid flow
- Strainers and filters are used to keep any contaminants out of hydraulic systems to extend the efficiency and life span of those systems.

Pumps supply the flow of fluid to a hydraulic system, there are two types of pumps, dynamic and displacement and the Navy uses displacement pumps.
- Displacement pumps use of constant pressure. Non-positive displacement is used for low-pressure, high-volume flow applications. Positive displacement is used when a definite volume of fluid for each cycle of pump operation is needed, regardless of the resistance offered. Fixed delivery positive displacement is used for specific volume applications. Variable volume positive displacement is used when the output volume needs to be adjusted by changing the speed or the size of the pump’s internal pumping chamber.
The electro-hydraulic steering gear is designed to receive an electric steering signal from the bridge or mechanical signal from the trick-wheel. This signal is converted through mechanical means to position and hold the ship's rudder at the selected rudder angle under all load conditions. It is capable of moving its respective rudder from 35° on one side to 35° on the opposite side at a speed of approximately 3.5° per second.

**Terminal Objective** – Demonstrate an understanding of the operation of the steering gear.
- **Enabling Objective** – Identify the components of the steering gear.
- **Enabling Objective** – Identify the operation of the steering gear.

### COMPONENTS

The development of the electro-hydraulic steering gear was prompted by the heavy power requirements of large, high-speed ships. The large water displacement, high speed and increased rudder torque of today's ships necessitate a powerful, reliable, and controllable means of steering a ship. The steering gear transmits power from the steering engine to the rudder stock. There are many different designs, but the principle of operation for all of them is the same. It consists of these major components: power unit assembly, ram and crosshead assembly, follow-up assembly, and service tank assembly and piping system.

The power unit assembly contains five components: electric motor, hydraulic pumps, rotary hydraulic power unit (RHPU)/electro-hydraulic power unit (EHPU), differential control and control rod, and rotary servo control.

- **The electric motor** supplies rotary power to the hydraulic pump.
- **Hydraulic Pump**, there are two types of hydraulic pumps: main and auxiliary.
- **The main hydraulic pump** is an axial piston, variable displacement, bidirectional, constant speed pump. It provides high pressure hydraulic fluid to the ram cylinder to move the ram. Once hydraulic fluid is supplied to the ram cylinder, hydraulic fluid returns from the opposite cylinder to the suction side of the pump.

- **The auxiliary pump** is a constant speed vane-type, fixed displacement pump. It provides fluid for the replenishing and servo circuits. The replenishing circuit provides fluid at a set pressure to make up for losses due to leakage in the main hydraulic system. It also powers the hydraulic motor in the rotary hydraulic power unit. The servo circuit operates various hydraulic valves and components.

- **RHPU/EHPU** performs the same function. The class of ship determines which type of power unit is used. It operates under normal conditions when steering commands are generated from the bridge. The unit runs by a hydraulic motor and the oil pressure from the replenishing circuits. It is located under and connected to the differential control assembly by an input shaft from the RHPU motor. The RHPU/EHPU receives an electrical signal from the bridge and converts it to a mechanical signal which performs a rotational output to actuate the differential control assembly.

- **Differential control assembly** control unit compares the ordered rudder angle command input with the actual rudder angle signal provided by the follow-up assembly, and places the main pump on or off stroke as needed to match the two signals.

- **Pump rotary servo control** are the connecting links between the differential control and the tilt box of the main hydraulic pump.

- **The ram and crosshead assembly** uses hydraulic fluid power created by the main pump to move the rudder. The ram converts the hydraulic fluid power to mechanical energy, which moves the rudderpost or rudder stock. The crosshead converts linear movement of the ram to radial movement of the rudderpost. The rudderpost or rudder stock is the connecting piece between the crosshead and the rudder. The rudder, located in the water at the stern of the ship, then turns the ship when placed at an angle to the direction of movement. There is packing or a seal installed around the rudderpost where it penetrates the ship's hull to prevent the steer.

- **The follow-up assembly** provides a mechanical or electrical feedback signal to the differential control unit through a rack and pinion gear. It connects to the rudder stock or rudder actuator to the differential control unit and operates continuously. When the ram and rudder move, the rack gear moves, turning the follow-up pinion gear. This pinion gear then drives the follow-up shaft which is attached to the differential control unit.

- **The service tank assembly** and the piping system contain five components: filters, supply tank or service tank, accumulator, cooler and valves.

- **Storage tanks** hold hydraulic fluid for use in emergency steering operations and to fill the main system, if needed. They are also used to temporarily hold fluid from the system when the system is drained for maintenance.

There are four different types of valves that in a steering gear piping system: transfer and blocking valves, shuttle valves, relief valves, vent and test valves.

- **Transfer and blocking valves** control the flow of oil to and from the ram of the "online" power unit. They maintain a hydraulic lock on the ram once the desired rudder angle has been reached.

- **Shuttle valves** are used in the steering gear to allow a passage for the accumulator to assist the main pump during peak demands. They have a relief valve which protects the system and components from excessive pressure.

- **Vent and test valves** prevent air from compressing and prevent the rudder from pulsating. To prevent this situation, some systems are equipped with vent and test valves in the hydraulic lines. The valves serve as test points for measuring pressure, bleeding air, draining water, and collecting fluid samples for analysis.

Every steering system is equipped with at least two methods of controlling or positioning the rudder in the event of a main system failure. Emergency equipment includes electrically powered pumps, hand pumps, ratchet wrenches, and chain falls. The electrically powered pumps and the hand pumps provide rudder movement at lower rates than the main system. The ratchet wrenches and chain falls are intended only for maintaining a rudder position or moving the rudder one or two degrees when the ship is not moving. The type of emergency equipment and the configuration of the equipment vary among different ships or ship classes.
CONTROLS AND INDICATORS
The controls and indicators of the steering gear are: the trick-wheel, mechanical rudder angle indicator, helm order, gauge board, and the sight glass.
- The trick-wheel provides for local control by actuating the steering gear differential manually.
- The rudder angle indicator displays the position of the rudder. There are three different types of rudder angle indicators located in various areas of the ship.
- The mechanical rudder angle indicator is located on the rudderpost or rudder stock and verifies local and remote rudder angle. It is used during emergency steering operations to show the true rudder position.
- The local angle indicator is located on the differential control unit.
- The remote rudder angle indicator or helm order/rudder angle indicator is located on the bridge.
- The helm order/rudder angle indicator has pointers superimposed on each other to display the helm position and the position of each rudder. The same scale, marked in degree increments for the maximum rudder travel left or right of zero, is used for both pointers. One pointer indicates the rudder position ordered by the helmsman and the other pointer indicates actual position of the rudder.

SAFETY
The safety devices involved with the steering gear are: relief valves, level switch, auto-change over transfer switch, hydraulic oil low-pressure switch, and temperature switch.
- Relief valves protect the system and components from excessive pressure.
- The level switch activates an alarm on the Interior Communications (IC) alarm panel before the oil level drops below the suction strainer.
- Auto-change over transfer switch shifts control to the standby unit when the online unit fails. It activates on low oil pressure, overload, loss of power, or low voltage.
- Hydraulic oil low-pressure switch activates an alarm on the IC alarm panel if the oil reaches a predetermined pressure.
- Temperature switch monitors the hydraulic oil temperature. It activates an alarm on the IC alarm panel in the steering gear room and illuminates a light on the bridge.

OPERATION
The steering gear is operated either locally or remotely from the ship's control console located on the bridge. When activated, the steering gear responds, positions, and holds the rudder at any selected position. There are two independent power unit assemblies that provide reliability in case failure of one of the units occurs. Some ships have two independent steering signal cables between the bridge and the steering gear room. In case there is damage to one of the cables, steering signals can be sent via the opposite cable.

There are some terms that require understanding:
- Hydraulic fluid is a virtually non-compressible fluid used to transmit power within a hydraulic system.
- Servo oil is hydraulic fluid used to power the control circuits and to replenish the main oil system.
- Main oil is the hydraulic fluid used to transmit power to the ram.
- Port or Starboard Unit/Cable denotes which power unit has control of the steering gear and the method the steering gear is receiving steering signals from the bridge for port or starboard steering.

NORMAL OPERATION
The first pump placed in operation controls the system, while the second pump is the standby unit. The stand-by pump is blocked from assuming control, but immediately assumes control if loss of power occurs to the online pump. When orders are given to change rudder angle, an electrical signal is sent from the bridge through the steering cables to the rotary hydraulic power unit. The differential control compares the rudder angle command input from the rotary hydraulic power unit to the actual rudder angle fed back from the follow-up assembly and moves the control rod connected to the rotary servo control. The servo control causes the tilt box of the main hydraulic pump to position itself at an angle, which places the pump on stroke. The angle of the tilt box determines the amount and direction of flow.

The pump then delivers the working fluid through the transfer and blocking valves to one end of the ram while drawing fluid from the other end. This forces the ram to move. The ram moves the crosshead which converts the linear movement of the ram to radial movement of the rudderpost. The rudderpost rearranges the rudder into the desired position. When the ram and rudder move, the rudder gear moves, turning the follow-up pinion gear, this pinion drives the follow-up shaft that is coupled to the differential control box. When the desired rudder position is reached, the follow-up assembly signals the differential control to return the pump stroke to neutral. The transfer and blocking valves close thereby holding the rudder in a hydraulic lock until another steering signal is received.

EMERGENCY OPERATION
There are two alternative methods for maintaining control of the ship’s steering in case of emergency:
- Standby power unit is the unit placed in the stand-by mode when the steering gear is initially started.
- Trick-wheel can assume local control of the steering gear by engaging it in case of emergency. This allows the steering room watch stander to input steering commands manually. A watch stander must be in verbal communication with the bridge to receive rudder commands.

Under normal conditions, the X1JV provides an alternate communications link between the same stations served by the maneuvering portion of 1JV circuit. Under emergency condition, the X40J provides a means of rigging communication lines between the steering gear watch and the helmsman.
Vertical package conveyor is used to move dry stores to and from different areas in a vertical direction. They have a great impact on reducing the number of hours required to move stores, parts, and to conduct breakouts. It is a useful piece of equipment, and Sailors must be able to perform corrective or preventive maintenance and troubleshoot issues that arise. In this lesson, you will learn to identify the major components and modes of operation and identify the safety devices and precautions for vertical package conveyors.

Terminal Objective – Identify the basic operating principles for vertical package conveyors.

- Enabling Objective – Identify the major components and modes of operation for vertical package conveyors.
- Enabling Objective – Identify the safety devices and precautions for vertical package conveyors.

The vertical package conveyor is designed to transfer stores vertically between the main and lower decks. It is operated or controlled by control stations, which are located at each deck level served. Each load is conveyed on carrier trays suspended on closed loop carrier chains.

The vertical package conveyor is comprised of three major components that make the conveyor function: drive assembly, control station, and trunk assembly.

- **The drive assembly** consists of an alternating current (AC) motor coupled with a speed reducer. The reducer is connected to a drive chain and secondary drive chains via a jackshaft. The jackshaft drives the carrier chain sprockets, which move the carrier chains.

- **Drive chains**, there a primary and two secondary chains. The primary transfers power from the speed reducer to the jackshaft. The secondary transfers power from the jackshaft to the head shafts.

- **Idler tensioner** is located on the secondary and primary drive chains and is used to adjust the drive chain tension.

- **Carrier chains** are driven by the secondary chain via the head carrier sprocket. It can support up to 20 carrier trays.

- **Head shaft assembly** supports and transmits the driving force for the carrier chains. There is a head shaft assembly mounted on each side of the conveyor. Each assembly has a head carrier sprocket and is driven by the secondary drive chain.

- **Tail shaft assembly** supports the carrier chains, moving them up or down within the trunk between loading and unloading points. The chain revolves around the head carrier sprocket at the top and the tail sprockets at the bottom. The sprocket is attached to the tail shaft assembly, which is also used to adjust the carrier chain tension.

- **Jackshaft drive sprocket** connects to the speed reducer via the primary drive chain. They function to transfer power from the speed reducer to the head shafts via the secondary drive chain.

- **Speed reducer** is a worm drive gear that reduces the motor speed to a slower functional speed for the jackshaft by using a gear ratio of 50:1. It is attached to the motor through the torque limiter.

- **Brake** provides positive braking for the drive assembly when the power is de-energized. It is located on the speed reducer and is electrically released with a spring set.

- **Torque limiter** connects the motor to the speed reducer. It uses a clutch-type coupling which serves as an additional overload safety device. The unit will slip if the conveyor jams or the load exceeds 15% above the rated capacity.

CONTROL STATIONS

Control stations control the direction of the drive motor and the mode of operation of vertical package conveyors. Each station contains an up and down push button and push/pull switches for run/stop. Emergency stop (E-STOP) switches are remotely located at each control station. They also provide the means to communicate between stations using sound-powered telephones. The components of the control stations provide control of the conveyor from each deck opening. The second deck control station has an indexing switch for continuous and semi-continuous index operation in addition to up/down and start/stop controls.

Two components of the control system are the proximity switch and the motor controller. The proximity switch is located on the second deck inside the trunk. It senses the carrier trays as they pass to stop the conveyor at each tray in the indexing mode. The motor controller starts, stops, and reverses the direction of the drive motor and protects it from overloads.

- **Motor cut off switch** is used in troubleshooting and removes 440 VAC while in the maintenance position.

- **Motor overload reset button** resets the thermal overload assembly after it has cooled.

- **Time meter** monitors and displays the accumulated hours of operation.

- **Motor overload light** flashes when the motor cut off switch is in the maintenance position.

- **Condition lamps** indicate when there is a problem with the conveyor.

- **Control power on/off switch** provides power to the control circuit of the motor controller.

- **Built in test equipment (BITE)** panel used in troubleshooting.

TRUNK ASSEMBLY

The trunk assembly provides a protective enclosure and support for the various components. It is installed in openings through the decks and attached to the ship structure by welded collars. It has two parts: the carrier tray assembly and the load/unload device.

- **The carrier tray** consists of a fork-like carrier tray, two carrier shafts, four cam followers, two guide arms, and two carrier chain links. It is used to convey packages between deck levels. The trays are connected to the carrier chain by the carrier shaft and 32-inch intervals. When in the working position, the carrier trays are horizontal. On the non-working side of the conveyor, the camming tracks at the top and bottom of the conveyor trunk cause the guide arms to rotate the tracks to a vertical position for travel.

- **The load/unload device** aids in loading and unloading packages from the conveyor. There are two types of devices in use, fixed and moveable. The fixed device is located at the top of the conveyor. The moveable device is located at all the other openings in four positions. Those four positions are load, stow, unload, and indexing.

- **Load**, horizontal position used when loading from a lower deck.
- **Stow**, vertical position that allows the door to be shut.
- **Unload**, thirty-degree incline position, on the lower deck, used when receiving packages.
- **Indexing swing position** used to off-load packages. This position is available on the second deck only.

### Modes of Operation
The vertical package conveyor has two modes of operation: Continuous and indexing.
- **Continuous** mode runs the conveyor continuously until manually stopped. In continuous mode, the conveyor moves packages between decks.
- **Indexing** mode is used only when striking up, or moving from a lower deck to an upper deck, and is controlled from the second deck. It stops the conveyor after one tray and must be manually restarted.

### Safety
Vertical package conveyors will be operated in accordance with all applicable safety precautions. It has various personnel safety devices installed to alert and protect the operators.
- **Clean-out Door Interlock** is located at the bottom of the conveyor and is used to clean up spills in the conveyor trunk. It will stop the conveyor if the clean-out door is open.
- **Door Interlock** prevents the conveyor from operating when more than two doors are open.
- **Audible Alarm**, warns personnel to stand clear. It sounds at the sending and receiving stations for three seconds before the conveyor starts to move.
- **Station Lighting**, is on to assist the operator when the door is open.
- **Chain Guard** keeps personnel away from chains while they are in motion.
- **Conveyor Shield**, keeps packages away from carrier chains while the conveyor is in motion.
- **Personnel Protective Shield** is used in conjunction with the load/unload device to prevent personnel from entering the conveyor.

The vertical package conveyor also has several equipment safety devices that protect the conveyor and its components.
- **Photo Electric Up and Over Travel Assembly** is located at the top of the conveyor and uses infrared light and reflector to protect against damage to packages left on conveyors during strike up.
- **Jam Limit Assembly** is located at each opening except the main deck. It stops the conveyor if a package is traveling out of bounds either up or down.
- **Down-over Travel Interlock** is located at the bottom of the conveyor trunk, it consists of an interlock switch activated by a spring-loaded tray. A force of at least 15lbs will activate the switch. If a package is left in the conveyor during strike down, it contacts the switch and stops the conveyor.
- **Door Block** is located on the door, it prevents the door from closing if the load/unload device is in any position except the stow position.
- **Thermal Overload** is located on the monitor controller; it protects the motor from over-heating.
- **Instantaneous Overload Relay** protects the motor against electrical overload.

### Personnel
When the vertical package conveyor is in operation, there are specific responsibilities and functions personnel are required to perform. Always ensure that the conveyor is clear of obstructions and personnel in the area are alerted prior to starting the vertical package conveyor. Remember, the conveyor should be operated only by qualified and authorized personnel and a minimum of a supervisor, safety observer, and package handler are required.

- **The safety observer** is responsible for the safety of all personnel at the level being and for stopping the conveyor under unsafe conditions.
- **The package handler** loads and unloads packages from the conveyor in a safe manner at the level being served.
- **The supervisor** coordinates safe handling of packages and communicates between stations using call signal stations or growlers and sound-powered telephones. The supervisor starts and stops the conveyor under normal and unsafe conditions and does not act as safety observer or package handler.
The anchor windlass is a very important piece of equipment used to raise and lower the ship’s anchor, or anchors. Whether for normal anchorage or for emergency use, every engineer must be familiar with the purpose, type, operation and safety precautions related to the use of the anchor windlass and related equipment.

**Terminal Objective** – Demonstrate an understanding of the purpose, types, components, operation, and safety precautions related to the Anchor Windlass.

- **Enabling Objective** – Identify the purpose, types, components, operation, and safety precautions related to the Anchor Windlass.

Although used intermittently and only for relatively short periods of time, a windlass must be able to handle required loads under severe conditions or else equipment damage and personnel injury can result. The task of raising or lowering your ship’s anchor, or anchors is dangerous. Therefore, you need to demonstrate an understanding of the purpose, types, components, operation, and safety precautions related to the anchor windlass.

There is one important purpose for the anchor windlass: to pull the anchor out of the water or to let it back down into the water. The terms used when pulling or letting it the anchor go are:

- **Pay out** means letting out the anchor chain under the control of the windlass.
- **Heaving in** means pulling in the anchor out of the water.

There are two types of anchor windlass, identified in part by the end of the ship in which they are installed.

- **Vertical shaft anchor windlass**, located on the bow or forward part of the ship. Their power plants are located in a below-deck, weather-protected windlass room.
- **Horizontal shaft anchor windlass** provide Navy ships capable of beaching themselves the ability to also free themselves. The horizontal shaft anchor windlass is installed on the stern or aft end of ships.

There are several types of power used to operate the anchor windlass:

- **Electric power** uses electric motors to drive the reduction gears that turn the wildcat and capstan. Electric power is used by electric anchor windlass systems.
- **Hydraulic power**, created by an electric motor drives a hydraulic pump which pumps fluid to a hydraulic motor, which in turn rotates the reduction gear to turn the wildcat and capstan.
- **Electrohydraulic anchor windlass** is used on ships with two forward anchor windlasses. This setup works well for most ships; since they are already equipped with a cross connect for the hydraulic fluid. The cross connect allows the port pump to be used on the starboard anchor windlass, and vice versa.

**OTHER TERMS**

- **Wildcat** is a drum fitted with whelps to engage the anchor chain.
- **Hand Power** is the oldest method, used on small vessels with light loads.
- **Gypsy heads**, handle lines for moorings and warping operations.
- **Capstan** is used to handle lines for mooring and warping operations.

The anchor windlass consists of many components that work together to raise and lower the ship’s anchor. Specific components and component locations can vary according to type of windlass, horizontal or vertical, and the type of power it uses, electric or electrohydraulic. There are six major components included in windlass systems:

- **Electric brake** is a solenoid-operated electromagnetic disc used to prevent the capstan from rotating in the event of a power loss. The brakes are applied automatically whenever power is lost or the master drum switch is stopped. Spring pressure forces the pressure plate against the friction linings and stops the shaft. To it, apply power to both the brake and electric motor.
- **Gear box** contains a reduction gear assembly. The reduction gear assembly is a triple reduction, parallel shaft, and helical reducer. It reduces the speed of the rotary input, increasing the output torque.
- **Clutch assembly**, also called the wildcat locking head, provides a method for connecting and disconnecting the wildcat and the anchor windlass drive shaft. The capstan drive shaft extends up through the center of a planet gear arrangement to the capstan. A clutch lever in the machinery room enables the operator to raise or lower a shift gear.
- **Hand brake** or manual brake surrounds the drum that is attached to the wildcat, is controlled by the brake and hand-wheels and is used to control the free-fall of the anchor chain or to stop a rotating wildcat. The assembly has two manual brake hand-wheels and either one can be used to operate the brake. One hand-wheel is located on the main deck, the other on the second deck in the machinery room.
- **Wildcat** is a drum mounted vertically or horizontally at the end of an anchor windlass shaft.
- **Capstan** is a vertical drum or barrel used to haul heavy mooring lines. It is mounted above the wildcat, or mounted separately as an independent unit. Capstans that are independent of an anchor windlass are usually electric-powered.

**ELECTRIC WINDLASS**

There are some specific components to certain types of anchor windlass systems.
- **The master drum switch** or electronic control assembly controls the operation and position of an anchor windlass using three positions: rise, lower, or off, and two speeds: high or low.
- **Two-speed electric motor** is mounted vertically, and has the ability to run in the raise or lower directions, at both high and low speeds.

**ELECTROHYDRAULIC WINDLASS**

Electrohydraulic anchor windlass is very similar to the electric anchor windlass, from the gearbox to the capstan. However, its electric motor drives a hydraulic pump and hydraulic motor drives the reduction gears. Control of this windlass is accomplished by controlling the stroke, or output, of the hydraulic pump. Five components specific to this type of windlass system are a single-speed electric motor, a hydraulic pump, stroke control hand-wheels, a hydraulic motor, and an expansion/replenishment tank.

- **The electric motor** for the electrohydraulic drive is usually a single-speed, alternating current, squirrel-cage type. The electric motor is connected to a variable-stroke hydraulic pump.
- **Hydraulic pump**, variable-speed, powered by the electric motor. The Windlass speed is determined by varying the stroke of the hydraulic pump. The stroke at which the hydraulic pump is set determines the quantity of hydraulic fluid delivered through piping to the hydraulic motor, which in turn determines the speed at which the hydraulic motor rotates.
- **Stroke control hand-wheel** varies the stroke of the hydraulic pump, is located on the weather deck and at the hydraulic pump in the windlass room. These hand-wheels also control the direction of rotation of the windlass and are suitably marked.
- **The hydraulic motor** together with the electric brake is coupled to the windlass gear box input shaft.
- **Expansion and replenishment tank** is located above the highest point on the hydraulic system, usually on the underside of the main deck. Maintain the fluid level in the expansion and replenishment tank.

**SAFETY**

Prior to operation ensure communications are established between the control station and the anchor windlass machinery room and that all non-operating personnel are clear of the area. There are many foot, hand, head, and eye hazards when working with an anchor windlass. Wear the following: snug-fitting, full embroidered set of coveralls, safety goggles, safety shoes, gloves, and a safety helmet. Keep clear of rotating machinery when it is operating, and do not operate rotating machinery with guards and covers removed.

Be aware of, and keep your eyes on, anchor chains. Each chain link weighs up to three hundred pounds for smaller vessels and three hundred sixty-five pounds for CVN. For your safety, review the following safety precautions. Keep your hands and feet off, and away from, moving anchor chains. Never walk backwards, step over, or straddle an anchor chain, or stand between the chain and the side of the ship during anchoring evolutions. To help keep a safe footing around chains, clean oily deck areas promptly and spread salt or sand over icy areas. Before starting the anchor windlass, fully disengage the wildcat-locking head, or clutch, and ensure the wildcat brake is set. To avoid excessive drag and overheating of the brake, apply the brake wheel sharply when the desired amount of chain has run out. The wildcat manual brake has no effect on the capstan head.

**METHODS OF OPERATION**

To operate the wildcat, there are three primary methods: free-fall, power raise or lower and independent capstan operation.
- **Free-fall method** happens when the wildcat lowers the chain by gravity.
- **Power raise or lower** is accomplished by the use of electric or electrohydraulic power.
- **Independent capstan operation** is accomplished by disengaging the wildcat from the capstan in order to pay out (give) or heave (take in) rope or line.
Engineers work with a variety of equipment that is not directly related to the main propulsion plan, such as water heaters, washers, and laundry equipment.

**Terminal Objective** - Demonstrate an understanding Auxiliary Equipment operation.
- **Enabling Objective** – Identify the operation of the Aerco Helitherm and Leslie Constantemp hot water heaters.
- **Enabling Objective** – Identify the operation of the DW-600B and DX25N washer-extractors.
- **Enabling Objective** – Identify the operation of laundry presses.

Hot water heaters provide hot water to various locations throughout the ship and play an important role as auxiliary equipment. The two common types of water heaters are: Aerco Helitherm and Leslie Constantemp. They provide hot water to the galleys, sculleries, and heads.

**AERCO HELITHERM WATER HEATER**

Is a passive-type; it supplies a reliable flow of hot water upon demand for dishwashers, washer-extractors, galley, etc. The heater different components to operate efficiently and effectively:
- **The heat exchanger** has connection for cold water inlet, a thermal element, and a hot water outlet.
- **The steam system**: steam in the coils of the steam system heats the water, and a steam riser carries steam into the heat exchanger and to the coils.
- **A loadalert unit** is a pipe assembly, which channels cold water into the heat exchanger and draws hot water across a temperature sensing element. A thermal element inside the loadalert unit monitors the average temperature of the hot water and signals the temperature regulator to open or shut to maintain hot water temperature.

- **A steam control valve** is a CXT-type temperature regulator. It consists of a temperature-sensing element, the bellows assembly, the temperature pilot valve assembly, the inner pilot valve, and the main valve.
- **The electrical over-temperature limit system** protects the heat exchanger from damage if the temperature rises above safe limits.

The system is aided by the use of valves: stop valves to isolate the steam control valve, check valve to maintain the proper direction of water flow, a bypass valve to bypass the steam control valve if it is not functioning and finally a heat exchanger relief valve to bleed off air pockets in the heat exchanger and protect the heat exchanger against over pressurization.

- **Anti-tampering device** prevents any unauthorized adjustments of the temperature regulator.
- **Thermostatic steam trap** conserves steam in the system and keeps moisture out of the system.
- **Union orifice** regulates the rate of condensate leaving the heat exchanger.
- **Monitoring devices** are used to monitor the operation and performance of the water heater.
- **Steam strainer** removes accumulated solids.

There are to circuits in the AERCO water heater: the water circuit and steam circuit:
- **The water circuit**: Cold water enters the upper header, and then travels down through the cold-water leg of the loadalert unit to the bottom of the shell. The cold water absorbs heat from the steam in the coils. As water is heated, it flows to the top of the shell. The hottest water is at the top. As more cold water flows in through the loadalert unit it aspirates some of the hot water into the hot water leg of the loadalert unit. The temperature of the hot water is sensed by the thermal element. The remaining hot water flows out to the system.

- **The steam circuit**: Steam goes through a steam strainer removing accumulated solids and is throttled by the steam control valve. Then enters the lower header and goes up through the steam riser to each coil. The steam in the coils heats the water in the shell. As the steam gives up its heat to the cold water, it condenses. Condensate drains through the condensate return and leaves through the condensate outlet in the lower header. The thermal element monitors the average temperature of the hot water. Changes in water temperature cause the liquid in the thermal element to expand and contract. The expansion and contraction of the liquid in the thermal element causes the steam control valve to open or shut to maintain water temperature. If the water temperature rises above the set point, the electrical temperature switch de-energizes the solenoid valve on the steam control valve. When the solenoid valve shuts, it causes a buildup of pressure which shuts the valve and cuts off steam to the heat exchanger. At the same time, the pilot light illuminates signaling that the water heater has shut down.

**LESLEY CONSTANTEMP WATER HEATER**

It works on the feed-forward principle. The Feed-Forward principle is an on-demand system. When the hot water is needed, the water heater will provide it. These water heaters provide as much hot water as necessary. Several advantages to this principle are that the system takes up less space, is lightweight, efficient, eliminates the need for a hot water tank, and delivers water at an accurately controlled temperature. The temperature range is from 110° to 185°F. It supplies hot water to various pieces of equipment, such as showers and scullery.
The water heater has several parts that aid in the proper operation:
- **The blend valve assembly** mixes hot water from the heat exchanger with cold inlet water to produce the desired outlet temperature, maintaining water temperature at 140°F from the set point.
- **The thermal safety switch** is a safety device that de-energizes the solenoid valve if the blend water exceeds the shut off point.
- **The Automatic Water Regulator (AWR)** also referred to as the loading valve, controls the inlet steam pressure to the heat exchanger.
- **A red indicator light** illuminates to inform the operator that the thermal switch has de-energized the solenoid valve due to a high blend water temperature.
- **The heat exchanger** consists of a coil that acts like a boudon tube.
- **Gauges** indicate the steam supply pressure to the steam control valve and the steam supply to the heat exchanger.
- **The steam control valve** controls steam pressure to the heat exchanger. It is controlled by cold-water pressure from the AWR. The cold-water pressure is used to load the diaphragm of the steam control valve.

**OPERATION**

Cold water enters the heat exchanger and the inlet of the blend valve assembly. As blend water is used, a pressure drop is sensed on top of the diaphragm of the blend valve. The pressure drop causes the blend valve stem to move up, opening the AWR. When the AWR opens, an increase in pressure is felt on top of the diaphragm of the steam control valve. The increase in pressure causes the steam control valve to open and allows more steam to the heat exchanger. The steam heats the cold water in the coils. The hot water from the coils mixes with the incoming cold water at the blend valve. The blend water temperature is maintained at a relatively constant temperature by constant adjustment with any changes in water usage.

**DW-600B AND DX25N WASHER-EXTRACTORS**

Washer-extractors inject water and detergent, wash and clean, rinse, drain and remove water. There are types of washer-extractors:

**DW-600B**

Is front-loading and has a formula control unit to automatically control the machine through a completely programmed wash formula, which includes fill, wash, heat, drain, rinse, and extract. The chemical supply consists of detergent, bleach, and fabric softener injection.

The DW-600B Washer-Extractor houses several components:
- **The front plate** provides support for the front bearing on the cylinder drum; it contains a sight glass, loading door, and thermostat control.
- **The shell** provides structural support and houses the cylinder drum. It contains the soap chute for adding detergent.
- **The auto supply dispenser** is a tank that divides into four compartments. It contains a solenoid valve, which controls the flow of hot water into the compartments. When the hot water switch is activated, it energizes the solenoid to allow hot water to flow to the supply dispenser. Hot water at a reduced pressure mixes with the laundry detergent agents and is then directed into the housing.

**DX25N WASHER-EXTRACTOR**

Is front-loading and has a formula control unit to automatically control the machine through a complete programmed wash formula including fill, wash, heat, drain, rinse, extract, and chemical supply injection. The maximum capacity is 20 pounds. The extractor is made of several components:
- **The frame** is corrosion resistant and houses the washer-extractor internal components.
- **The front-loading door** is used to access the wash tub for loading and unloading the machine, it has a watertight gasket to prevent leakage.
- **The wash tub** is constructed of stainless steel and is perforated to allow for drainage during extraction.
- **The wash/extract motor** is a two-speed reversible motor that drives the tub through a belt and a flywheel.
- **Reversing timer** causes the motor to turn the tub in the opposite direction for one revolution.
- **The dispenser** is located on top of the machine and has three separate bins for soap, bleach, and fabric softener.
- **Supply water connection** provides supply water to the dispenser.
- **The vent/overflow** connection allows air to flow into or out of the tub as it drains or fills. The drain has an electrically operated valve that allows the water to drain during operation.

There are two safety devices installed on the DX25N washer-extractor; the door interlocks and the emergency stop switch. As the washer-extractor is in operation, the door interlocks prevent you from opening the door. The emergency stop switch allows you to immediately stop the operation of the washer-extractor. When this occurs, a red emergency stop light illuminates.
LAUNDRY PRESS

The purpose is to apply heat and pressure on the fibers of garments to dry, straighten, and add creases. There are two: the standard press and the dry cleaning press. To ensure that uniforms are properly pressed, you need to become familiar with it.

- The dry cleaning press is designed for wool and polyester synthetic blend garments such as dress whites and khakis. The two types of the dry cleaning presses are type 1 (steam) and type 2 (electric). It operates at a lower temperature and pressure than the standard press to prevent burns and possible melting of garments.

- The standard press is designed for pressing cotton and cotton blend garments such as utility shirts and trousers. The two types of standard presses are type 1 (steam) and type 2 (electric).

The presses are composed of the following:

- Safety control bar: used to open the press and prevents the press from closing if an object, such as a hand, is in the way.
- The buck: is the tapered steel board that allows different sides of material to be pressed. It is covered with a mesh/spring base pad, two layers of flannel, and an outer cover cloth.
- The table: is mounted to the frame. The table provides a support for the lower pressboard (buck) and is used to mount the two operating buttons or lever controls.
- Doors and panels: are used to perform maintenance. The internal areas behind the doors and panels contain the pulleys, gears, springs, and other moving parts.
- The base: is the main foundation to which all components are attached.
- Pushbuttons: are attached to the table and located ten inches apart. The pushbuttons must be pressed simultaneously in order to operate the press.
- The bracket assembly: is a device to which the head is mounted. It pivots to lower the head to the buck.
- The head springs: return the head to the open position when LP air is vented off. The springs are adjustable to maintain tension.
- The control panel: consists of an on/off switch, a thermostat, and a buck temperature thermostat. The control panel only applies to the Type 2 presses.
- The snubber: prevents the head from slamming open or closed. It must be filled with oil.
You must have a basic knowledge of the operating principles of air conditioning and refrigeration (AC&R) systems. EPA certification is required to service AC&R systems, but you may assist in maintenance efforts without basic certification. This lesson provides the information you need to identify the components, units, and safety precautions for air conditioning and basic refrigeration systems. Then, it presents the information for you to identify the characteristics and components of a basic refrigeration system and its cycle. Lastly it introduces the characteristics and components of an air conditioning system and its cycle.

**Terminal Objective** - Demonstrate an understanding of air conditioning and refrigeration systems and their safety precautions.
- **Enabling Objective** - Identify the purpose, terms, and safety precautions for AC and basic refrigeration systems.
- **Enabling Objective** - Identify the characteristics and components of a basic refrigeration system and its cycle.
- **Enabling Objective** - Identify the characteristics and components of an air conditioning system and its cycle.

AC&R play a key role in day to day ship operations. Refrigeration helps food stay fresh longer by keeping it cold. Air conditioning maintains spaces at prescribed temperature, humidity, air cleanliness, and oxygen content. Air conditioning involves ventilation and heating; however the focus will be on the removal of heat, which is refrigeration. Understanding the basics of air conditioning and refrigeration can help prepare you to maintain these important systems.

The main purposes for air conditioning are to maintain comfortable crew living and working space and to protect temperature-sensitive electronics and electrical equipment. It also maintains the proper temperature in ammunition storage spaces to prevent the deterioration of ammunition components and prevent the buildup of explosive vapors. Refrigeration primary purpose is for the preservation of food.

**HEAT RELATED TERMS**

Heat is a form of energy that can never be lost; only transferred from one object to another. The First Law of Thermodynamics states that energy can be neither created nor destroyed only changed in form.

- **Heat flows** from areas of high concentration to areas of low concentration, such as from hot to cold. The rate of heat transfer is affected by the temperature difference between two objects.
- **Heat transfers** from one form to another by a few different methods: Radiation is transferred in the form of waves, similar to light or radio waves. Conduction takes place when two objects are in direct contact with one another and Convection occurs when heat flows through a fluid medium.

It is important to know the difference between heat and temperature. Heat is a form of energy. Temperature is the intensity of heat. The quantity of heat energy in a substance is measured in British Thermal Units (BTU). The BTU is the amount of heat required to raise the temperature of 1 pound of pure water 1°F. Temperature, as you know, is measured in degrees, which indicates the intensity of the heat in a given substance. It does not indicate the number of BTUs in the substance. Sensible heat is heat that is added or removed from a substance while it is NOT undergoing a change in its physical state and is measured with a thermometer because it causes a change in temperature. Latent heat is heat energy that is added or removed from a substance while it is in the process of changing its physical state. Latent heat cannot be measured with a thermometer because there is no change in temperature. There are three types of latent heat:

- **Latent heat of fusion** does not cause a rise in temperature until the conversion from a solid to a liquid is complete.
- **Latent heat of condensation** does not cause a temperature change until the conversion from a gas to a liquid is complete.
- **Latent heat of vaporization** does not cause a change in temperature until the conversion from a liquid to a vapor is complete.

**REFRIGERATION**

A refrigeration ton is a unit of measure for the amount of heat removed from a substance. It is based on the cooling effect of one ton (2000 lbs.) of ice at 32° F melting in 24 hours. The capacity of a refrigeration unit is usually stated in refrigeration tons. Refrigerator is a cooling agent that is used to absorb heat. It is referred to as a chlorofluorocarbon (CFC) or hydrochlorofluorocarbon (HCFC). Refrigerant is non-flammable and non-corrosive in its pure form. Refrigerant has no ill effects on products. It has a high latent heat value, which refers to its ability to absorb heat, and it boils at a low temperature.

- **Saturation temperature** is also referred to as the boiling point or the condensing temperature, at which a refrigerant will change state from a liquid to a vapor or vice versa.
- **Superheated vapor** is refrigerant vapor that is heated above its saturation temperature, there is no liquid present.
- **Subcooled liquid** is liquid refrigerant that is cooled below its saturation temperature.

Understanding the relationship between heat energy and temperature along with pressure and temperature can give a better understanding of the air-conditioning and refrigeration process. The Pressure-Temperature Relationship (PTR) is explained as follows: the boiling point of any liquid varies according to its pressure. By decreasing the pressure acting on the liquid, the temperature at which it will boil will decrease. By increasing pressure acting on a liquid, the temperature at which it will boil is increased. Refrigerant boils at any extremely low temperature. By increasing the pressure acting on the refrigerant, we can increase the temperature at which it will boil.

**LEAK DETECTION**

Detection of refrigerant leaks is very important; correcting refrigerant leakage, no matter how small the problem, is one of the most important functions in operating a plant. Leak Detectors fall under two categories: portable leak detectors and area monitors.
- **Portable leak detectors** pinpoint where a specific refrigerant leak is located. There are four types:
  - **Fluorescent dye leak detection** is based on a dye additive that turns a bright yellow-green or white color when exposed to ultraviolet or UV light.
  - **Halide torch leak detector** is a fast reliable method used to check for chlorofluorocarbon or CFC. It is only suitable for use on CFC refrigerant leaks. It consists of a propane or acetylene fuel source, a burner containing a copper element, and a sniffer or exploring hose.
- **Portable leak detectors** detect very small refrigerant leaks but, because of their sensitivity, they are often overwhelmed in the event of a large leak and unable to locate the exact source.
- **Soapsuds** may be used if it is impractical to use a portable leak detector. A special mixture of a soap and water solution is applied to pipe joints to find a suspected leak. Any leakage causes bubbles to form.

Area Monitors check the level of refrigerant vapor present in compartments and continuously monitor a specific area and warn with audible and visual alarms of a major refrigerant leak.

- **Electronic leak detectors** are the most sensitive and widely used leak detector, run along the piping and joints of the refrigerant plant to pin-point leaks and reacts visually and audibly when a leak is detected.

**SAFETY**

A few safety precautions include:

- If skin comes in contact with some refrigerants, it may cause frostbite. If this occurs, use lukewarm water to bring the temperature of the skin back up and seek medical attention.
- Always use certified hoses when handling refrigerant to minimize the change of refrigerant release to atmosphere.
- Refrigerant displaces oxygen, it can cause asphyxiation. Keep this in mind if you are in a space where there is a chance that refrigeration could be released in to the atmosphere.
- Gas cylinders must always be stored in the upright position and properly secured.
- Never expose gas cylinders to temperatures above 125°F. The internal pressure could become dangerously high and they could rupture.

**REFRIGERATION SYSTEM COMPONENTS**

- **The compressor** acts as a pump for the refrigerant. It is a positive displacement, high-speed reciprocating-type pump. It separates the high pressure-side from the low pressure-side of the system. It raises the temperature and boiling point of the refrigerant vapor by compressing it.
- **Condenser** removes the latent heat of condensation, condenses the refrigerant vapor, and sub cools the liquid refrigerant.
- **A receiver** acts as a storage tank for the liquid refrigerant to prevent surging during high demands. It maintains a liquid seal to keep the refrigerant vapor out of the liquid line leading to the Thermostatic Expansion Valve (TXV).
- **TXV** separates the high pressure-side from the low pressure-side. It controls the amount of refrigerant flowing to the evaporator based on the superheated temperature at the outlet of the coil.
- **The evaporator** consists of coils installed in the space to be cooled. The tubing is normally finned, which increases the area available for heat transfer. This is the area where the refrigerant absorbs heat from the space. As the refrigerant absorbs heat, it boils and turns to vapor.

**ACCESSORIES**

- **A dehydrator** removes moisture from the refrigerant.
- **A moisture** indicator contains a chemically treated element that changes color to indicate the moisture level in the refrigerant.
- **A suction** strainer is usually installed in the compressor suction to prevent foreign matter from damaging the compressor.

**VALVES**

Nearly all hand-operated stop valves in the refrigerant plant are of the packless type; a diaphragm separates the upper part from the lower part.

- **The solenoid valve** is an electrically operated valve. It receives an electrical signal from the thermostatic switch to open or close. The valve starts and stops the flow of refrigerant to the TXV to maintain the refrigerated spaces within the desired temperature range.
- **The evaporator pressure regulating (EPR) valve** is set to keep the pressure in the coil from falling below the pressure corresponding to the lowest evaporator temperature desired in that space. The EPR valve is not really a temperature control. It is only a device to prevent the temperature from becoming too low.
- **Water regulating valve (WRV)** controls the quantity of cooling water flowing through the condenser.
- **Spring-loaded relief valve** is installed in the compressor discharge line or internally on the compressor to protect against excessive pressure.

**SWITCHES**

The refrigeration system contains several types of switches that prevent damage to the system:

- **Low-pressure cutout switch** stops the compressor when the pressure in the suction line drops below a set point. It resets automatically and the compressor starts when the suction pressure rises.
- **High-pressure cutout switch** shuts off the compressor if the discharge pressure rises above the set point.
- **Oil failure switch prevents** the compressor operation in the event of low oil pressure.
- **Water failure switch stops** the compressor in the event of loss of cooling water to the condenser.

**BASIC REFRIGERATION CYCLE**

The cycle consists of:

- **Expansion:** Refrigerant is sent to the TXV, where it is force through the small opening of the valve and is atomized for faster heat removal.
- **Evaporation:** The atomized refrigerant removes heat and changes its state from liquid droplets to vapor.
- **Compression:** The vapor is then compress in the compressor to increase its temperature for faster condensation.
- **Condensation:** Once the vapor’s pressure and temperature has been raised, the condenser will remove the heat via conduction. The vapor transformed back to a liquid refrigerant is then transfer to the receiver to start the cycle again.
**AIR CONDITIONING**

Air conditioning is a key element for maintaining a productive work environment by allowing control of the cooling and heating of work and living spaces. Shipboard ventilation is necessary for the proper circulation of air. It primarily uses two-speed electric motors to drive intake and exhaust fans:

- **Axial flow fan** are generally installed in duct systems. The motor is cooled by the air flowing past it.
- **Centrifugal flow** fan are generally used to exhaust explosive or hot gases from spaces.

In chilled water circulation systems, chilled water is piped to fan-coil assemblies in various spaces in the ship. Fan-coil assemblies allow the chilled water to flow through cooling coils. A fan forces air to flow across these coils. As the air flows across the coils, the chilled water absorbs the heat in the air. Condensation from the air being cooled is drained to the bilge or the waste water system.

Vapor compression units or centrifugal air conditioning units use chilled water to condition the air. The chilled water absorbs the heat from the space to be cooled. The heat in the chilled water is removed by the primary refrigerant system in the water chiller. There are four stages of vapor compression:

- **Condensation** is where the refrigerant vapor is condensed using the seawater in a condenser.
- **Expansion**, a float valve or expansion orifice allows the liquid refrigerant to undergo a pressure drop, which lowers its temperature and boiling point.
- **Evaporation**, the heat absorbed from the chilled water causes the refrigerant to vaporize.
- **Compression**, a turbo compressor is used to compress the refrigerant vapor, which raises its temperature.
In the Lube Oil Quality Management Program (LOQM), there are different personnel duties and responsibilities. There are different types of lubricating oils and removal procedures for contaminants in the lube oil system. There are also different procedures and intervals for sampling lubricating oil, along with different testing procedures. In addition, the Navy Oil Analysis Program (NOAP) was created to monitor the condition of equipment and oil. In this lesson, we will identify the elements of an effective shipboard LOQM program.

**Terminal Objective** - Identify the elements of an effective shipboard Lube Oil Quality Management Program.
- **Enabling Objective** - Identify the purpose, personnel duties and responsibilities, and types of lube oil analyzed in the Lube Oil Quality Management Program.
- **Enabling Objective** - Identify the removal procedures for contaminants in the lube oil system.
- **Enabling Objective** - Identify the procedures and intervals for sampling lubricating oil.
- **Enabling Objective** - Identify the lubricating oil testing procedures.
- **Enabling Objective** - Identify the purpose of the Navy Oil Analysis Program (NOAP) and the documentation for tracking lube oil quality.

Proper lubrication is important to ensure continuously reliable operation of all shipboard machinery. An administrative program has been developed to monitor and control the lubrication of equipment. The LOQM program has three primary objectives:
- **Establish** standardized procedures for ensuring the quality of shipboard lubricating oil and hydraulic fluids, during receipt, transfer, stowage and usage.
- **Permit** early detection of unsatisfactory or contaminated lubricants and hydraulic fluids.
- **Conserve** lubricating oils and hydraulic fluids by eliminating unnecessary oil changes.

**RESPONSIBILITIES**

- **Lube Oil Quality Manager**, appointed in writing by the CO, normally it would be the MPA, but as a minimum will be an officer in the Engineering Department. The Manager reports directly to the Engineer Officer and is the primary supervisor in charge of ensuring the highest level of lube oil quality. The Manager will monitor the LOQM program, supervises receipt and strike down of new bulk lube oil to make sure tests are performed in accordance with NSTM 262 and recorded on a Lube Oil Log, keeping the Engineer Officer informed of all such actions; reviews, signs, and submits Lube Oil Logs daily to the Engineer Officer for review, being alert for excessive consumption and contamination; identifies causes and corrective actions when indicated; ensures ship’s force establishes high, low and normal levels in equipment with soundable sumps and submits NOAP samples as required by PMS.

**LUBRICANTS**

Lubricants are required by different types of equipment to ensure proper operation. The more common types of oil and some of the equipment in which they are used are: Select each type of oil for more information.
- **MS 2190 TEP** - natural oil composed of paraffin base stocks with antioxidant, anti-foaming, and anti-corrosion additives. It is the most common type of lubricating oil found onboard and is used in steam turbines, main reduction gears, controllable pitch propellers, line shaft bearings, generator bearings, high pressure air compressors, and low pressure air compressors.
- **MS 9250** is also known as Reciprocating Internal Combustion Engine (RICE) oil, it contain additives to keep soot from depositing on engine parts, to neutralize the acidic products of combustion, and to reduce the wear of internal parts. It is the primary oil used by the Navy and is used in main propulsion diesel engines, diesel generator engines, and small boat diesel engines.
- **MIL-L-23699** is synthetic oil used in main propulsion gas turbine engines and Gas Turbine Generators (GTG).
- **VV-L-825** is used in refrigerant systems due to its low pour point and good oxidative resistance.

**LIMITS AND ANALYSIS**

Lubricating oils deteriorate for reasons such as: contamination by water, sediment, foreign particles, fuel, oxidation, and chemical breakdown. In addition, replenishment with an incorrect lubricant will cause deterioration. Other causes are:
- **Water** increases frictional resistance, causes the oil film to break down prematurely, corrodes any parts not continuously covered with oil and causes corrosion in the entire system.
- **Sediment** may enter during maintenance or the result of wear and friction between system components. It can cause scoring of surfaces, degrading performance, increasing machinery noise, and eventually leading to equipment failure. It may also dissolve in the oil, affecting viscosity, further contributing to equipment damage by clogging filtering elements, and decreasing oil flow and pressure.
- **Breakdown** of the oil can be caused by exceeding the rated temperatures and pressures, or it may result from or be accelerated by contamination. However, proper operation of the Lube Oil System should prevent breakdown of the lubricant indefinitely. Periodic chemical analysis by the NOAP laboratory should identify breakdown by excessive changes in acidity and viscosity.

If lube oil fails to meet applicable limits, NOAP laboratory personnel will advise shipboard personnel in resolving the problem. Blending or mixing new oil into chemically deteriorated used oil to restore use limits is not permitted. On the other hand, when use limits are exceeded only due to water and solid contaminants, ships should make every effort to remove these contaminants through purification rather than discarding oil.
OIL PURIFICATION

Oil cleanliness is very important; all these processes are done to keep the oil system clean. The purification of oil is a very intricate process. The main tool used to purify oil is the centrifugal purifier.

All ships with centrifugal purifiers will operate the purifiers daily while underway until no visible indication of contamination remains and no water is discharged from the purifier. Oil in the lubrication system should be pumped to the settling tanks and renovated during annual sump inspection. Following these procedures and properly maintaining associated equipment, oil should remain in serviceable condition for an extended period. Piping system arrangements generally provide for two purification methods: batch purification and continuous purification.

- **Batch**, in this process the lubricating oil is transferred from the sump to a settling tank using the purifier pump or transfer pump. The oil is heated in the settling tank and its temperature is maintained at 160°F for 24 hours using heating coils. Water and other impurities are stripped from the bottom of the settling tank. The oil is then centrifuged and returned to the sump from which it was taken or to a storage tank. This process is also called renovation.

- **Continuous**, in this process the centrifugal purifier takes suction from a sump, purifies the oil, and returns it to the same sump. Prior to purification, oil passes through a heater, raising its temperature to the correct level for purification. Then the centrifugal purifier removes any water and impurities not trapped by filters or strainers. Note that all oil must be returned to the sump from which it is being taken while the equipment is operating.

PURIFIER

Removing lube oil impurities is done extensively by centrifugal purifiers. The centrifuge consists of a cylindrical vessel or separator bowl which rotates at a high speed while the contaminated oil passes through it. The centrifugal force forces the heavier matter toward the outer edge of the bowl. The heavier matter such as water and sediment moves to the outer most part of the bowl while the lighter purified oil moves to the center. Only materials that are insoluble in one another can be separated by centrifugal purifiers. Emulsified oil should be purified by pumping it to the settling tank and heating it to 160°F. The oil should be heated continuously for 24 hours. The impurities are then drawn off through the low point drain, and the settling tank volume recirculated through the purifier three times. If it still fails the clear and bright test, the oil should be discarded for shore disposal. This means a stable oil/water emulsion is present and cannot be broken down by a centrifuge.

When cleanliness has been lost, the system should be flushed. Before flushing, the interior surfaces of sump stowage and settling tanks should be cleaned with lint free cloths soaked in kerosene. The tank should then be wiped dry. The tank is then filled with enough oil to maintain normal operation. The oil is heated to 165°F. The oil is then circulated through the system while the temperature is maintained. Then, the oil is sampled for cleanliness. If it is necessary, the system will continue to be flushed until cleanliness has been met for a period of two consecutive hours.

TAKING LUBE SAMPLES AND TESTING PROCEDURES

All machinery containing lubricating oil or hydraulic fluids, including line shaft bearings, must be fitted with sample connections at the lowest point possible in the sump: the connections must be seal-welded or brazed in place as opposed to threaded into the sump to prevent leakage from the sump or contamination from outside, sample lines on non-pressurized systems are required to have a threaded cap on the end, the cap must be connected by a chain and must be kept in place except when samples are being taken. The cap prevents contamination of the sample line and prevents residual fluid in the line from draining out to the bilge; sample lines on pressurized systems will not have these caps because a leaking sample cutout valve could result in a spray leak around the cap. Satisfactory lube oil samples should be returned to the sump of origin. Unsatisfactory samples suitable for renovation should be returned to a lube oil settling tank. Unsatisfactory lube oil samples or machinery sump oil determined to be unsuitable for renovation by the Engineer Officer will be disposed of in accordance with the OPNAVINST 5090.1 Series, Navy Environmental Protection Manual.

Specified sampling intervals for shipboard testing are provided by the PMS, EOSS, or applicable technical manuals. Unless otherwise specified, equipment using 2000-series oil should be sampled within 24 hours prior to starting the equipment and daily when the equipment is operating. This includes machinery in auto start configuration. A sample should be taken upon receipt of oil, prior to oil transfer, after an equipment casualty, and under any unusual operating conditions. Equipment with sump capacity of one gallon or less shall not be sampled. Purifier discharge should be held for 30 minutes after starting, and every four hours thereafter. 2309, air conditioning, refrigeration, and deck machinery equipment will be tested and sampled in accordance with PMS only.

The shipboard evaluation of oils is very important for any ship. There are many qualitative and quantitative methods available to assess lube oil contamination while on board ship. The visual test for an oil sample is used to determine the presence of free water and solid particulate matter. The criteria for this observation are a clear and bright appearance of the oil. The term clear refers to the absence of visible particulate matter. The term bright refers to the absence of visible free water, moisture, or other factors that affect the color and clarity of the oil sample.

In addition to particulate matter and water contamination, color changes can occur in lube oil for a variety of reasons. Copper and tin contamination may cause a greenish color. Overheated oil or finely divided rust may cause a black coloration. Oil in service gradually changes from yellow to brown over time due to chemical deterioration. Color changes may or may not have significant effect on lube oil. As a general rule, sudden changes in color should be investigated. Shore laboratories and shipyards have spectrometric and physical test capabilities for lube oil analysis and should be consulted on a case-by-case basis to determine if an oil change is necessary.

Equipment with on-line purification must pass a visual (clear and bright) test. If the sample fails, the oil must be purified. Oil that doesn’t have free water but fails to meet the bright criteria of the visual test requires the transparency test. For the transparency test, a PMS card is held behind the sample bottle. If the card can be read through the oil sample, it passes the transparency test. If it is also clear, the sample is satisfactory. If the card cannot be read, the sample fails the transparency test and requires a bottom sediment and water test. Oil that is bright (or has passed the transparency test) but has visible sediment requires the visible sediment test. This test allows a qualitative assessment of the level of particulate contamination in a sample and allows samples to be screened prior to the bottom sediment and water test.

The sample is allowed to sit for ten minutes so all sediment will settle to the bottom. The bottle is then gently tipped onto its side and allowed to sit for another ten minutes. If a solid unbroken line of sediment accumulates along the intersection of the bottom of the bottle and the side, or if any individual particle is greater than 1/8 inch along any axis, the sample fails the visible sediment test and requires a bottom sediment and water test. If the line formed is broken and none of the particles are greater than 1/8 inch, the sample is satisfactory. Oil that fails the transparency test, visible sediment test, or the visual test for visible free water requires a bottom sediment and water test. This test uses a centrifuge.
Diesel engines are part of the LOQM program; 9000-series diesel engine lube oil tests are distinctly different. The high viscosity of lubricating oils causes much of the difficulty in starting diesel engines. As carbon residue and insoluble contaminants build up in the oil, the viscosity increases. This oil thickening can cause wearing problems or difficulty in starting the engine. In addition, fuel oil can leak into the oil pan due to bad seals, which can decrease the viscosities of the lube oil and causes the flash point of the oil to lower. This is a potentially hazardous situation and can cause a crankcase explosion. Both of these conditions can be checked using the viscosity test. Viscosity is also temperature-dependent, so it is very important that both oil samples are within one degree of each other. If the result is within a maximum of 40% thickening, or 5% fuel oil dilution, the sample is satisfactory. The acidity test involves mixing the oil sample with a chemical which is color sensitive to acid. As the level of acid increases, the chemical will change from blue to green to yellow. By comparing this color change to a standard color-coded indicator card, we can determine the acid content of an oil sample. If the result is blue, the sample is satisfactory. If the result is green or yellow, the sample is unsatisfactory.

NOAP AND LOGS
NOAP is a part of the tri service Joint Oil Analysis Program (JOAP) which was established to provide timely and accurate oil analysis results to Army, Navy, and Air Force customers through laboratories using standardized testing procedures. The purpose of NOAP is to have a program that monitors the condition of equipment and oil as a preventative maintenance tool, through taking routine analysis of oil samples drawn from different Navy machinery. NOAP laboratories are off ships that test samples submitted by ships and provide detailed reports on the properties of the oil. NOAP is primarily a spectrographic analysis program to measure metal wear particles present in machinery lube oil. The laboratories maintain records of sample results and can apply trend analysis to identify the wear of equipment components. This allows the labs to predict equipment failure and recommend corrective action before damage occurs.

All sampling, testing, and transfers of lube oil must be recorded in logs. Daily Lube Oil Logs are maintained to record sampling and testing for each type of oil. Receipt and transfer of oil is recorded in the transfer logs. Finally there is a Lube Oil Sounding Log to record sump, and storage and settling tank levels. The Daily Lube Oil Logs are maintained in a central location. The space supervisor must review and initial the log for each sample. Unsatisfactory sample entries are to be circled and annotated with the reason for unsatisfactory sample and corrective action taken. All lube oil storage and settling tanks must be sounded daily, as well as, before and after each transfer with the results recorded in a log.
Lube oil can properly do its job only when kept pure and at the proper temperature and pressure. The lube oil’s job is to keep the ship running smoothly. Engineer’s is to keep the lube oil pure and flowing to the systems that need it.

**Terminal Objective** - Demonstrate an understanding of the purpose, operation, and components of the Lube Oil Purification and Transfer System.

- **Enabling Objective** - Identify the purposes and major components of the Lube Oil Purification and Transfer System.
- **Enabling Objective** - Identify the components and operating characteristics of the DeLaval Purifier.
- **Enabling Objective** - Identify the operating precautions of the DeLaval Purifier.

The Lube Oil Purification and Transfer System is very important because it keeps the ship’s oil clean and flowing into the ship’s systems; therefore, it is important to identify the purposes and the major components of the system. An improperly operating Lube Oil Purification and Transfer System can cripple a ship. The Lube Oil Purification and Transfer System has four major purposes: receiving, storing, transferring, and purifying lube oil.

The system receives lube oil a few different ways: gravity fed from main deck risers into storage tanks, pumped onboard via deck risers from tanker trucks and delivered via hoses, ship-to-ship. Lube oil storage tanks vary in capacity depending on the ship and maintain a ready supply of oil for use in propulsion plant and auxiliary equipment. Lube oil can be removed from the storage tank when needed to replenish an equipment lube oil sump using either the lube oil transfer pump or the lube oil purifier. Dirt, sludge, metal particles, water, and other foreign substances can contaminate lube oil. Normal operation of ship’s equipment contaminates lube oil over time. In some instances, lube oil may be received in a contaminated condition.

**PURIFICATION AND TRANSFER COMPONENTS**

The major components of the Lube Oil Purification and Transfer System include a storage tank, a settling tank, a heater, piping and valves, and a purifier.

- **The Lube Oil Storage Tank** provides a readily available supply of lubricating oil for use by the propulsion plant and auxiliary machinery.
- **The Settling Tank** provides a storage area and place for the process of separating water and sediment from the lube oil. It is used in the batch purification method to purify lube oil. The capacity varies in each tank.
- **The Lube Oil Heater** is installed in the lube oil flow path between the purifier inlet pump discharge and the purifier bowl. This decreases the viscosity of the oil, allowing contaminants to be easily separated from the lube oil.
- **Piping and valves** can be aligned to purify and transfer lube oil to any one of the following, without affecting other components.

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**DELAVAL PURIFIER COMPONENTS**

The DeLaval Lube Oil Purifier is used to remove water, sludge, and particulate matter from the lube oil. The DeLaval is a disc type, centrifugal force purifier.

- **The frame** houses the purifier internal parts and supports the inlet and outlet pumps and the electric motor.
- **The inlet pump** pumps the dirty oil into the purifier. When activated, the lever engages the inlet pump bypass valve, and the primitive valve starts and stops the flow of dirty oil to the inlet pump.
- **The outlet pump** pumps the clean oil from the oil box to the piping system. It is identical to the inlet pump.
- **The priming valve** starts and stops the flow of water to form the water seal in the purifier bowl, and is used during start-up. It is also used during shutdown to reclaim the oil from the purifier bowl.
- **The inlet pump** pumps the dirty oil into the purifier at approximately 225 GPH. It is a positive displacement gear type pump with an internal relief valve that protects the pump from excessive pressure that could damage it.
- **The discharge valves** start and stop the flow of dirty oil from the inlet pump to the purifier.
- **The strainer removes** large particulate matter in the dirty oil before the oil reaches the purifier pumps.
- **The speed indicator** shows the lube oil purifier speed; 7200 revolutions per minute are normal. When the button is depressed, the plunger moves in and out against your finger 72 times a minute, indicating that the purifier is running at the proper speed.
- **The brake lever and brake** stops the bowl assembly rotation. When the brake lever is parallel to the frame, the brake disengages. When the brake lever is perpendicular to the frame, the brake engages.
- **The clean oil sample valves** are used to draw clean oil entering the purifier, for inspection and testing.
- **The dirty oil sample valves** are used to draw dirty oil entering the purifier, for inspection and testing.
- **The inlet pump suction valve** starts and stops the flow of dirty oil to the inlet pump.
- **The inlet pump bypass valve** regulates the amount of oil to ensure that the purifier is operating at its designed capacity of two-hundred-twenty-five gallons per hour.
- **The bowl locking screws** are threaded through the frame and into the bowl to hold the bowl stationary for disassembly. The bowl locking screws will also be used during reassembly.

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**- The outlet pump discharge valve** starts and stops the flow of clean oil from the outlet pump.

**- The oil observation port** allows you to check the proper oil flow from the bowl assembly. It collects water being removed from the oil and receives water for priming. No oil should be flowing in the water box. Oil flows in the water box only when the purifier does not have a formed water seal. This oil is lost to the oily wastewater tank.
- The electric motor operates the purifier drive train and inlet and outlet pumps.
- The hinge and locking device enables you to open and lock the frame cover in place.
- The hold down clamp must be tight, forming a seal between the cover and the frame by compressing the O-ring.
- The cover clamp acts to hold the cover down on the frame.
- The frame cover top is hinged and swings down on top of the frame enclosing the bowl assembly. It contains separate passages for the clean oil and water from the purifier bowl.
- The inlet arm directs the dirty oil to the bowl. Cover clamp hooks hold the inlet arm and cover down to form a seal between the cover and frame.
- The pressure gauge measures the lube oil back pressure to the bowl in the inlet piping.
- The thermometer monitors the temperature of the dirty oil that is flowing to the purifier.
- The oil filler cap screws into the oil fill port and has a dipstick attached to check the oil in the purifier sump.
- The water drains form a flow path from the water box to the oily water drains.

The drive train generates the centrifugal force that allows the components in the purification section to physically separate contaminants from the lube oil.

- Clutch blocks transfer rotary motion from the motor shaft and hub to the worm wheel.
- The worm wheel is a single helical gear that turns the worm gear. The worm is keyed to, and turns, the spindle.
- The hub is keyed to the motor shaft and transfers rotary motion from the motor shaft to the clutch blocks.
- The spindle is a shaft that supports and turns the bowl assembly.
- The bowl assembly is driven by the spindle shaft and contains the internal oil-purifying components.
- A regulating tube is located below the inlet arm and directs dirty oil to the distribution plug and into the rotating bowl.
- The clean oil chamber receives purified oil from the bowl and directs it to the oil observation port and outlet oil pump.
- A water chamber receives excess water from the bowl and directs it to the water observation port and water drain.
- The distribution plug is a tapered device located at the bottom of the regulating tube.
- A coupling nut holds the discharge ring in place.
- The small bowl O-ring is a neoprene O-ring fitted into the groove around the top of the bowl top.
- The bowl top has ribs on the underside to ensure pressure is evenly applied to all discs when the coupling ring is tightened.
- The locating lug, together with the locating slot, allows alignment of the bowl top with the bowl shell.
- The top disc is the largest disc and has no ribs, holes, or flanges.

The bottom disc has fins on the bottom to impart motion to the incoming oil as the bowl spins.

- Discharge rings maintain the water seal in the bowl and ensure that the water and purified oil is discharged to their respective chambers in the cover.
- A coupling ring slips over the bowl top and is tightened onto the bowl shell using left-handed threads.
- The locating slot, together with the locating lug, allows alignment of the bowl top with the bowl shell. The slot may be on either the bowl top or bowl shell.
- The large bowl O-ring is a neoprene O-ring fitted into a groove on the top of the bowl shell, or on the bottom of the bowl top.
- Intermediate discs vary in number, depending on the purifier. They separate water and dirt from the oil. Each disc has six oblong holes to distribute oil evenly into the spaces between the discs in the assembly.
- A locating pin aligns with a hole on the bottom of the tubular shaft.
- The bowl shell is spun at 7200 RPM and contains the tubular shaft and discs. Be sure to consult the manufacturer’s technical manual for proper size.
**ENGINEERING TERMINOLOGY**

Personnel frequently encounter acronyms when consulting references, reading instructions, completing forms, and communicating verbally and in writing. It is important to be familiar with common acronyms, and to know the terminology, which they represent. This glossary provides a list of acronyms used in the Basic Engineering Common Core course. Refer to this list as a reference for frequently used acronyms.

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<td>ABC</td>
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<td>CAGE</td>
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<td>CD</td>
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<td>IUC</td>
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<td>IVCS</td>
<td>Interior Voice Communication System</td>
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<td>RCI</td>
<td>Reactor Plant Cleanliness Inspector/Certifier</td>
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<td>RFI</td>
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<td>SMS</td>
<td>System Management Subsystem</td>
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<td>SNAP</td>
<td>Shipboard Non-tactical Automated Data Processing Program</td>
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<td>SOEAPL</td>
<td>Summary of Effective Allowance Parts Lists</td>
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<td>SOMS</td>
<td>Shift Operations Management System</td>
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<td>SPAWARSYSCOM</td>
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<td>SPMIG</td>
<td>Standard PMS Material Identification Guide</td>
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<td>SUBSAFE Certification Boundary Book</td>
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<td>SSTG</td>
<td>Ship’s Service Turbine Generator</td>
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<td>Shipboard Training Enhancement Program</td>
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<td>Significant Threshold Shift</td>
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<td>Ship’s Unique Data</td>
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<td>Tank Level Indicator</td>
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<td>Test, Measuring, and Diagnostic Equipment</td>
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<td>Technical Manual Deficiency Evaluation Report</td>
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<td>Total Protection</td>
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<td>Test Pressure Drawing</td>
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<td>Transition Radiation Effect on Electronics</td>
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MODULE 1

1. ____________ sets a minimum level of knowledge and skill that must be attained to qualify for a watch station.

2. Who updates the PQS progress chart?

3. Who reviews the PQS progress chart is reviewed and how often is it reviewed?

4. What are the 3 sections of PQS?

5. Who can sign PQS line items once they are completed?

6. (T/F) To get a PQS line item signed off, the trainee must be able to answer or perform the task for a particular item.

7. Do not operate power tools where ______________ or ______________ are present.

8. What safety manual gives guidance on HAZMAT control and storage?

9. What do you wear when handling sharp objects that will protect your hands?

10. What must you always wear while working in and engineering spaces on the ship?

11. What are some responsibilities of the Safety Officer?

12. What type of hearing protection is required when the average noise level in a space goes above 104db?

13. Single hearing protection is required when continuous noise levels are greater than how many db?

14. What kind of goggles should you use while grinding or chipping on the ship?
15. What safety equipment should be used to prevent you from falling while working at high areas?

16. Who ensures all eyewash station PMS is being completed?

17. What does an Ocenco EEBD consist of?

18. What should you do if the pressure gauge on the Ocenco EEBD is out of the green zone? Who should you report it to?

19. What is the purpose of an EEBD?

20. What is another name for a paint chipper and what is it used for?

21. What are the 4 types of calipers?

22. What NSTM would you look in to find a torque value for a specific grade of bolt?

23. What should AWAYS be done before making repairs on installed electrical equipment?

24. Who would you report to if you had any doubts about the condition of a power tool you were about to use?

25. What is Objective Quality Evidence (OQE) used for?

26. What is the Work Center Supervisor’s (WCS) job in respects to Quality Assurance?

27. What part of the 43P-1 can be used as a table of contents?

28. PMS schedules are broken down into how many schedules? What are they?

29. How many EEBDs are queried in the Main Engine Rooms (MERs)?

30. How is a burn classified?

31. What type of stretcher is designed to float?

32. What are the 3 types of heat exposure injurie?
33. Reading on the WBGT may only be taken after verifying internal calibration to be within what?

34. What is the term used to describe a total breakdown of the body’s heat balance?

35. How often are dry bulb temperatures recorded in manned spaces?

36. At what temperature do we have to start taking dry bulb temperature readings hourly?
MODULE 2

1. What is the primary difference between a duplex gauge and a differential pressure gauge?

2. Whose responsibility is it to review Night Orders?

3. What are the three legal logs/records and how long are they retained onboard the ship?

4. What are the three parts of the EOSS?

5. What are the 4 parts of the EOCC and which of the 4 parts do you have to memorize?

6. Who is responsible for the physical security of the MRG (Main Reduction Gear)?

7. What is the primary difference between the SORM and the EDORM?

8. In the Engineering Document Hierarchy which document takes precedent over all others?

9. At what db level is double hearing protection required? And what does double hearing protection involve?

10. What is the primary difference between Oily waste and Waste oil?

11. What does I.A.M.I.S. stand for? (hint; ORM)

12. What is the maximum allowable oil discharge to the sea?

13. Who do you report a Hazardous Waste spill to?

14. Why are there special precautions for disposing of plastic waste?

15. In your own words define ORM?

16. When should you use ORM?

17. What is the primary difference between packing and a gasket?
18. Name three direct reading devices.
19. Who serves as the plant control officer in the absence of the engineering officer?
20. How many prong plugs electrical tools must have?
21. What is the primary difference between a lagging pad and a flange shield?
22. Name the types of valves that can be throttled.
23. Where is a lagging pad used?
24. What is the purpose of a Flange Safety Shield?
25. Name the two types of Gate Valves and the difference between the two.
26. What is the most common type of valve in the engineering plant?
27. What type of valve would you use to protect equipment or a system from over pressurization?
28. When referring to a valve what is the seat?
29. What are the four principles of ORM?
30. How do you properly install an O-Ring?
31. What instrument is used to precisely align machinery?
32. Draw the symbol for: globe valve, duplex gauge, check valve.
33. What is the benefit of a duplex strainer over a simplex strainer?
34. Why do we use standardized symbols for piping system drawing?
35. Why does the Navy make you draw out piping systems that you will be responsible for?
36. When calling a station to make a report what is the proper communication procedure?
37. What is used to verify prober valve alignment for each combo of tanks, components and systems when accomplishing an evolution?

38. What part of the EOP provides tank capacity?

39. What in-port watch is responsible for the physical security of the ship and takes control of security forces in the event of a security alert?

40. Which document would the engineering officer use to establish a timeline for bringing the plant into operation?

41. What document contains maintenance requirements pertaining to all equipment in the command?

42. How many hours of work can an EGL have?

43. What are flange shields usually constructed of?

44. Who are the cold iron reports directed?
MODULE 6

1. What is the purpose of the ballasting system?

2. Define the following terms: Ballast, De-ballast and Clinometer.

3. How are the sea valves at the bottom of the ballast tanks opened and closed?

4. How are the ballast tank vents valves opened and closed?

5. What are the 2 methods used for ballasting?

6. Name the 4 normal ways de-ballasting can be accomplished.

7. What is used for emergency ballasting?

8. What is used for emergency de-ballasting?

9. What type of ships has the automatic fuel oil compensating systems?

10. How are tanks above the water line emptied?

11. How are tanks below the water line emptied?

12. What is the OWS process?

13. What are some things that the OWS can’t process?

14. Why is the OWS discharge 3 feet above the water line?

15. What are the 3 stages in OWS?

16. How long is the time delay for the Oil content monitor OCM?

17. What type of displacement is a centrifugal pump?

18. What causes the fluid friction to increase?

19. What must be done to a non-self-priming pump before starting?
20. What type of liquids are centrifugal pumps used for?

21. What does the pump impeller discharge into?

22. Why do we use wearing rings in pump casings?

23. What is the mechanical seal or stuffing box used for?

24. What is the purpose of the recirculating line?

25. A rotary pump is ______ priming and is a __________ displacement pump.

26. What pump has 2 spur gears that mesh together and revolve in opposite directions?

27. What pump uses rotating screws create the moving force for the liquid?

28. Which pump moves water with pockets formed by the rotor, sliding vane, and cylinder wall?

29. Which pump uses a plunger or a piston that moves back and forth within a cylinder?

30. Which pump has no moving parts and is used for pumping large quantities of liquid?

31. Which pump consists of a propeller fitted into a narrow tube like casing?

32. How are heat exchangers classified?

33. What is the definition of conduction?

34. What are the various types of flow in a heat exchanger?

35. What are some of the construction types of heat exchangers?

36. Define the following gears: spur gear, rack and pinion, bevel, worm and worm wheel, single helical, double helical.

37. What is the stern tube shaft used for?
38. What is the bulkhead stuffing box used for?

39. What is the purpose of the main line shaft bearing?

40. What are the tube bearing and strut bearings used for?

41. Which unit provides a means to lock the engine and shaft?

42. What is the purpose of having bearings?

43. Define the following: sliding friction, rolling friction and fluid friction

44. What type of movement do the following bearings limit? Split journal, split journal combination, Kingsbury thrust bearing, ball thrust, combination radial thrust ball bearing and cylindrical roller bearings.

45. Define the following fuel tanks: storage, service, contaminated, collecting, and overflow.

46. What is the purpose of the swash plate?

47. What are the two ways to directly read fluid levels in a tank?

48. What ways do we test fuel tanks for the presence of water?

49. Define the following lube oil tanks: storage, settling and stripping.

50. What must be accomplished prior to entering a void or poorly vented tank?

51. What is the CHT system designed for onboard ships?

52. What type of tank holds the ships potable water?

53. What is the purpose of a coupling?

54. What are the three types of misalignments?

55. What two couplings allow for a slight misalignment?
56. What type of coupling allows for two shafts to be connected not on the same plane?

57. Name the couplings above.

58. What is potable water?

59. What are the fill and suction manifold used for onboard ships?

60. What is the purpose of the potable water pump?

61. What is the purpose of the brominator?

62. What does the recirculating brominator do?

63. What is the purpose of the AMCW?

64. What is the function of the seachest?

65. What type of pump is used in the AMCW system?
66. What are the functions of the following: pump suction valve, pump vent valve, inlet valve, y strainer, orifice, recirculating outlet valve, AMCW pump discharge check valve, duplex strainer, strainer outlet valve, and heat exchanger.
MODULE 7

1. What is the Leslie Constantemp water heater used for?

2. What is the steam control valve controlled by?

3. What is the purpose of the blend valve assembly?

4. Water temperature is maintained within how many degrees +/- of the desired set temp?

5. What sets the desired temperature of the blend water?

6. What is the purpose of the automatic water regulator loading valve?

7. What is the temperature range for the Leslie Water Heater?

8. What is the purpose of the unloading control valve?

9. What does the unloading control valve prevent?

10. How many stages does an LP air compressor usually have?

11. How many stages does an HP air compressor usually have?

12. How many intercoolers will there be on a 2 stage compressor?

13. How many intercoolers will there be on a 4 stage compressor?

14. What are the pressures ranges for the following compression systems: LP, MP, and HP.

15. What color hand wheel is used for LP air?

16. What color hand wheel is used for HP air?

17. What is the purpose of the separator?

18. What is the priority valve used for?
19. Why do we use flexible hoses on compressors?

20. What are the 2 control methods for operating a compressor system?

21. What is the purpose of using a dehydrator in a compressed air system?

22. In your own words, describe a Type I dehydrator.

23. If you get a dehydrator high temperature alarm, what does that indicate?

24. How moisture is removed in a type I dehydrator

25. In your own words, describe a Type II dehydrator.

26. What allows the type II dehydrator to be able to be in continuous operation?

27. What causes a high dew point level alarm on a type II dehydrator?

28. On a type II dehydrator, what prevents both towers from being online at the same time?

29. What is an air receiver used for?

30. Name and explain the 3 modes of LPAC operation

31. When blowing down or purging an air system, how long must this be done for?

32. What is the purpose of the distilling plant?

33. In your own words describe how a drop of Sea water becomes a drop of Potable water in a flash type distilling plant.

34. On what principle does Hydraulics work and in your own words define it.

35. In your own words describe the normal operation of the steering gear.

36. Define and explain the use of the following: Trick Wheel, Auto-Change Over –-Over Transfer Switch, Accumulator, and Rudder Angle Indicator.
37. How many safety devices are there for the Vertical package conveyor? And what are they?

38. Describe the difference between Type one and Type two Dehydrator

39. What are the three types of Air compressors and what are their PSI ranges?

40. What is a TXV and what does it do?

41. What is the most common type of lube oil used in the navy?

42. What are the two types of Lube Oil Purifier?