



# INTRO TO SHIP SYSTEMS AND MARITIME TECHNOLOGIES



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# SHIPBOARD SAFETY

## LESSON 1

# Effective Communication on the Job

Many problems on the jobsite are due to poor communication. It is not only between management and the worker; but often the rest of the organization is not communicating effectively.

The three types of communication are:

**Written** – On the job this will include shift reports, turnover sheets to supervisors, deficiency reports, etc. This type of communication should be clear, concise and to the point. There should be no room for interpretation when the report is written clearly. Instead they are often written to be ambiguous or misleading; this is leading the worker into a trouble situation. Deficiency reports (DR's) are often used to document problems with the jobsite. This is effective only if the problem is written out clearly and the answer is clear as well.

**Verbal** – This is the most common. It is by word of mouth that we do so much communicating. But often times, we assume that the person that is receiving the information is as knowledgeable about the job as we are. They often have very little idea what it is that we are talking about. This is where the problem starts. We then give very little detail and often give incorrect information accidentally. Verbal information is quickly forgotten. If the information is important, it should be recorded by shift reports or similar.

**Graphic** – Drawings, photographs and videos are great means of communication. They can show a problem and what the possible hazards are. People are generally graphic oriented and respond best to seeing photos of accidents, especially if they are often in the same situation. The thought of "That could have been me" is often the response in safety posters and videos. If you are passing along graphic communication in the form of drawings, sketches, etc., you must make sure that they are correct in all aspects. Again, there should be no chance of mis-interpretation on the part of another worker.

With all forms of communication, it is most important to get all the information across in a short, concise message, no matter which type of communication you should use. Make sure to keep it simple and write or draw everything. Do not rely on someone's memory, especially when you are passing along lots of information.

# Work Area Safety Awareness

Make sure to familiarize yourself with required safety precautions when entering into different or unfamiliar surroundings.

Before you turn on a switch, start machinery, or open a valve, check out the location of the other people in the area. Make sure all safety gear is attached to the equipment.

Make sure to pay attention to the surface that you are walking upon. If the surface is uneven or has slippery or loose spots, it is easy to lose your footing and fall.

All electrical cords, hoses, ropes, etc. should be out of the walk path. If they must cross a walk path, they should be elevated or covered over to eliminate the trip hazard.

Make sure the walk path is well lit. This includes all work areas, stairways, and any other personnel passage.

If you are working in sight of other people, you should install barricades to prevent flying sparks & debris from hitting them.

**YOU ARE IN CHARGE OF SAFETY ON YOUR JOB!**

**All regulations can be found at the following website:**

**<http://www.osha.gov/>**

**Review the section for Ship Repair (1915) and General Work (1910).**

# Detection and Prevention of Deliberate Malpractice

A fine and/or imprisonment are required by federal law if you are found guilty of fraud or falsification of records against the government.

*Legal Jargon:* “Whoever, in any matter within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals or covers up by any trick, scheme or device a material fact, or makes any false, fictitious or fraudulent statements or representations, or makes or uses any false writing or document knowing the same to contain any false, fictitious or fraudulent statement or entry, **shall be fined not more than \$10,000 or imprisoned not more than five years or both.**”

## *Examples of Deliberate Malpractice are:*

1. Deliberately accepting unsatisfactory work.
2. Intentionally performing unsatisfactory work.
3. Verifying by signature that an action was taken, knowing in fact that the action was not taken, or without performing the required checks to assure the action was taken.
4. Tampering with calibrated instruments in order to avoid rejection of work.
5. Falsifying dates on records to comply with frequency or deadline requirements.
6. Falsifying data in order to have work accepted, thereby avoiding further required work, or to cover up a deviation from a procedure.
7. Intentionally performing unacceptable work.
8. Concealing information on malpractice known to have been committed by others.
9. Verifying action based on hearsay when personal observation was required.
10. Issuing a procedure known to contain an unauthorized deviation from requirements.
11. Knowingly waiving a requirement without authority to do so.

### ***Cases of Deliberate Malpractice are more likely to occur from:***

1. When supervision is lacking; Management is not properly providing the required amount of oversight to the employees.
2. There is an insufficient amount or quality of quantitative measurement or testing done for the work.
3. Workers are often assigned to tasks they are not capable of performing.
4. Management shows a lack of interest or refuses to take action on suspected malpractice cases.
5. On-site job checks are not done; only paperwork reviews are completed.
6. Work conditions are poor, which may induce employees to acts of malpractice.
7. Independent oversight is not done.

### ***Examples of Preventive Actions:***

Improve Supervision.  
Internal Audits and Surveillance.  
Develop Awareness of Consequences of Malpractice.  
Determine Sensitive Areas.  
Use Overcheck Programs.  
Records Control.  
Carefully Assign Personnel.

### **A Word to the Wise**

Before you determine a case of deliberate malpractice has occurred be sure you have all the facts. The observation of errors and corrections of errors does not automatically mean deliberate malpractice has occurred. The appearance of deliberate malpractice must be proven without a doubt.

All problems noted on a job site should be reported to a supervisor and documented on a deficiency report. This will be submitted to management & engineering departments for the proper resolution. At no time, should a problem ever be ignored or covered up.

# Personal Protective Equipment

All workers should wear safety equipment as required by the job site they work at. The common safety equipment includes:

Hard Hat  
Safety Glasses  
Ear Plugs  
Safety Shoes  
Leather Gloves  
Safety Harness

Do not modify the PPE after it is issued.

Hard hats with the liners out are almost useless.

Normal sunglasses will not protect the eyes when a piece of metal shoots at it.

Safety shoes, for most trades, should be: mid height, leather and have very good traction. Some shops will require special shoes, ex. Electricians. Normal boots will not suffice. If a heavy piece drops on your foot (this happens frequently), the steel toe will protect your foot. Normal shoes will let your toes get crushed. Cloth or cheap leather gloves will rip easily allowing the worker to get cut. A high quality pair of leather gloves will protect your hands from sharp edges. Always wear the required PPE for your job!

## FYI

Other PPE may be required that is not listed here.



# Blind-Side Work

When working on bulkheads, decks and overheads, it is especially important to check out what is on the other side of the barrier. Accidents happen frequently because workers don't look on the blind side of the bulkhead. Fires are frequently the problem; but could just as easily cause injury to personnel, damage to equipment, even explosions, if there are flammable vapors or gasses on the other side of the bulkhead.

It is relatively easy to sound out and locate the space. After finding the approximate compartment opposite your work site; you should have a work mate tap the bulkhead with a hammer. You can easily pinpoint the location of the tapping when you come near it. After locating the tapping, you should tap back to confirm the location was spotted. This also serves the purpose of having the mechanic on the other side confirm that you are in the correct position. At this point you should check the area opposite the jobsite for dangerous obstacles or hazards. Once clear, you should post a fire watch or lookout when performing work that could be hazardous to that space.

## **FYI**

For your own safety, always know what is on the other side of the bulkhead!

# Respirator Awareness

To deal with the hazards that are a daily concern for workers, the respirator was developed. A respirator allows the worker to be in a hazardous environment and still breath in clean, filtered air. This takes much of the hazard out of hazardous work.

Respirators are attached to the worker by a facepiece. The facepiece is held in place with straps. Typically 1-2 filters are attached to the facepiece or air is fed into the facepiece. The wearer of the respirator must be fitted to the correct size of respirator. Half-face respirators are often worn by painters, welders, etc. Full-face respirators are an alternative for the worker that may be using caustic chemicals or that requires eye protection.

To determine the proper filtration system required, the worker must refer to one of the many charts, books or references available. The filter is determined by the type of mask and the material which needs to be filtered out. Some filters are used multiple times and then discarded and replaced. Others may be used once and discarded.

There are two basic types of respirator:

- Negative-pressure respirators allow the worker to breath in filtered air using mechanical filters and chemical media.
- Positive-pressure units force clean air into the system.

Respirator usage is recommended at any time that fumes/vapors/gasses may be ingested. Full face respirators are especially advantageous as they serve to prevent breathing in toxic substances and also prevent foreign particles from getting into the eyes while working.

**FYI**

**This course  
does not qualify  
you for a  
respirator!**

# Fall Protection

When employees are working aloft, or elsewhere **at elevations more than 5 feet above a solid surface**, either scaffolds or a sloping ladder, meeting the requirements of this subpart, shall be used to afford safe footing, or the employees shall be protected by safety belts and lifelines.

Employees visually restricted by **blasting hoods, welding helmets, and burning goggles** shall work from scaffolds, not from ladders, except for the initial and final welding or burning operation to start or complete a job, such as the erection and dismantling of hung scaffolding, or other similar, nonrepetitive jobs of brief duration. **OSHA 1915.77(c)**

The harness is generally not required if the worker is standing on a deck or solid staging if there are handrails securely attached.

The harness is worn comfortably on the body as shown. It is attached to a secure position by the use of a **shock absorbing lanyard** or a self retracting lifeline. Special attention should be paid to where you are securing the lanyard. Is the attachment strong enough to hold the person falling, any tools they are holding and the added force of the fall? Do not attach to items that the lanyard could slip off or that may not be able to handle the entire load. The full body harness distributes the force of the fall to the entire body as opposed to safety belts in which the force is concentrated on the waist level position.



## **FYI**

*Effective January 1, 1998, waist belts are not acceptable as part of a personal fall arrest system. – OSHA*

# Staging

Staging is used to provide a stable work surface at elevated positions. Staging is built using several different designs and is constructed onsite to accommodate the specific situations of each jobsite.

Staging should be built to accommodate the total number of workers, their tools and any force applied to it. A safety factor should be applied that mandates that the staging is built to withstand a greater amount of weight than should ever be allowed to step upon that staging. Falls on the jobsite are a significant hazard; staging should be built to prevent any possibility of this.

Before working on staging, you should perform a list of checks to the staging:

- Is the staging secured and supported safely?
- Is it level?
- Is there a safe ladder or other type of access?
- Is there sufficient decking to perform the job safely?
- Are there handrails at the proper height to prevent falls?
- Are kickboards provided to prevent personnel and tools from falling from the staging?



## **FYI**

**No employee is to alter staging under any condition without proper training and directives to do so. Staging is typically installed when the worker is 5 feet above the deck.**

# Asbestos Usage in Shipyards

Asbestos is a fire and heat resistant material that was commonly used in the form of insulation. It is a naturally occurring mineral. Asbestos has been used for insulation, gaskets, sealing pipes and valves, housing shingles, brake liners and many other uses. The use of asbestos was stopped years ago. However, for some of its uses, there has never been an acceptable substitute found. It is still used certain industry with great care.

The danger of asbestos comes when it is an airborne state. It is breathed in by workers. Often, it was on the clothing of those same workers and transported home to wife and children. Several occurrences of family getting asbestos related diseases have been accounted for.

For years, asbestos was widely used as insulation in the shipbuilding industry. Workers were exposed unknowingly to asbestos. The fibers were seen in clouds in the air and those fibers were breathed in since no one wore respirators at the time. The dangers were unknown at the time so few precautions were taken to control the dust. The fibers of asbestos often become airborne while fitting the insulation by cutting, during the removal process also.

The asbestos related diseases include:

**Asbestosis:** a pulmonary condition, only caused by exposure to asbestos, where scar tissue builds up in the lungs causing breathing problems and low blood flow.

**Mesothelioma:** a type of cancer only caused by asbestos exposure that attacks the lining around the lungs and/or heart and/or abdomen.

**Asbestos Related Lung Cancer:** asbestos exposure can lead to the formation of a malignant tumor that blocks the air passages. Cigarette smoking drastically increases the chance of developing an asbestos-related lung cancer in exposed workers. Asbestos workers who smoke have a fivefold greater risk of developing lung cancer than non-smokers, and those asbestos workers who smoke have a risk that is 50 to 90 times greater than non-smokers.

# Electrical Safety on the Job

Many hazards exist on the jobsite, but none are as serious or deadly as the risks due to electrical shock.

The risks of electrical shock are:

**Burns** – electrical shock can cause very deep burns due to the large amount of energy typically involved, especially in an industrial environment. Damage to tissue actually occurs as a result of current passing through, heating the tissues from the inside out. Did you know that more workers die from the burns associated with a shock rather than from the shock itself?

**Ventricular Fibrillation** – if an electrical current has a direct pathway to the heart, ventricular fibrillation can occur. This is a condition where the heart begins to beat, or *twitch*, in an uncoordinated manner, most often leading to cardiac arrest! This arrest can lead to death within a matter of seconds if not addressed immediately!

**Arc-Flash Hazards** – statistics show that up to 80% of electrical injuries involve thermal burns due to arcing faults. The arc flash in an electrical fault produces the same type of light radiation from which electric welders protect themselves using face shields and dark safety glasses, leather gloves and full-coverage clothing! The blast produced by vaporizing metallic components can break bones and cause irreparable damage to internal organs, once you get past the severe burns inflicted on unprotected skin!



**Electrocution** – the term was actually developed after the first use of the Electric Chair in 1890, combining the terms Electrical and Execution! The term now refers to all circumstances of death due to electrical contact.

**Lethality Factors** – how lethal a shock is depends on the following factors:

1. Current – the higher it is, the more lethal it will be
2. Duration – the longer it is, the more lethal it will be
3. Pathway – if it flows through the heart muscle, the more lethal it will be
4. Voltage – the higher the voltage, the lower the resistance, therefore it will travel faster and farther, doing more damage.

**Static Electricity** – refers to the build-up of electric charge on the surface of objects. These charges remain on the surface until they are bled off to a ground of some sort or neutralized by a *DISCHARGE*. This discharge can be significant enough to ignite flammable materials and cause electrical shock to you the worker!



## Basics of Electrical Safety

Disconnecting or making safe the equipment involves the removal of all energy sources and is known as isolation. The steps necessary to isolate equipment are often documented in an isolation procedure or a lockout tagout procedure. The isolation procedure generally includes the following tasks:

1. Identify the energy source(s)
2. Isolate the energy source(s)
3. Lock and/or Tag the energy source(s)
4. Prove that the equipment isolation is effective

The locking and/or tagging of the isolation point lets others know not to de-isolate the device.

The National Electric Code states that a safety/service disconnect must be installed within sight of serviceable equipment. The safety disconnect ensures the equipment can be isolated and there is less chance of someone turning the power back on if they can see the work going on. These safety disconnects usually have multiple places for locks so more than one person can work on equipment safely.

In industrial processes it can be difficult to establish where the appropriate danger sources might be. For example, a food processing plant may have input and output tanks and high temperature cleaning systems connected, but not in the same room or area of the factory. It would not be unusual to have to visit several areas of the factory in order to effectively isolate a device for service (e.g. device itself for power, upstream material feeders, downstream feeders and control room).

Modern safety manufacturers provide a range of isolation devices specifically designed to fit various switches, valves and effectors. For example, most modern circuit-breakers have a provision to have a small padlock attached to prevent their activation. For other devices such as ball or gate valves, plastic pieces which either fit against the pipe and prevent movement, or clam-shell style objects, which completely surround the valve and prevent its manipulation are used.

A common feature of these devices is their bright color, usually red to increase visibility and allow workers to readily see if a device is isolated. Also, the devices are usually of such a design and construction to prevent it being removed with any moderate force. (That is to say that an isolation device does not have to stand up to a chainsaw, but if an operator forcibly removes it, it will be immediately visible that it has been tampered with).

To protect one or more circuit breakers in an electrical panel a lockout tagout device called the Panel Lockout can be used. It keeps the panel door locked and prevents the panel cover from being removed. The circuit breakers remain in the off position while electrical work is done.





# ENTERING CONFINED SPACES AND HOTWORK

## LESSON 2

# 1. Definitions

## Confined Space:

A space which has limited or restricted openings for entry and exit. It lacks natural ventilation. It may contain hazardous contaminants or have oxygen enriched or deficient atmosphere. This space is not intended for normal occupancy on a continuous basis. You should not be working in a confined space alone.

Ex., Tanks, Voids

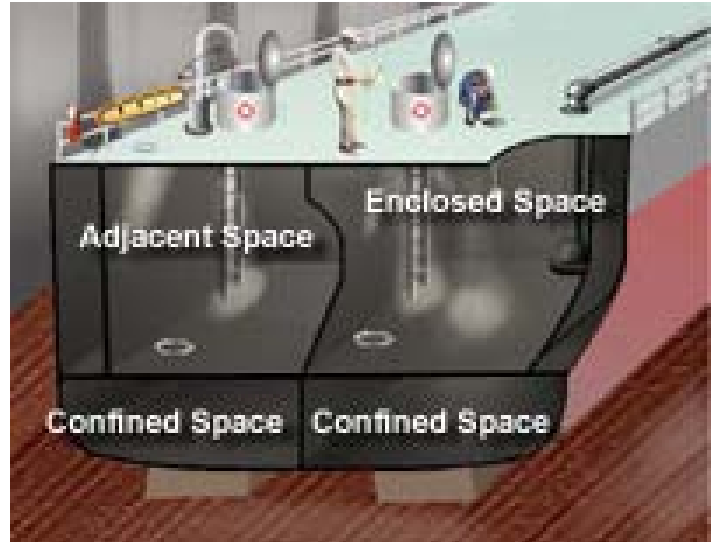
## Poorly Ventilated Enclosed Space:

A space which has restricted air movement and could easily become hazardous to personnel due to the presence of toxic, flammable, or combustible materials.

## Well Ventilated Enclosed Space:

A space, which has restricted natural air movement.

Ex. Engine Room



## Gas-Free Engineer:

The person in charge of administration of the Confined Space Program for a shipyard.

## Competent Person / Marine Chemist:

The person trained to test and inspect confined and poorly ventilated spaces for sufficient oxygen levels for personnel access. They also ensure the site is acceptable for hot work.

## Immediately Dangerous to Life or Health (IDLH):

Compartment has a less than 19.5% or greater than 22% of oxygen or the flammable or explosive vapors are at 10% or more of the lower explosive limit. Then the compartment is considered IDLH. No personnel are allowed to enter IDLH areas without a Self-Contained Breathing Apparatus (SCBA).

## **Inerting:**

A gaseous atmosphere that is not conducive to chemical reactions, such as helium or nitrogen.

## **Permissible Exposure Limit (PEL):**

PEL is the OSHA standard a worker may be exposed to of toxic materials. If the concentration levels of the toxins should go above PEL, then the workers will not be allowed in the area.

Ex. Lead work

## **Lower Explosive Limit (LEL):**

Lower explosive limit means the lowest concentration of a substance that will produce a fire or flash when an ignition source (flame, fire, etc.) is present.

## **Upper explosive limit (UEL)**

Upper explosive limit means the maximum concentration of flammable vapor in air above which propagation of flame does not occur on contact with a source of ignition.

## **2. Competent Person / Marine Chemist**

Competent Persons are highly trained personnel specially trained to perform testing of oxygen levels for confined and poorly ventilated spaces prior to personnel entry. They make the determination on whether hot work can be safely performed in the space. This person will issue a Gas Free Certificate stating the levels in the compartment and the work involved. They also inspect opposite sides of bulkheads or decks prior to work being performed.

Having a Competent Person checking the work space is not sufficient as the only person checking the space. The mechanic working the job must check the space also. Conditions change frequently and should be inspected.

Reasons why it is important to have a confined or poorly ventilated enclosed space checked by a Competent Person prior to entering:

- (a) Lack of sufficient oxygen to support life.
- (b) Excessive oxygen levels, which increase the danger of fire or explosion.

- (c) Presence of flammable or explosive atmospheres and materials.
- (d) Presence of toxic atmospheres and materials.

### 3. Gas Free Certificate

A gas-free certificate is issued if the following conditions are met:

- Oxygen is between 19.5 percent and 22 percent.
- The concentration of flammable vapors is below 10 percent of the lower explosive limit (LEL).
- Toxic materials in the atmosphere are within permissible concentrations.
- Any residues or materials will not produce uncontrolled release of toxic materials under existing atmospheric conditions.

A gas-free certificate must be posted and up to date outside each space prior to going into that space. The mechanic should be aware that the Competent Person issued the certificate after a satisfactory inspection was completed. This inspection could be hours prior to the mechanics entry in a compartment. Another inspection should be performed by the mechanic prior to work.

**Conditions change!  
Be aware of your  
surroundings!!!**

Make sure you understand the safety rules and regulations when working in a confined or poorly ventilated enclosed space. It is the responsibility of the person entering the space to do so. Remember, your life may depend upon it! Report any unsafe conditions to your supervisor immediately. Warn others in the area of any unsafe conditions. Report injuries to your supervisor immediately or as soon as possible.

### 4. Category of Certificate:

**Gas free certificates to be issued by the Competent Person shall have categories similar to the following:**

#### **No Entry - No Hot Work.**

This category shall be used when:

- (a) There is danger due to toxic materials, vapors or gases present or likely to evolve under prevailing conditions or danger of suffocation due to oxygen to an oxygen deficiency.
- (b) There is danger of fire or explosion due to the presence of flammables or explosive materials, vapors or gases, or oxygen enrichment present, or likely to evolve under prevailing conditions.

- (c) There is danger of fire, explosion or toxic hazards in the presence of hot work due to the existence of flammable, explosive, toxic or reactive residues, vapors or gases, or oxygen enrichment; or,
- (d) There is a danger of fire, explosion or toxic hazards in the presence of hot work, due to boundary spaces, which have not been protected.

### **Safe for Entry - Not Safe for Hot Work**

This category shall be used when:

- (a) Toxic materials, vapors, or gases, if present, are below Permissible Exposure Limits (PELs), or are not likely to evolve in excess of the PEL and oxygen content is sufficient (19.5% TO 22%) and suitable for personnel, or such conditions are adequately and consistently controlled by ventilation.
- (b) There is danger of fire, explosion, or excessive toxics in the presence of hot work due to flammable or explosive materials, vapors, or gases.
- (c) There is danger of fire, explosion, or excessive toxics in the presence of hot work due to boundary spaces that have not been protected as required.

### **Safe for Entry - Safe for Hot Work**

This category shall be used when:

- (a) Toxic materials, vapors, or gases are not present or likely to be evolved and oxygen levels are sufficient and suitable for personnel or such conditions are controlled by proper ventilation within established permissible exposure levels (PELs).
- (b) Flammable materials, vapors, or gases have been removed, are not likely to evolve, and/or are controllable by ventilation.
- (c) Surrounding boundary spaces have been inspected and protected as required.

## **5. Emergency and Rescue Procedures**

Rescue operations in a confined or poorly ventilated space shall be reviewed by the gas free engineer periodically. This is to determine weaknesses or potential problem areas that may affect the possible rescue.

### **RESCUE**

**In the event of an emergency aboard ship/submarine, personnel shall:**

Notify the quarterdeck by the fastest means possible. The quarterdeck will notify the fire department. This may include a CASCON system.

Stand-by and await further instructions before leaving the quarterdeck personnel whether on phone or in person.

Direct the rescue party to the victim or the scene of the emergency.

### **In the event of an emergency ashore, personnel shall:**

Notify the fire department by phone or pull the nearest fire alarm.

Stand-by and await further instructions before leaving the quarterdeck personnel whether on phone or in person.

Direct the rescue party to the victim or the scene of the emergency.

It is important to note that rescue personnel are specifically trained in confined space rescue tactics.

Rescue Personnel will wear appropriate gear they have been specially trained for:  
SCBA - Self Contained Breathing Apparatus  
Harness with a lifeline.

The rescue party will perform CPR or other emergency medical treatment as required on the jobsite after they are removed from the confined space. Then the victim will be transported to the nearest appropriate medical facility as required by the situation.

**YOU SHOULD NEVER ATTEMPT TO RESCUE SOMEONE THAT HAS BECOME TRAPPED OR UNCONSCIOUS IN A CONFINED OR POORLY VENTILATED ENCLOSED AREA. THIS IS AN OFTEN FATAL DECISION FOR UNSUSPECTING CO-WORKERS!**

## **6. Personal Protective Equipment**

Personal protective equipment (PPE) shall be provided and used by all personnel entering into confined or poorly ventilated enclosed space as appropriate for each condition or space.

Personnel shall be trained, medically qualified and fitted with appropriate respiratory protection in accordance with NIOSH requirements when respirators are required.

Respirator usage for each job will be specified by:

- a) Management.
- b) Approved technical procedures/instructions
- c) Local OSHE Instructions
- d) or the Safety Division

If you are unsure of the type of respirator required for new or unusual work, you should contact the safety office for guidance.

You are not to enter the following types of spaces under any circumstances:

- a) confined spaces not certified Safe for Entry or the Safe for Entry certification has expired.
- b) oxygen deficient atmospheres (below 19.5% oxygen) or oxygen enriched (above 22% oxygen).
- c) immediately dangerous to life and health (IDLH) atmospheres (10% or greater lower explosive limit).
- d) Toxic atmosphere at IDLH level.

Personnel that are to enter into IDLH spaces as above are required to wear a self-contained breathing apparatus (SCBA). The requirements for this type of respirator are:

- a) Prior to entry into a hazardous area, personnel shall be inspected for proper clothing, which is commensurate with hazards involved, proper equipment, which is in good operating condition and intoxication resulting from drinking of alcoholic beverages or use of drugs. No one shall be allowed on the job if intoxicated.
- b) Physical Examination - Personnel assigned to work in confined spaces shall receive physical examinations in accordance with current requirements.

## 7. Ventilation

Special care shall be taken when working in confined and poorly ventilated enclosed spaces due to the levels of oxygen. They can be depleted or enriched. Either is deadly to unprepared workers. In this situation, mechanical ventilation shall be established to provide fresh breathable air.

OSHA manuals are specific on the type of ventilation required for specific processes. The use of mechanical exhaust ventilation in confined or poorly ventilated enclosed spaces is used for:

- (a) Removal of contaminated air (flammable or toxic) from the space and maintain safe levels of concentration in terms of Permissible Exposure Limits (PELs) or Lower Explosive Limits (LELs) as appropriate.
- (b) Provide fresh, respirable air in the space for breathing.
- (c) Capture and remove contaminants generated within the spaces or dilute such contaminants to safe levels of concentration in terms of applicable PELs or LELs.

## 8. Hot Work in a Confined or Poorly Ventilated Enclosed Space

### (a) Hot Work Operations

Hot work is any work which produces heat at or greater than 400°F by any means. This includes welding, torch cutting, plasma cutting, brazing and back gouging.

It is also considered hot work while working with spark producing ignition sources and flammables or flammable atmospheres.

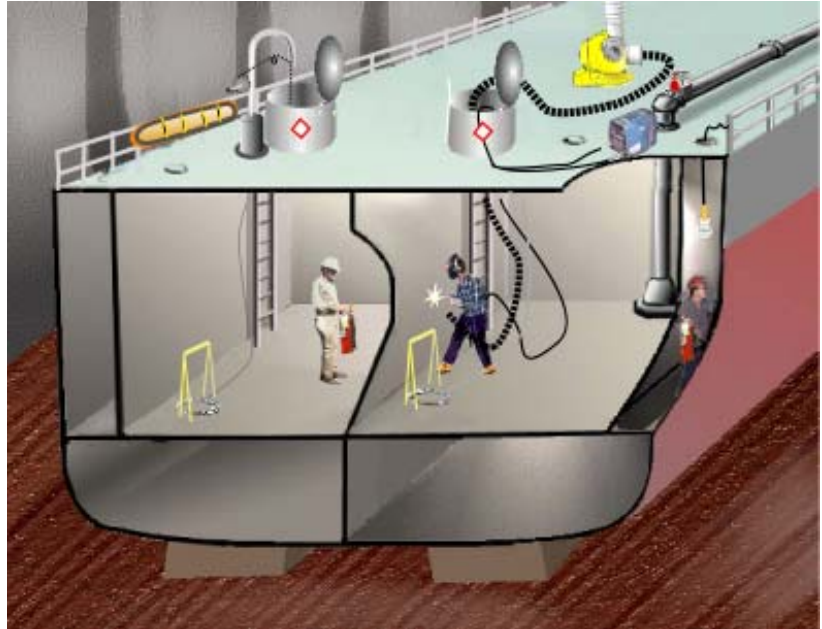
### (b) Space Cleaning and Ventilating

Flammables & combustibles shall be removed from the space if possible. Combustibles include: wood, paper, rope, rags, trash, etc. (Any material which leaves an ash when burned).

If they cannot be removed, they shall be protected and inspected by the Competent Person.

### (c) Boundary Spaces

Hot work does not only affect the space in which you are working. The adjacent spaces are also affected. Spaces adjacent to the hot work will also be inspected, cleaned & ventilated as required prior to hot work being performed.





(d) Fire Prevention

Firewatch: The fire watch is a specially trained person whose sole duty is to observe the hot work process, be aware of the potential for sparks and fires. He shall have a knowledge of the proper use of fire extinguishing equipment. He shall have that equipment immediately available on the job site.

More than one fire watch may be required for certain jobs. A firewatch may be positioned on the opposite side of a bulkhead or deck when performing hot work there. Communication shall be established for the hot work operator and the firewatch in order to stop hot work.

(e) Fire Extinguishing Equipment

Appropriate fire fighting equipment shall be furnished by the employer. The correct selection shall be based upon the flammable and combustible material in the compartment and the type of compartment in which it is to be used.

Vaporizing liquid extinguishers shall not be used in confined or Poorly Ventilated Enclosed Spaces.

CO<sup>2</sup> is an excellent fire fighting agent, but has special hazards associated with it. The discharge of CO<sup>2</sup> into a confined space will deplete the oxygen level and be hazardous to personnel. For this reason, special consideration shall be taken prior to using this type of fire fighting equipment.

For Class A (combustible or flammable residues), a water type fire extinguisher or water hose equipped with a fog nozzle is the best choice for fire fighting.

Fire extinguishing equipment shall be selected based on:

- (a) The extinguishing agents ability to suppress the fire.
- (b) Any hazards which may be created by the discharge of the agent into the space.
- (c) The capacity of the equipment in relationship to the size.
- (d) Intensity of the anticipated fire.

Note: Exceptions may be made in the selection of fire protection where restrictions exist due to the nature of the space or ship.

Ex: Submarines

If a CO<sup>2</sup> fire extinguisher is discharged into a confined or poorly ventilated space, the space shall be evacuated and shall be re-inspected by a Competent Person prior to the commencement of work.

## 9. General Safety Precautions

The Competent Person shall inspect all confined spaces prior to personnel entering the space.

Reminder: Conditions change! The gas free certificate was issued at the time the Competent Person performed his inspection. The area may have changed since that time or another shop may have introduced flammable/toxic materials into the area. Use caution anytime you are working in a confined or poorly ventilated space. It is the responsibility of the person performing the work to comply with the gas free certificate.

It is estimated that about 15 people die per year in confined space accidents. It is up to you to work safely!

**Never work in a  
confined space alone!**

### Buddy System

Always use the "Buddy System". Keep at least two people on a job in a confined space at all times. One person shall be inside the space and one person outside keeping constant communication with the other person.

Alternative: Two persons enter the approved confined space together.

If a confined or poorly ventilated enclosed space has an expired gas free certificate, personnel shall not enter that space.

Immediately leave the space if you are becoming dizzy, sleepy or develop a headache while working in a confined or poorly ventilated enclosed space. Immediately report your condition to your Supervisor at once!

Oxygen is depleted quicker and carbon Dioxide levels are raised quicker in a confined or poorly ventilated space with a large number of people working in that space. Natural ventilation may be sufficient for those spaces but will be determined by the Competent Person.

If you find someone unconscious in a confined or poorly ventilated space, **DO NOT ATTEMPT RESCUE!** Immediately call the fire department or pull the nearest alarm box.

Do not use lighting that is not Non-explosion proof in a confined or poorly ventilated space that contains residual combustible or flammable liquids.

All workers should carry a flashlight with them at all time while working on a confined or poorly ventilated enclosed space for emergency situations. A second flashlight is recommended. A small flashlight hung on your hip is preferred for a second flashlight.

# NAVAL SHIP CLASSES

## LESSON 2A

# SHIPS CLASSES

The purpose of this training is to enlighten the students of the types of Naval Warships commonly seen at the local shipyards. Private & federal shipyards in this area rely on the Navy for a large part of their work. While working on these ships, it will be beneficial to student and the employer that these future mechanics are aware of the differences in the classes of these ships. Naval Warships are not the only type of vessel seen in local shipyards but it the most common. The list on the next few pages is not an all-inclusive listing of naval ships. However, it is a list of the most common naval vessels seen in this area.

## COMMON NAVAL WARSHIP DESIGNATORS

### AIRCRAFT CARRIERS

CV	Aircraft Carrier
CVN	Aircraft Carrier, Nuclear Powered

### AMPHIBIOUS

LHA	AMPHIBIOUS ASSAULT SHIP (GENERAL PURPOSE)
LHD	AMPHIBIOUS ASSAULT SHIP (MULTI-PURPOSE)
LCC	Amphibious Command Ship
LPD	Amphibious Transport Dock Ship
LSD	Dock Landing Ship

### GUIDED MISSILE CRUISER

CG	Guided Missile Cruiser
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### DESTROYERS, ESCORTS AND FRIGATES

DDG	Guided Missile Destroyer
EDD	Destroyer, Self-Defense Test Ship (after 2005)
FFG	Guided Missile Frigate

### LITTORAL WARFARE SHIPS

FSF	Fast Sea Frame
LCS	Littoral Combat Ship (after 2004)
PC	Coastal Patrol Craft/Submarine Chaser (173 ft)

### MINE WARFARE SHIPS

MCM	Mine Countermeasures Ship
MHC	Coastal Minehunter

## **AUXILIARY SHIPS**

AFDL	Small Floating Drydock
AKE	Dry Cargo Ship
APL	Floating Barracks
ARDM	Medium Repair Dock
AS	Submarine Tender

## **SUPPORT CRAFT**

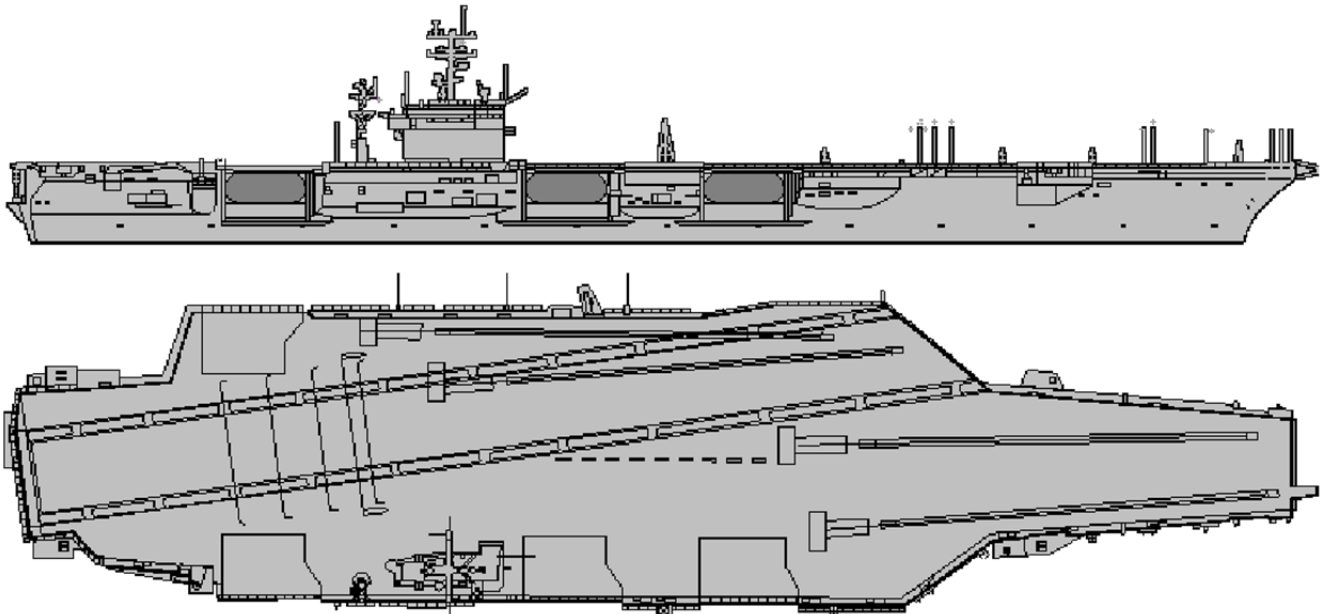
DSRV	Deep Submergence Rescue Vehicle
DSV	Deep Submergence Vehicle
IX	Unclassified Miscellaneous
NR	Nuclear Powered Research Submersible
DSRV	Deep Submergence Rescue Vehicle
DSV	Deep Submergence Vehicle
IX	Unclassified Miscellaneous
NR	Nuclear Powered Research Submersible
YLC	Salvage Lift Craft
YNG	Gate Craft
YOGN	Gasoline Barge
YON	Oil Barge
YOS	Oil Storage Barge
YP	Seamanship Training Craft
YR	Repair Barge
YRB	Repair and Berthing Barge
YRBM	Repair, Berthing, and Messing Barge
YRDH	Hull Repair Barge
YRDM	Machinery Repair Barge
YTB	Large Tug
YTL	Small Tug
YTT	Torpedo Trials Craft
YWN	Water Barge

## **SUBMARINES**

AGSS	Auxiliary/Experimental Submarine
SSBN	Submarine, Ballistic Missile, Nuclear Powered
SSGN	Attack Submarine, Guided Missile, Nuclear Powered
SSN	Attack Submarine, Nuclear Powered
SSN 688	Attack Submarine, Nuclear Powered – LOS ANGELES CLASS
SSN 774	Attack Submarine, Nuclear Powered – VIRGINIA CLASS
SSN 21	Attack Submarine, Nuclear Powered – SEAWOLF CLASS

# AIRCRAFT CARRIER – CVN / CV

Since World War II, the U.S. Navy's carriers have been the national force of choice. In over 80% of the times when the World was faced with international violence, the United States has responded with one or more carrier task forces. Over the past 25 years, requirements for USN carrier forces to be on station to respond to a crisis have increased.



**NIMITZ CLASS**

## Description

Aircraft carriers provide a wide range of possible response for the National Command Authority.

## Features

The aircraft carrier continues to be the centerpiece of the forces necessary for forward presence. Whenever there has been a crisis, the first question has been: "Where are the carriers?" Carriers support and operate aircraft that engage in attacks on airborne, afloat, and ashore targets that threaten free use of the sea; and engage in sustained operations in support of other forces.

Aircraft carriers are deployed worldwide in support of U.S. interests and commitments. They can respond to global crises in ways ranging from peacetime presence to full-scale war. Together with their on-board air wings, the carriers have vital roles across the full spectrum of conflict.

The *Nimitz*-class carriers, eight operational and two under construction, are the largest

warships in the world. *USS Nimitz* (CVN 68) was the first to undergo its initial refueling during a 33-month Refueling Complex Overhaul at Newport News Shipbuilding in Newport News, Va., in 1998. The next generation of carrier, CVN 21, the hull number will be CVN 78, is programmed to start construction in 2007 and is slated to be placed in commission in 2014 to replace *USS Enterprise* (CVN 65 which will be over its 50-year mark. CVN 79 is programmed to begin construction in 2012 and to be placed in commission in 2018.

## **Background**

The Carrier Mission is:

- To provide a credible, sustainable, independent forward presence and conventional deterrence in peacetime,
- To operate as the cornerstone of joint/allied maritime expeditionary forces in times of crisis, and
- To operate and support aircraft attacks on enemies, protect friendly forces and engage in sustained independent operations in war.

## **General Characteristics, *Nimitz* Class**

**Builder:** Newport News Shipbuilding Co., Newport News, VA.

**Date Deployed:** May 3, 1975 (*USS Nimitz*).

**Unit Cost:** About \$4.5 billion each.

**Propulsion:** Two nuclear reactors, four shafts.

**Length:** 1,092 feet (332.85 meters).

**Beam:** 134 feet (40.84 meters); Flight Deck Width: 252 feet (76.8 meters).

**Displacement:** Approximately 97,000 tons (87,996.9 metric tons) full load.

**Speed:** 30+ knots (34.5+ miles per hour).

**Crew:** Ship's Company: 3,200 - Air Wing: 2,480.

**Armament:** Two or three (depending on modification) NATO *Sea Sparrow* launchers, 20mm *Phalanx* CIWS mounts: (3 on *Nimitz* and *Dwight D. Eisenhower* and 4 on *Vinson* and later ships of the class.).

**Aircraft:** 85.

## **General Characteristics, *Enterprise* Class**

**Builder:** Newport News Shipbuilding Co., Newport News, VA.

**Date Deployed:** November 25, 1961 (*USS Enterprise*).

**Propulsion:** Eight nuclear reactors, four shafts.

**Length:** 1,101 feet 2 inches (335.64 meters).

**Beam:** 133 feet (39.9 meters); 252 feet (75.6 meters).

**Displacement:** 89,600 tons ( 81,283.8 metric tons) full load.

**Speed:** 30+ knots (34.5 miles per hour).

**Crew:** Ship's Company: 3,350 - Air Wing 2,480.

**Armament:** Two *Sea Sparrow* missile launchers, three *Phalanx* 20 mm CIWS mounts.

**Aircraft:** 85.



**General Characteristics, *John F. Kennedy Class***

**Builder:** Newport News Shipbuilding, Newport News, VA.

**Date Deployed:** September 7, 1968.

**Propulsion:** Eight boilers, four shafts, 280,000 total shaft horsepower.

**Length:** 1052 feet (315.6 meters).

**Beam:** 130 feet (39.6 meters); Flight Deck Width: 252 feet (76.8 meters).

**Displacement:** 82,000 tons (74,389.1 metric tons) full load.

**Speed:** 30+ knots (34.5 miles per hour).

**Crew:** Ship's Company: 3,117 - Air Wing 2,480.

**Armament:** Sea Sparrow missiles with box launchers, Three 20mm Phalanx CIWS.

**Aircraft:** Approximately 85.

**General Characteristics, *Kitty Hawk Class***

**Builder:** New York Ship Building Corp., Camden, NJ.

**Date Deployed:** April 29, 1961 (USS Kitty Hawk).

**Propulsion:** Eight boilers, four geared steam turbines, four shafts, 280,000 shaft horsepower.

**Length:** 1062.5 feet (323.8 meters).

**Beam:** 130 feet (39 meters); Flight Deck Width: 252 feet (76.8 meters).

**Displacement:** Approx. 80,800 tons (73,300.5 metric tons) full load.

**Speed:** 30+ knots (34.5+ miles per hour).

**Crew:** Ship's Company: 3,150 - Air Wing: 2,480.

**Armament:** Sea Sparrow launchers, 3 20mm Phalanx CIWS mounts.

**Aircraft:** 85.

# AMPHIBIOUS ASSAULT SHIPS - LHA/LHD/LHA(R)



USS IWO JIMA (LHD-7)

## Description

The largest of all amphibious warfare ships; resembles a small aircraft carrier; capable of Vertical/Short Take Off and Landing (V/STOL), Short Take Off Vertical Landing (STOVL), Vertical Take Off and Landing (VTOL) tilt-rotor and Rotary Wing (RW) aircraft operations; contains a well-deck to support use of Landing Craft Air Cushion (LCAC) and other watercraft.

## Features

Modern U.S. Navy Amphibious Assault Ships project power and maintain presence by serving as the cornerstone of the Amphibious Readiness Group (ARG) / Expeditionary Strike Group (ESG). A key element of the Seapower 21 pillars of Sea Strike and Sea Basing, these ships transport and land elements of the Marine Expeditionary Brigade (MEB) with a combination of aircraft and landing craft.

The *Tarawa*-class LHA provides the Marine Corps with a superb means of ship-to-shore movement by helicopter in addition to movement by landing craft. Three LHAs—which have extensive storage capacity and can accommodate both LCUs and LCACs—were unusually active during *Operations Desert Shield/Storm*. Since that time, LHAs (and, later, LHDs) have been participants in major humanitarian-assistance, occupation, and combat operations in which the United States has been involved. Such operations have included providing support to NATO forces engaged in keeping the peace in Bosnia, taking part in

rescue operations in the offshore waters of African countries ravaged by civil war, and in Kosovo in 1999, and participating in *Operation Enduring Freedom* in the Arabian Sea and the Gulf of Oman in 2001 and 2002. Also, during 2000, *USS Essex* (LHD 2) swapped forward-deployed naval force assignments with *USS Belleau Wood* (LHA 3) as the “big-deck” amphibious ship in Sasebo, Japan. *USS Iwo Jima* (LHD 7) was commissioned in June 2001, and had her first deployment in 2003.

In April 2002 a construction contract was awarded for LHD 8 (Makin Island) with contract delivery to the Navy scheduled no later than 31 July 2007. In 2003, the majority of the amphibious assault ships participated in *Operation Iraqi Freedom*, conducting concurrent Well Deck and Flight Deck operations as an integral part of the multi-national forces operations. In 2003, *USS Peleliu* (LHA 5) deployed as centerpiece of an Expeditionary Strike Group (ESG), introducing a new concept of operations, replacing the Amphibious Ready Groups (ARGs). With delivery of LHD 7, the Navy and Marine Corps has a flexible force of ships—LHAs/LHDs, LPDs, and LSD 41/49s—that can provide 12 fully capable Expeditionary Strike Group forces to fulfill anticipated Marine Corps Lift and forward-presence requirements. The amphibious capability of the fleet will be improved with construction of LHD 8 and the replacement of the *Austin*-class LPDs by *San Antonio*-class LPDs.

## Background

Amphibious warships are designed to support the Marine Corps tenets of Operational Maneuver From the Sea (OMFTS) and Ship to Objective Maneuver (STOM). They must be able to sail in harm’s way and provide a rapid buildup of combat power ashore in the face of opposition. Because of their inherent capabilities, these ships have been and will continue to be called upon to also support humanitarian and other contingency missions on short notice. The United States maintains the largest and most capable amphibious force in the world. The WASP-class are currently the largest amphibious ships in the world. The lead ship, *USS Wasp* (LHD 1) was commissioned in July 1989 in Norfolk, Va. LHA Replacement or LHA(R) is the next step in the incremental development of the “Big Deck Amphib”. She is being designed to accommodate the Marine Corps’ future Air Combat Element (ACE) including F-35B Joint Strike Fighter (JSF) and MV-22 *Osprey*, provide additional vehicle and cargo stowage capacities and enable a broader, more flexible Command and Control capability.

## Program Status

LHDs 1-7 are in-service. LHD 8 is under construction and expected to deliver in July 2007. LHAR program is in the early stages. The lead LHAR is planned for delivery to the Fleet in 2013.

## General Characteristics, LHA(R) Class

**Builder:** TBD (currently undergoing functional design).

**Date Deployed:** Scheduled for delivery to the fleet in 2013.

**Propulsion:** Two marine gas turbines, two shafts, 70,000 total brake horsepower.

**Length:** 921 feet (280.7 meters).

**Beam:** 116 feet (35.4 meters).

**Displacement:** Approximately 50,100 long tons (50,905 metric tons) full load.

**Speed:** 20+ knots.

**Aircraft:** A mix of: F-35B Joint Strike Fighters (JSF) STOVL aircraft; MV-22 *Osprey* VTOL tiltrotors; CH-53E *Sea Stallion* helicopters; UH-1Y *Huey* helicopters; AH-1Z *Super Cobra* helicopters; MH-60S *Seahawk* helicopters.

### **General Characteristics, *Wasp* Class - LHD**

**Builder:** Northrop Grumman Ship Systems Ingalls Operations, Pascagoula, MS.

**Date Deployed:** July 29, 1989 (*USS Wasp*)

**Propulsion:** (LHDs 1–7) two boilers, two geared steam turbines, two shafts, 70,000 total shaft horsepower; (LHD 8) two gas turbines, two shafts; 70,000 total shaft horsepower, two 5,000 horsepower auxiliary propulsion motors.

**Length:** 844 feet (253.2 meters).

**Beam:** 106 feet (31.8 meters).

**Displacement:** LHDs 1-4: 40,650 tons full load (41,302.3 metric tons)

LHDs 5-7: 40,358 tons full load (41,005.6 metric tons)

LHD 8: 41,772 tons full load (42,442.3 metric tons).

**Speed:** 20+ knots (23.5+ miles per hour).

**Crew:** Ships Company: 104 officers, 1,004 enlisted  
Marine Detachment: 1,894.

**Armament:** Two RAM launchers; two NATO *Sea Sparrow* launchers; three 20mm *Phalanx* CIWS mounts (two on LHD 5-7); four .50 cal. machine guns; four 25 mm Mk 38 machine guns (LHD 5-7 have three 25 mm Mk 38 machine guns).

**Aircraft:** 12 CH-46 *Sea Knight* helicopters; 4 CH-53E *Sea Stallion* helicopters; 6 AV-8B *Harrier* attack aircraft; 3 UH-1N *Huey* helicopters; 4 AH-1W *Super Cobra* helicopters. (planned capability to embark MV-22 *Osprey* VTOL tilt-rotors).

### **General Characteristics, *Tarawa* Class - LHA**

**Builder:** Ingalls Shipbuilding, Pascagoula, MS.

**Date Deployed:** May 29, 1976 (*USS Tarawa*)

**Propulsion:** Two boilers, two geared steam turbines, two shafts, 70,000 total shaft horsepower.

**Length:** 820 feet (249.9 meters).

**Beam:** 106 feet (31.8 meters).

**Displacement:** 39,400 tons (40,032 metric tons) full load.

**Speed:** 24 knots (27.6 miles per hour).

**Crew:** Ships Company: 82 officers, 882 enlisted  
Marine Detachment 1,900 plus.

**Armament:** Two RAM launchers; two *Phalanx* 20 mm CIWS mount; three .50 cal. machine guns; four 25 mm Mk 38 machine guns.

**Aircraft:** 12 CH-46 *Sea Knight* helicopters; 4 CH-53E *Sea Stallion* helicopters; 6 AV-8B *Harrier* attack aircraft; 3 UH-1N *Huey* helicopters; 4 AH-1W *Super Cobra* helicopters.

## CRUISERS - CG



***USS Port Royal (CG 73)***

### **Description**

Large combat vessel with multiple target response capability.

### **Features**

Modern U.S. Navy guided missile cruisers perform primarily in a Battle Force role. These ships are multi-mission [Air Warfare (AW), Undersea Warfare (USW), and Surface Warfare (SUW)] surface combatants capable of supporting carrier battle groups, amphibious forces, or of operating independently and as flagships of surface action groups. Cruisers are equipped with *Tomahawk* cruise missiles giving them additional long range strike mission capability.

### **Background**

Technological advances in the Standard Missile coupled with the AEGIS combat system in the *Ticonderoga* class cruisers have increased the AAW capability of surface combatants to pinpoint accuracy from wave-top to zenith. The addition of *Tomahawk* in the CG-47 has vastly complicated unit target planning for any potential enemy and returned an offensive strike role to the surface forces that seemed to have been lost to air power at Pearl Harbor.

The lead ship of the class, *USS Ticonderoga* (CG 47) was decommissioned on 30

September 2004.

**General Characteristics, *Ticonderoga* Class**

**Builder:** Ingalls Shipbuilding: CG 47-50, CG 52-57, 59, 62, 65-66, 68-69, 71-73

Bath Iron Works: CG 51, 58, 60-61, 63-64, 67, 70.

**Date Deployed:** 22 January 1983 (*USS Ticonderoga*)

**Unit Cost:** About \$1 billion each.

**Propulsion:** 4 General Electric LM 2500 gas turbine engines; 2 shafts, 80,000 shaft horsepower total.

**Length:** 567 feet.

**Beam:** 55 feet.

**Displacement:** 9,600 tons (9,754.06 metric tons) full load.

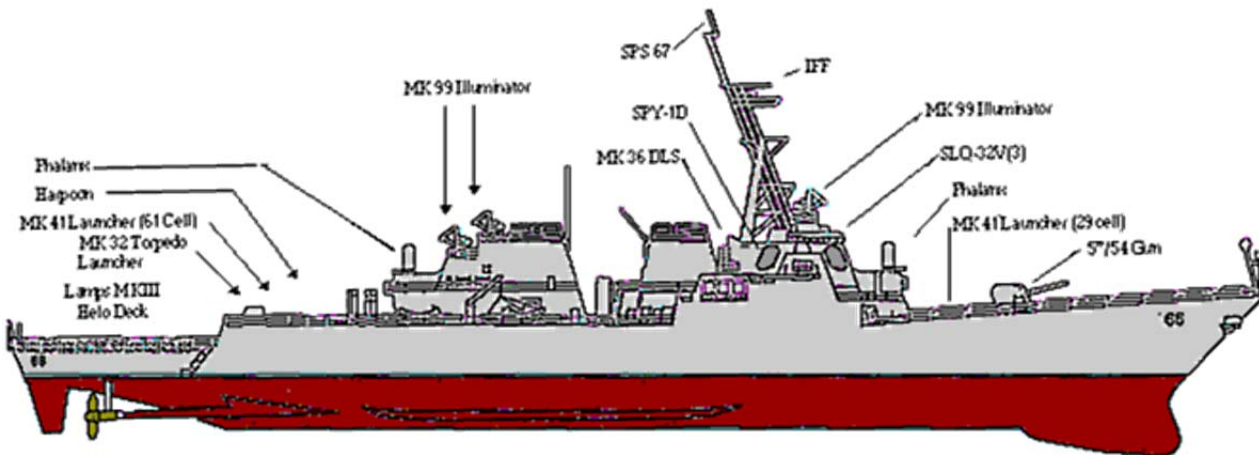
**Speed:** 30 plus knots.

**Crew:** 24 Officers, 340 Enlisted.

**Armament:** MK26 missile launcher (CG 47 thru CG 51) Standard Missile (MR) or MK41 vertical launching system (CG 52 thru CG 73) Standard Missile (MR); Vertical Launch ASROC (VLA) Missile; Tomahawk Cruise Missile; Six MK-46 torpedoes (from two triple mounts); Two MK 45 5-inch/54 caliber lightweight guns; Two Phalanx close-in-weapons systems.

**Aircraft:** Two SH-2 *Seasprite* (LAMPS) in CG 47-48; Two SH-60 *Sea Hawk* (LAMPS III).

# DESTROYERS - DDG



**USS Arleigh Burke (DDG 51)**

## Description

These fast warships provide multi-mission offensive and defensive capabilities, and can operate independently or as part of carrier battle groups, surface action groups, amphibious ready groups, and underway replenishment groups.

## Features

Destroyers and guided missile destroyers operate in support of carrier battle groups, surface action groups, amphibious groups and replenishment groups. Destroyers primarily perform anti-submarine warfare duty while guided missile destroyers are multi-mission [Anti-Air Warfare (AAW), Anti-Submarine Warfare (ASW), and Anti-Surface Warfare (ASUW)] surface combatants. The addition of the Mk-41 Vertical Launch System or *Tomahawk* Armored Box Launchers (ABLs) to many *Spruance*-class destroyers has greatly expanded the role of the destroyer in strike warfare.

## Background

Technological advances have improved the capability of modern destroyers culminating in the *Arleigh Burke* (DDG 51) class. Named for the Navy's most famous destroyer squadron combat commander and three-time Chief of Naval Operations, the *Arleigh Burke* was commissioned July 4, 1991, and was the most powerful surface combatant ever put to sea. Like the larger *Ticonderoga*-class cruisers, DDG 51's combat systems center around the *Aegis* combat system and the *SPY-ID*, multi-function phased array radar. The combination of *Aegis*, the *Vertical Launching System*, an advanced anti-submarine warfare system, advanced anti-aircraft missiles and *Tomahawk*, the *Burke*-class continues the revolution at sea.

The DDG 51 class incorporates all-steel construction. In 1975, the cruiser *USS Belknap* (CG 26) collided with *USS John F. Kennedy* (CV 67). *Belknap* suffered severe damage

*and casualties because of her aluminum superstructure. On the basis of that event, the decision was made that all future surface combatants would return to a steel superstructure. And, like most modern U.S. surface combatants, DDG 51 utilizes gas turbine propulsion. These ships replaced the older Charles F. Adams and Farragut-class guided missile destroyers.*

**General Characteristics, Arleigh Burke class**

**Builder:** Bath Iron Works, Ingalls Shipbuilding.

**SPY-1 Radar and Combat System Integrator:** Lockheed Martin

**Date Deployed:** July 4, 1991 (*USS Arleigh Burke*)

**Propulsion:** Four General Electric LM 2500-30 gas turbines; two shafts, 100,000 total shaft horsepower.

**Length:** Flights I and II (DDG 51-78): 505 feet (153.92 meters)

Flight IIA (DDG 79-98): 509½ feet (155.29 meters).

**Beam:** 59 feet (18 meters).

**Displacement:** Hulls 51 through 71: 8,315 tons (8,448.04 metric tons) full load

Hulls 72 through 78: 8,400 tons (8,534.4 metric tons) full load

Hulls 79 and on: 9,200 tons (9,347.2 metric tons) full load.

**Speed:** in excess of 30 knots.

**Crew:** 23 officers, 300 enlisted.

**Armament:** Standard missile; Harpoon; Vertical Launch ASROC (VLA) missiles; Tomahawk®; six Mk-46 torpedoes (from two triple tube mounts); one 5

**Aircraft:** LAMPS III electronics installed on landing deck for coordinated DDG 51/helo ASW operations (DDG 51-78). Two SH-60 Seahawk LAMPS III helicopters (DDG 79-105)



## FRIGATES - FFG



**USS Ingraham along USS Sacramento & USS Carl Vinson**

### **Description**

Frigates fulfill a Protection of Shipping (POS) mission as Anti-Submarine Warfare (ASW) combatants for amphibious expeditionary forces, underway replenishment groups and merchant convoys.

### **Background**

The guided missile frigates (FFG) bring an anti-air warfare (AAW) capability to the frigate mission, but they have some limitations. Designed as cost efficient surface combatants, they lack the multi-mission capability necessary for modern surface combatants faced with multiple, high-technology threats. They also offer limited capacity for growth. Despite this, the FFG 7 class is a robust platform, capable of withstanding considerable damage. This "toughness" was aptly demonstrated when *USS Samuel B. Roberts* struck a mine and *USS Stark* was hit by two *Exocet* cruise missiles. In both cases the ships survived, were repaired and returned to the fleet. *USS Stark* was decommissioned in May 1999.

The Surface Combatant Force Requirement Study does not define any need for a single mission ship such as the frigate and there are no frigates planned in the Navy's five-year shipbuilding plan.

### **Point Of Contact**

Public Affairs Office  
Naval Sea Systems Command  
Washington, D.C. 20362

### **General Characteristics, *Oliver Hazard Perry* Class**

**Builder:** Bath Iron Works: FFG 8, 11, 13, 15, 29, 32, 36, 39, 42, 45, 47, 49, 50, 53, 55, 56, 58, 59

Todd Shipyards, Seattle: FFG 28, 31, 37, 40, 48, 52

Todd Shipyards, San Pedro, Calif.: FFG 9, 12, 14, 19, 23, 30, 33, 38, 41, 43, 46, 51, 54, 57, 60, 61.

**Date Deployed:** 17 December 1977 (*Oliver Hazard Perry*)

**Propulsion:** Two General Electric LM 2500 gas turbine engines; 1 shaft, 41,000 shaft horsepower total.

**Length:** 445 feet (133.5 meters); 453 feet (135.9 meters) with LAMPS III modification.

**Beam:** 45 feet (13.5 meters).

**Displacement:** 4,100 tons (4,165.80 metric tons) full load.

**Speed:** 29 plus knots (33.4+ miles per hour).

**Crew:** 17 Officers, 198 Enlisted.

**Armament:** Standard Missile (MR); *Harpoon* (from Standard Missile Launcher); Six MK-46 torpedoes (from two triple mounts); One 76 mm (3-inch)/62 caliber MK 75 rapid fire gun; One *Phalanx* close-in-weapons system.

**Aircraft:** Two SH-60 (LAMPS III) in FFG 8, 28, 29, 32, 33, 36-61

One SH-2 (Lamps Mk-I) in FFG 9-19, 30, 31.

# ATTACK SUBMARINES - SSN



**USS Los Angeles**

## **Description**

Attack submarine, designed to seek and destroy enemy submarines and surface ships.

## **Background**

The concept of technical superiority over numerical superiority was and still is the driving force in American submarine development. A number of Third World countries are acquiring modern state-of-the-art non-nuclear submarines. Countering this threat is the primary mission of U.S. nuclear attack submarines.

Their other missions range from intelligence collection and special forces delivery to anti-ship and strike warfare. The Navy began construction of *Seawolf*-class submarines in 1989. *Seawolf* is designed to be exceptionally quiet, fast well-armed with advanced sensors. It is a multi-mission vessel, capable of deploying to forward ocean areas to search out and destroy enemy submarines and surface ships and to fire missiles in support of other forces.

The first of the class, *Seawolf* (SSN 21), completed its initial sea trials in July 1996. Attack submarines also carry the *Tomahawk* cruise missile. *Tomahawk* launches from attack submarines were successfully conducted during *Operation Desert Storm*.

In late 1998, the contract was let for building the first of the New Attack Submarine. This class, the *Virginia*-class fully embraces the new strategic concept in ... *From the Sea and Forward... From the Sea*. It is the first U.S. submarine to be designed for battlespace dominance across a broad spectrum of regional and littoral missions as well as open-ocean, 'blue water' missions. The *Virginia*-class achieves the right balance of core military capabilities and affordability.

The *Benjamin Franklin*-class were converted from Fleet Ballistic Missile submarines and carry drydeck shelters. They are equipped for special operations and support SEALs. The former missile spaces have been converted to accommodations, storage, and recreation spaces.

#### **General Characteristics, *Virginia* class**

**Builder:** General Dynamics Electric Boat Division and Northrop Grumman Newport News

**Date Deployed:** Commissioned 23 October 2004

**Propulsion:** One nuclear reactor, one shaft

**Length:** 377 feet (114.8 meters)

**Beam:** 34 feet (10.4 meters)

**Displacement:** Approximately 7,800 tons (7,925 metric tons) submerged

**Speed:** 25+ knots (28+ miles per hour, 46.3+ kph)

**Crew:** 134: 14 Officers; 120 Enlisted

**Armament:** *Tomahawk* missiles, twelve VLS tubes, MK-48 ADCAP torpedoes, four torpedo tubes.

#### **General Characteristics, *Seawolf* class**

**Builder:** General Dynamics Electric Boat Division.

**Date Deployed:** *USS Seawolf* commissioned 19 July 1997;

*USS Connecticut* commissioned 11 December 1998

*USS Jimmy Carter* commissioned 19 February 2005

**Propulsion:** One nuclear reactor, one shaft

**Length:** SSNs 21 and 22: 353 feet (107.6 meters)

SSN 23: 453 feet (138.07 meters)

**Beam:** 40 feet (12.2 meters)

**Displacement:** SSNs 21 and 22: 9,138 tons (9,284 metric tons) submerged;

SSN 23 12,158 tons (12,353 metric tons) submerged

**Speed:** 25+ knots (28+ miles per hour, 46.3+ kph)

**Crew:** 140: 14 Officers; 126 Enlisted

**Armament:** *Tomahawk* missiles, MK-48 torpedoes, eight torpedo tubes.

#### **General Characteristics, *Los Angeles* class**

**Builder:** Newport News Shipbuilding Co.; General Dynamics Electric Boat Division.

**Date Deployed:** November 13, 1976 (*USS Los Angeles*)

**Propulsion:** One nuclear reactor, one shaft

**Length:** 360 feet (109.73 meters)

**Beam:** 33 feet (10.06 meters)

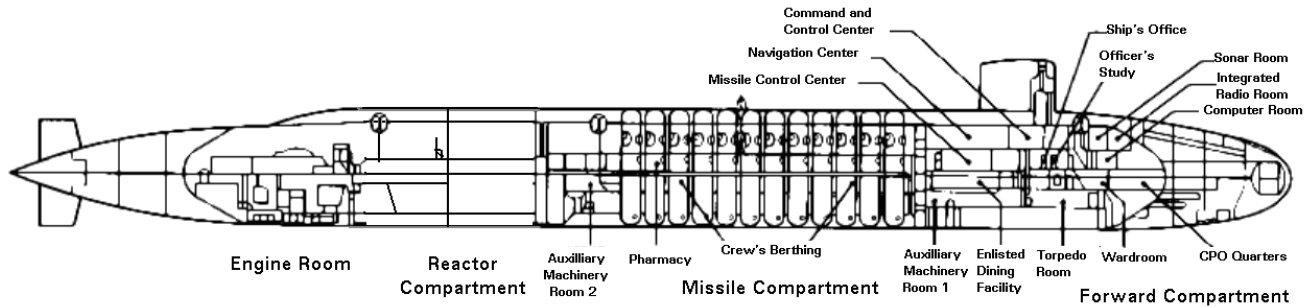
**Displacement:** Approximately 6,900 tons (7011 metric tons) submerged

**Speed:** 20+ knots (23+ miles per hour, 36.8 +kph)

**Crew:** 13 Officers; 121 Enlisted

**Armament:** *Tomahawk* missiles, VLS tubes (SSN 719 and later), MK-48 torpedoes, four torpedo tubes (*Seawolf* has 8).

# FLEET BALLISTIC MISSILE SUBMARINES - SSBN



**SSBN-726 Ohio Class FBM Submarine**

## Description

Nuclear-powered submarines armed with long-range strategic missiles.

## Features

The first eight *Ohio* class submarines (*Tridents*) were originally equipped with 24 *Trident* I C-4 ballistic missiles. Beginning with the ninth *Trident* submarine, *USS Tennessee* (SSBN 734), all new ships are equipped with the *Trident* II D-5 missile system as they are built, and the earlier ships are being retrofitted to *Trident* II. *Trident* II can deliver significantly more payload than *Trident* I C-4 and more accurately.

The *Ohio*-class submarines are specifically designed for extended deterrent patrols. To decrease the time in port for crew turnover and replenishment, three large logistics hatches are fitted to provide large diameter resupply and repair openings. These hatches allow sailors to rapidly transfer supply pallets, equipment replacement modules and machinery components, significantly reducing the time required for replenishment and maintenance. The class design and modern main concepts allow the submarines to operate for 15+ years between overhauls.

The first four *Ohio*-class submarines are scheduled for conversion over the next five years to guided missile submarines (SSGN) with an additional capability to transport and support Navy special operations forces.

## Background

Strategic deterrence has been the sole mission of the fleet ballistic missile submarine (SSBN) since its inception in 1960. The SSBN provides the nation's most survivable and enduring nuclear strike capability. The *Ohio*-class submarine replaced aging fleet ballistic missile submarines built in the 1960s and is far more capable.

*Ohio*-class/*Trident* ballistic missile submarines provide the sea-based "leg" of the triad of U.S. strategic deterrent forces. The 18 *Trident* SSBNs (each carrying 24 missiles), carry 50 percent of the total U.S. strategic warheads. Although the missiles have no pre-set targets when the submarine goes on patrol, the SSBNs are capable of rapidly targeting their missiles should the need arise, using secure and constant at-sea communications links.

## General Characteristics, *Ohio* Class

**Builder:** General Dynamics Electric Boat Division.

**Date Deployed:** November 11, 1981 (*USS Ohio*)

**Propulsion:** One nuclear reactor, one shaft.

**Length:** 560 feet (170.69 meters).

**Beam:** 42 feet (12.8 meters).

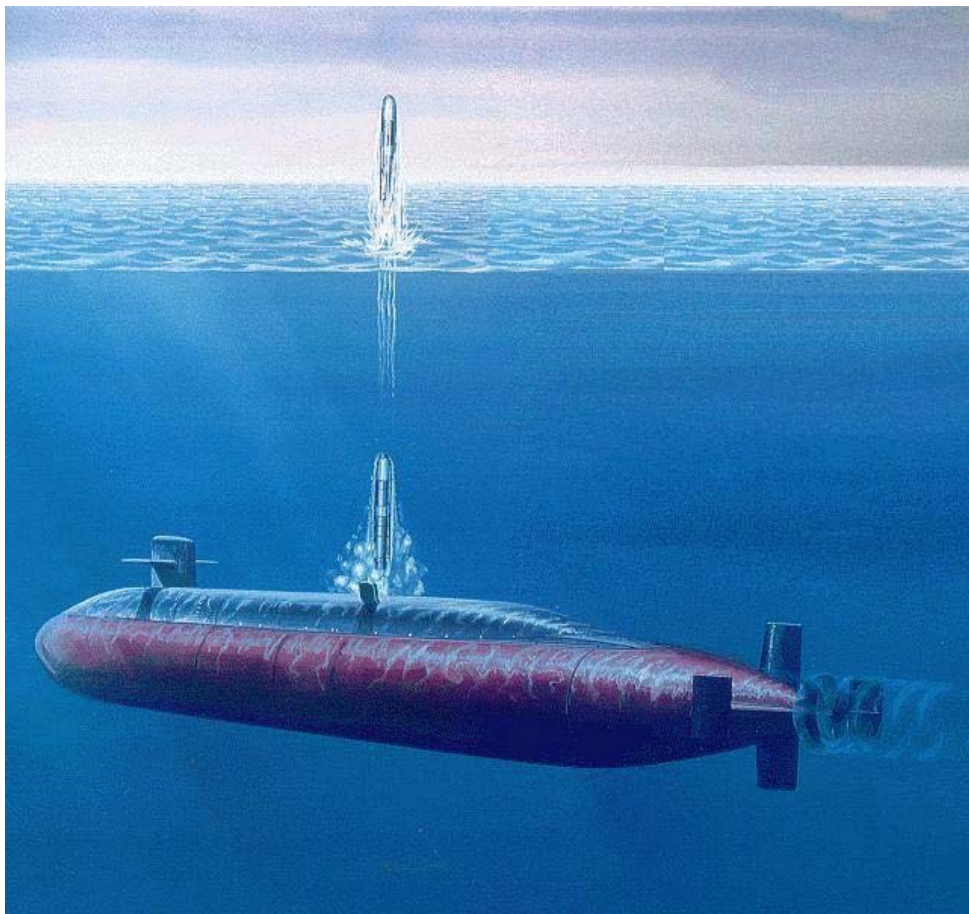
**Displacement:** 16,764 tons (17,033.03 metric tons) surfaced; 18,750 tons (19,000.1 metric tons) submerged.

**Speed:** 20+ knots (23+ miles per hour, 36.8+ kph).

**Crew:** 15 Officers, 140 Enlisted.

**Armament:** 24 tubes for *Trident* I and II, MK-48 torpedoes, four torpedo tubes.

## GUIDED MISSILE SUBMARINES - SSGN



### Description

Nuclear-powered submarines armed with tactical missiles and the ability to transport and support special operations forces.

### Background

Four Ohio-class Trident submarines that were previously scheduled for inactivation during Fiscal Years 2003 and 2004 are being converted to guided missile submarines (SSGN)

over a five-year period ending in 2007. The primary missions of the SSGN will be land attack and Special Operations Forces (SOF) insertion and support. Secondary missions will be the traditional attack submarine missions of intelligence, surveillance and reconnaissance (ISR), battle space preparation, and sea control.

These ships will be armed with up to 154 Tomahawk® or Tactical Tomahawk® land attack missiles. They will have the ability to carry and support a team of 66 SOF personnel for up to 90 days as compared to 15 days for a SOF outfitted fast attack submarine (SSN). Clandestine insertion and retrieval of these Special Operations Forces will be enhanced by the ability to host dual dry deck shelters and/or Advanced Seal Delivery System. Each SSGN will be able to conduct a variety of peace-time, conventional deterrent, and combat operations all within the same deployment.

USS Ohio (SSGN 726) entered the conversion yard on 15 November 2002. On 14 January 2003, USS Florida (SSGN 728) became the first Ohio-class submarine to launch a cruise missile. The launch was made from underwater in the Gulf of Mexico.

### **General Characteristics, *Ohio* Class**

**Builder:** General Dynamics Electric Boat Division.

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**Speed:** 20+ knots (23+ miles per hour, 36.8+ kph).

**Crew:** 15 Officers, 144 Enlisted.

**Armament:** Tomahawk missiles, MK 48 torpedoes; 4 torpedo tubes.

**This information is given for a broad overview of the types of naval warships. It is not meant to cover all types of ships. The information will change frequently as ships are commissioned and decommissioned.**

#### **Sources –**

**[www.navy.mil](http://www.navy.mil) – public website**

**<http://fas.org>**

## Other Types of Non-Naval Ships / Boats

### **TUGBOAT (Tug)**

Tug boats are used to maneuver, primarily by towing or pushing, other vessels in harbors, over the open sea or through rivers and canals. Tugboats are also used to tow barges, disabled ships, or other equipment like towboats.

### **CONTAINER SHIP**

Container ships are cargo ships that carry all of their load in truck-size containers, in a technique called containerization. They form a common means of commercial intermodal freight transport.



### **CARGO SHIP (Freighter)**

A cargo ship or freighter is any sort of ship or vessel that carries cargo, goods, and materials from one port to another. Thousands of cargo carriers ply the world's seas and oceans each year; they handle the bulk of international trade. Cargo ships are usually specially designed for the task, often being equipped with cranes and other mechanisms to load and unload, and come in all sizes. Today, they are almost always built of welded steel, and with some exceptions generally have a life expectancy of 25 to 30 years before being scrapped.



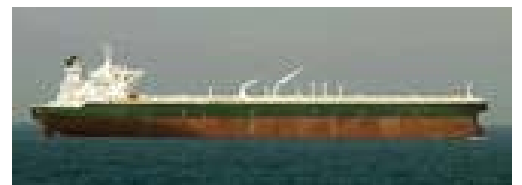
### **BULK CARRIER**

A bulk carrier, bulk freighter, or bulker is a merchant ship specially designed to transport unpackaged bulk cargo, such as grains, coal, ore, and cement in its cargo holds. Since the first specialized bulk carrier was built in 1852, economic forces have fueled the development of these ships, causing them to grow in size and sophistication. Today's bulkers are specially designed to maximize capacity, safety, efficiency, and to be able to withstand the rigors of their work. Today, bulkers make up 40% of the world's merchant fleets



### **TANKER**

A tanker is a ship designed to transport liquids in bulk. Petroleum tankers are a particular brand of tanker all their own. This type is sometimes referred to as a tankship.





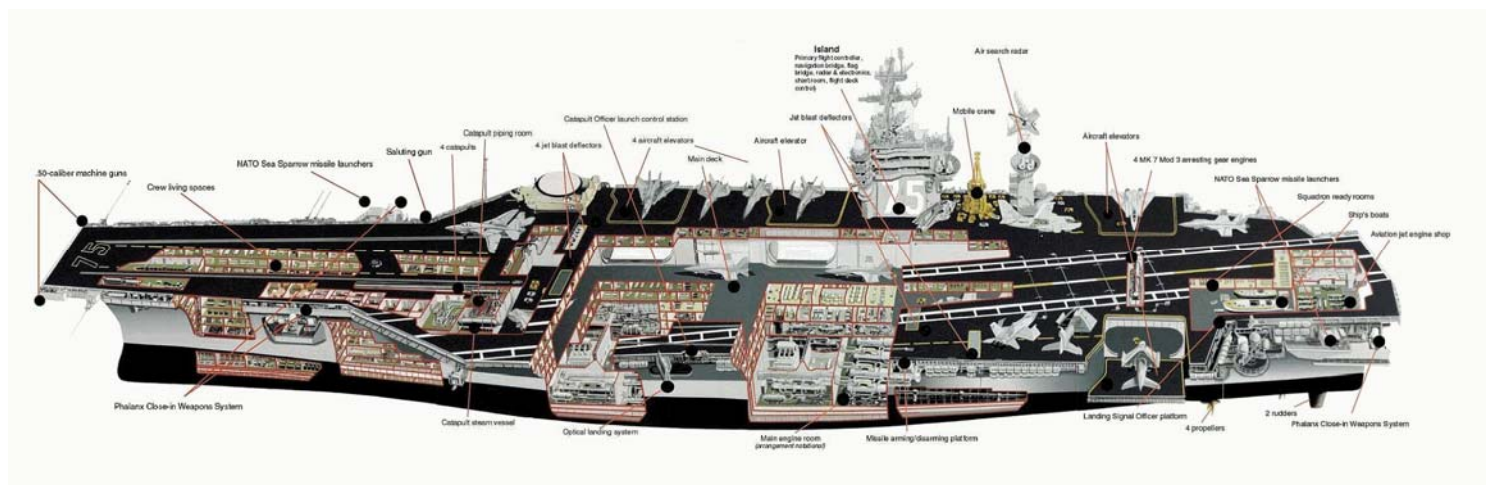
# SHIPS

# COMPARTMENTATION

## LESSON 3

While working onboard naval vessels, you will need to have a basic understanding of the nomenclature and be able to identify your location on the ship. Your location is broken down into several key points, which will be discussed.

This lesson should help you understand what that information represents and how to get around on a naval vessel.



Cutaway of a Nuclear Aircraft Carrier (CVN-71)

### A. Compartment Numbering

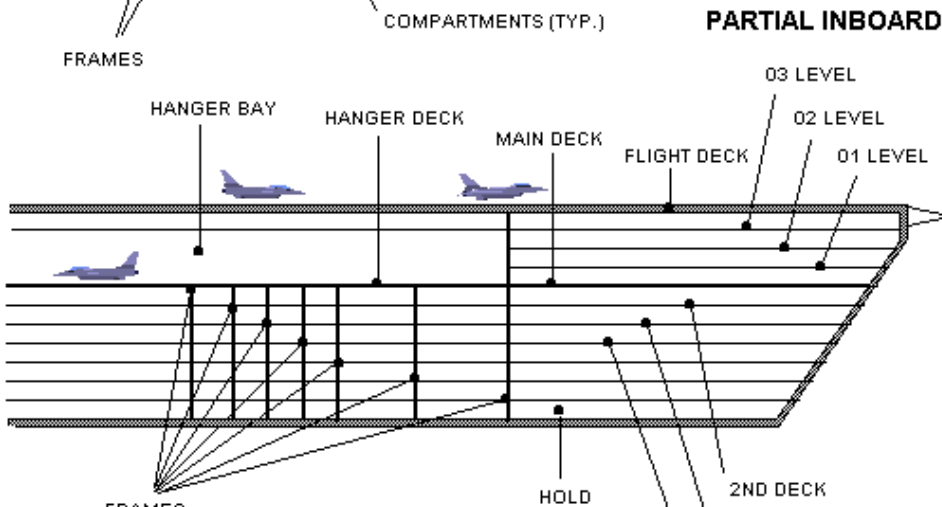
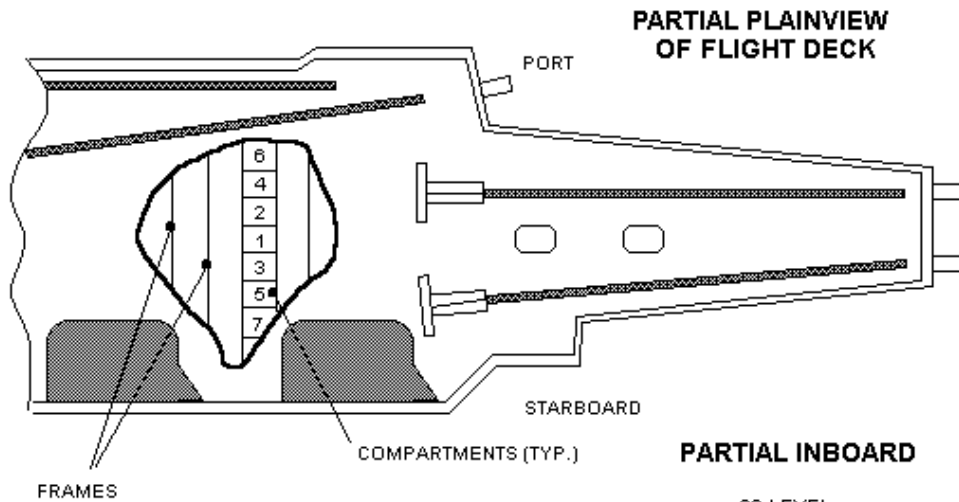
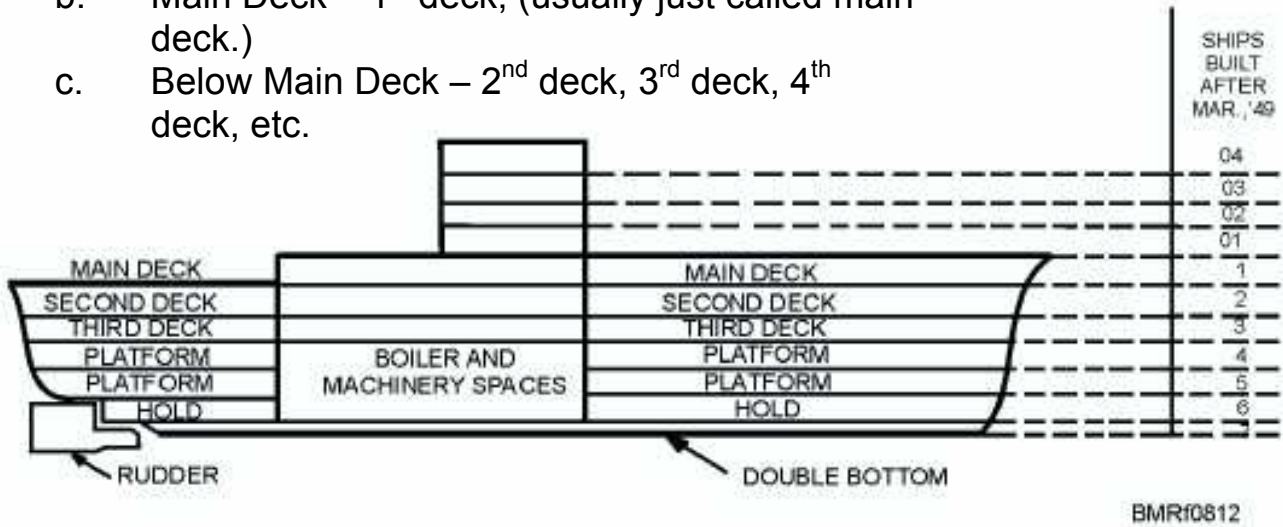
The compartment number is broken down into 4 key parts. Each part is critical to the identification of that space.

1. Deck/level Number
2. Frame Number
3. Relationship to Centerline of Ship
4. Compartment Usage

This information is explained below how each part of the compartment number interacts.

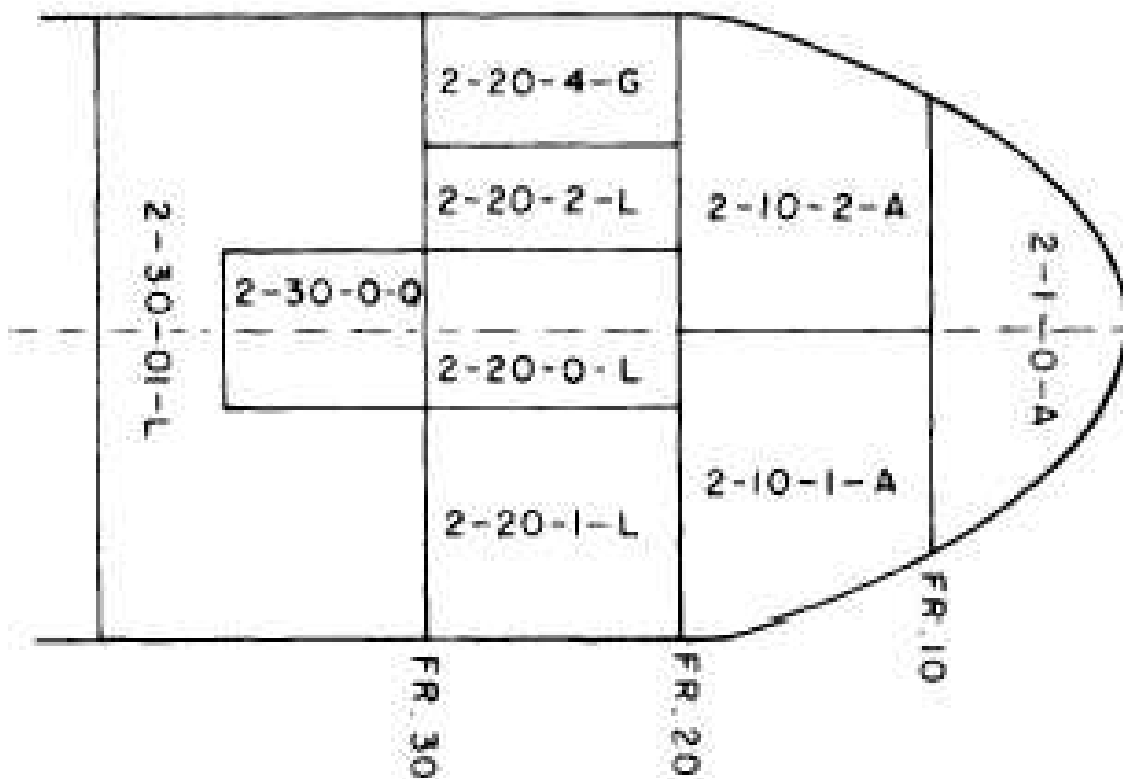
1. **Deck/level Number** – This number tells you how high up you are in relation to the Main Deck of the ship. The floor of a ship is called a deck or level. The main deck and below are called decks. Above the main deck is called a level. This is correct only if the deck is continuous across the length of the ship. If not, the deck is considered a platform.

- a. Above Main Deck – 01 level, 02 level, 03 level, etc.
- b. Main Deck – 1<sup>st</sup> deck, (usually just called main deck.)
- c. Below Main Deck – 2<sup>nd</sup> deck, 3<sup>rd</sup> deck, 4<sup>th</sup> deck, etc.



2. **Frame Number** – The frames are the transverse structural strength members of the ship. They are installed at set intervals to strengthen the hull of the ship. We number these frames starting at the forward perpendicular and use that to identify our location from forward to aft.

- a. Frame Number is the same as frame number of forward bulkhead of compartment.
- b. When bulkhead is located between two frames, compartment takes number of frame immediately aft of bulkhead.

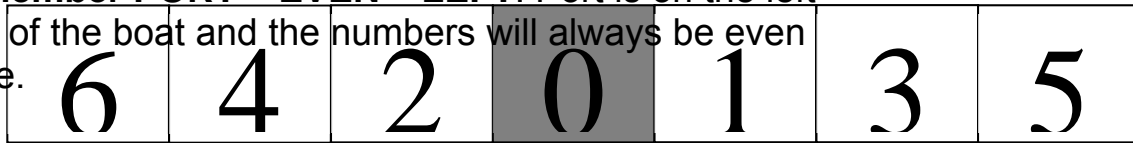


3. **Relationship to Centerline of Ship**

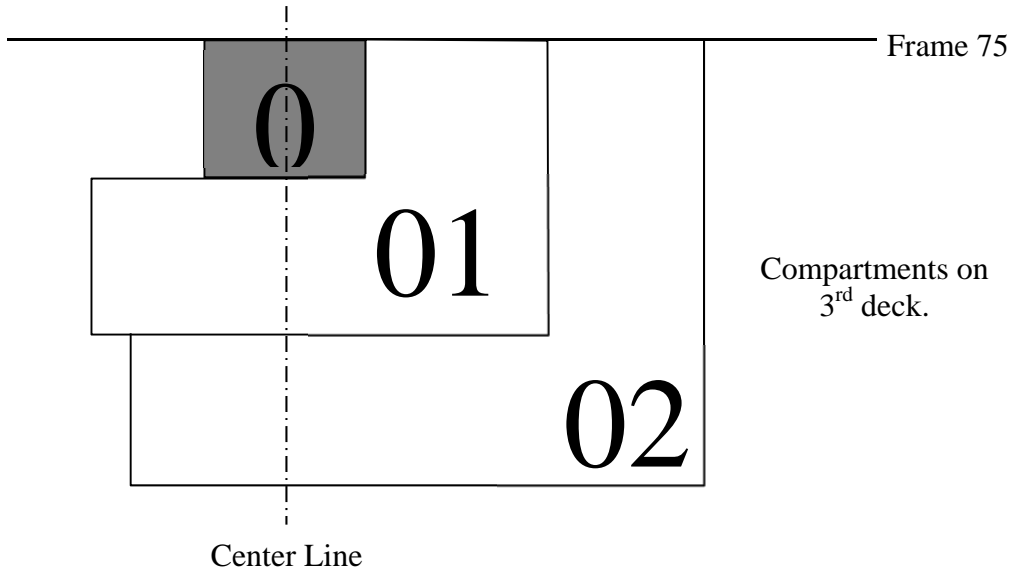
- a. Compartments with centerline running through them are numbered 0.
- b. Compartments located completely to starboard of centerline are given odd numbers.
- c. Compartments located completely to port of centerline are given even numbers.

- d. Where more than one compartment is located to starboard or port, the first compartment will be numbered 1, the second, 3, or the first, 2, and the second, 4. More compartments call for larger consecutive numbers.

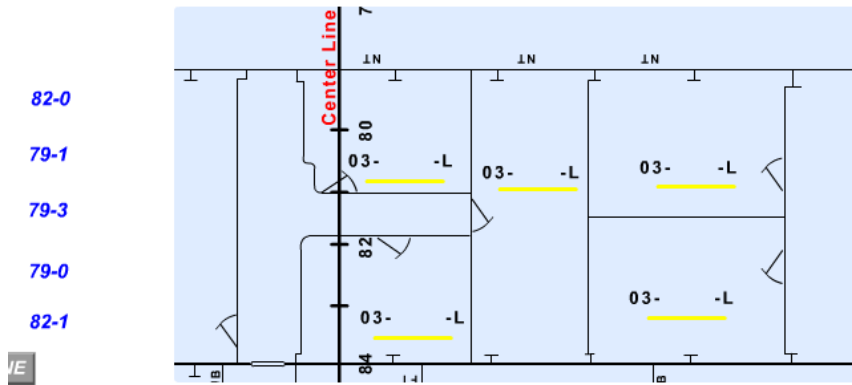
**Remember PORT – EVEN – LEFT.** Port is on the left side of the boat and the numbers will always be even there.



- e. Where more than one compartment with centerline passing partially through it shares the same deck and bulkhead number, the compartment with centerline passing through its forward bulkhead is 0. The other compartments are numbered 01, 02, 03, and so on.



Which compartment # completes each compartment?



#### 4. Compartment Usage Designation

The compartment number is finished off by a letter. This letter shows the general usage of that space. Below each letter is identified.

- A - Stowage spaces
- C- Vital ship and fire control spaces
- E - Machinery/Engineering spaces
- F - Fuel tanks
- G- Gasoline tanks
- K - Stowage space for chemicals and semi-safe and dangerous materials
- L - Living spaces; Quarters, Medical, and Dental
- M - Ammunition spaces
- Q - Spaces not fitting in other categories, misc. spaces, not manned
- T - Vertical access trunks
- V - Void compartments
- W - Water storage tanks

Note: Compartments or tanks whose contents are carried as cargo have a double letter designation such as AA, FF, GG, and so on.

#### B. Compartment Usage

The letter previously used gives a very generic usage such as a living space. However, the middle line of the compartment number tells exactly what the compartment is used for.

## C. Access Closures

The third line of a compartment number shows the location of the access closure (or the doorway). This information is helpful when multiple accesses are in a compartment or when the access is not readily located. Label plates for access closures shall be combined with compartment designation plates.

1. The first line of the inscription shall give the access closure number.
2. The second line is for the name of the compartment to which access is provided.
3. The third line is the compartment number.

### Example 1

**4-16-2**

**C.P.O. Storeroom**

**4-14-2-A**

#### A. First Line (4-16-2) is the access closure number.

4 - Access closure is on the 4th deck.

16 - Access is at frame 16.

2 - First access on port side off centerline at frame 16.

#### B. Second Line (C.P.O. Storeroom) is the name of the compartment.

Chief Petty Officers' storeroom.

#### C. Third Line (4-14-2-A) is the compartment number.

4 - The compartment has its base on the 4th deck.

14 - The forward most frame within the compartment is frame 14 or the forward bulkhead is frame 14.

2 - The first compartment on port side off centerline with forward most frame/bulkhead being frame 14.

A - Use of compartment is a storeroom.

**Example 2**  
**2-51-2**  
**C.P.O. Storeroom**  
**2-51-2-A**

Example 2 is similar to Example 1, except it is located on the 2nd deck and has its access located in the forward boundary of the compartment.

**Examples of Compartment Letters with type of Compartment**

**A - Stowage Spaces;**

Ex. - storerooms, issue rooms, refrigeration compartments.

**AA - Cargo holds;**

Ex. - cargo holds and cargo refrigeration compartments.

**C - Control centers for vital ships and fire control operations**

(normally manned);

Ex. - plotting rooms, communication centers such as radio, radar, and sonar operating spaces such as the pilot house.

**E - Engineering/Machinery control centers**

(normally manned);

Ex. - main propulsion spaces, boiler rooms, pump rooms, generator rooms, switchboard rooms, steering gear rooms.

**F - Oil stowage compartments/Fuel tanks (for use by ship);**

Ex. - fuel-oil, diesel-oil, lubricating-oil.

**FF - Oil stowage compartments (cargo);**

Ex. - compartments carrying various types of oil as cargo.

**G - Gasoline stowage compartments (used by ship);**

Ex. - gasoline tanks, cofferdams, trunks, and pump rooms.



**GG - Gasoline stowage compartments** (cargo);  
Ex. - gasoline compartments for carrying gasoline as cargo.

**K - Chemicals and dangerous materials**  
(other than oil and gasoline).  
Ex. - chemicals, semi-safe materials, and dangerous materials carried for ship's use or as cargo.

**L - Living spaces;**  
Ex. - berthing spaces, staterooms, washrooms, heads, brigs, sickbays, hospital spaces, and passageways.

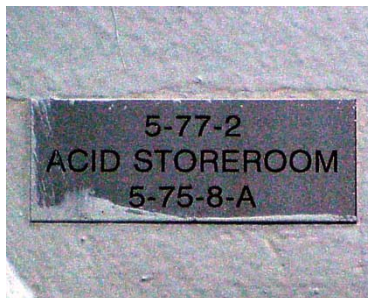
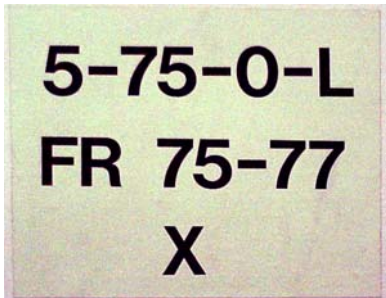
**M - Ammunition spaces;**  
Ex. - magazines, handling rooms, gun mounts, shell rooms, ready service rooms.

**Q - Miscellaneous spaces** not covered by other letters;  
Ex. – shops, offices, laundry, pantries, unmanned engineering, electrical, and electronic spaces.

**T - Vertical access trunks;**  
Ex. – escape trunks or tubes.

**V - Void compartments;**  
Ex. - cofferdam compartments (other than gasoline), void wing compartments, wiring trunks.

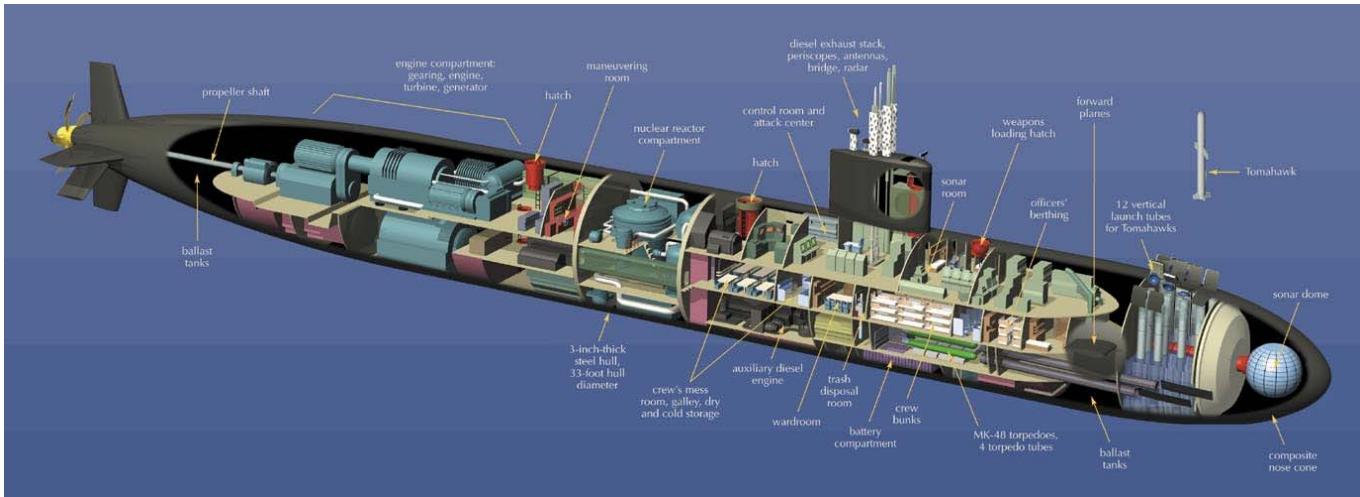
**W - Water compartments;**  
Ex. - drainage tanks, fresh water tanks, reserve feed tanks.



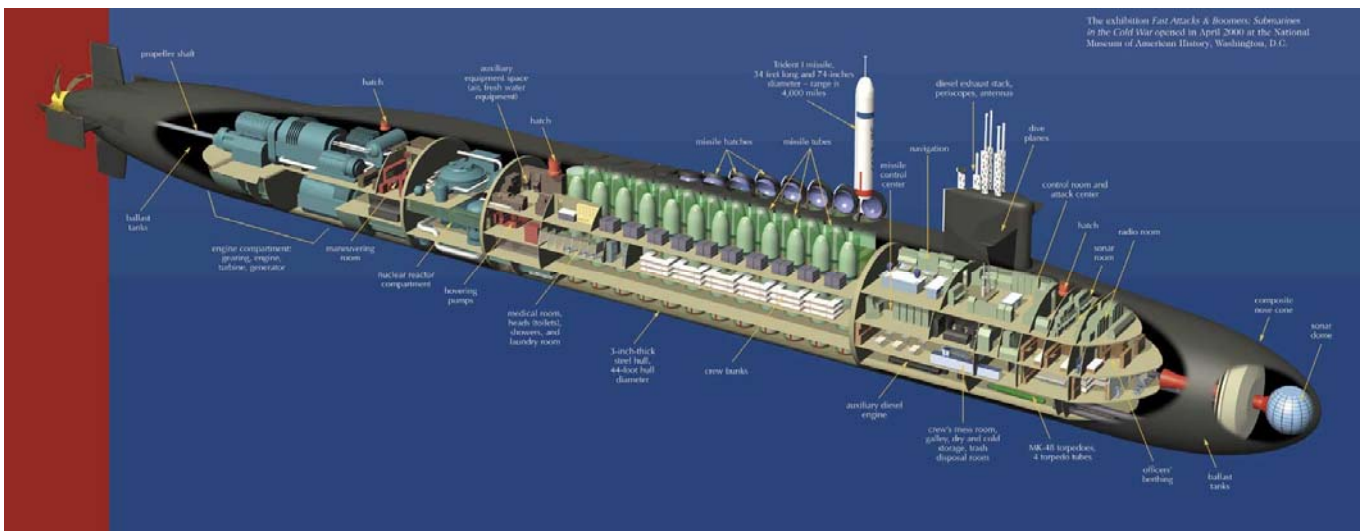
## Submarines:

The main difference in surface craft & submarines is that a submarine will have only 2-3 levels. On a 688 class submarine, the forward levels are called upper, mid & lower levels. Back aft, there are only upper & lower levels. Ohio class submarines have 4 decks instead of 2-3.

## Summary/Review



Cutaway of a Los Angeles Class (688) Submarine



Cutaway of an Ohio Class Submarine

# **BASIC SHIPS NOMENCLATURE FOR GENERAL TRADES**

## **LESSON 4**

# I. GENERAL TERMS

## 1. BOW

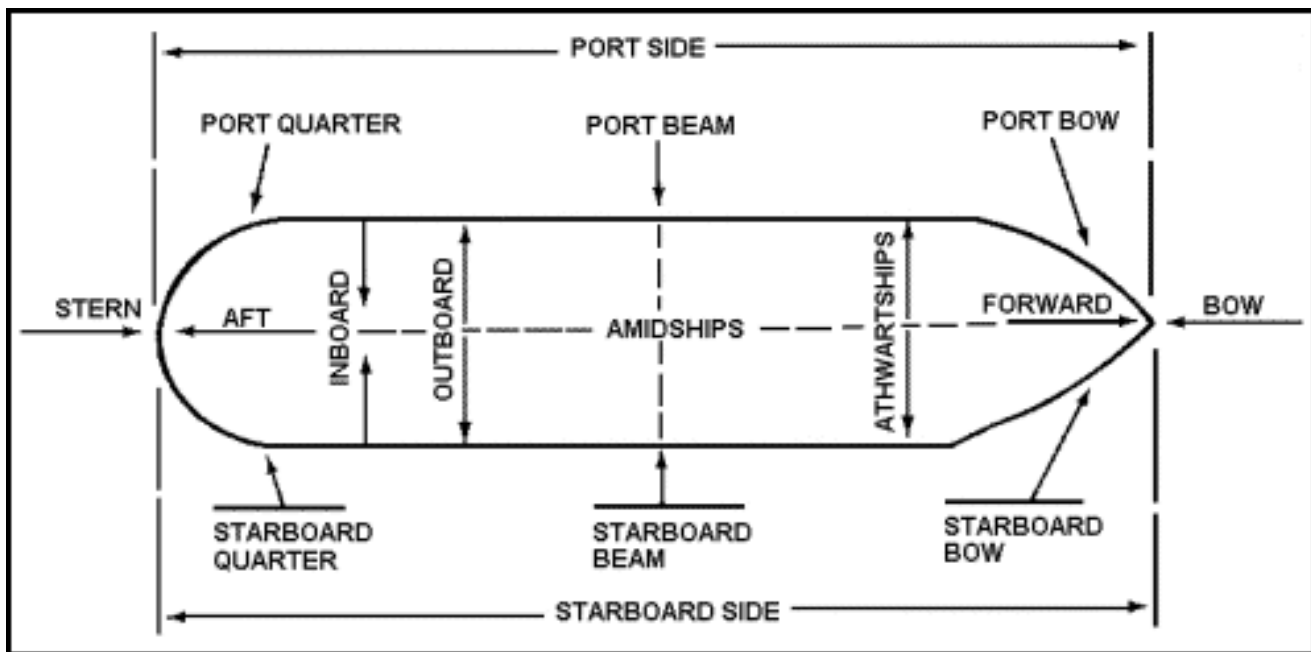
Forward end of the ship.

## 2. STERN

Aft end of the ship.

## 3. STEM (Prow)

Where the starboard and port sides intersect to form the forward leading edge of the ship.



## 4. STARBOARD

When looking forward, starboard is the right side of the ship.

## 5. PORT

When looking forward, port is the left of the ship.

## 6. FORWARD

Toward the stem.

**7. AFT**

Toward the stern.

**8. INBOARD**

Towards the centerline of a ship.

**9. OUTBOARD**

Away from the centerline of a ship.

**10. AMIDSHIPS**

In the vicinity of the middle portion of a ship, as distinguished from the ends.

**11. MIDSHIP**

Exact center of the ship; located at the midpoint between the forward and aft perpendiculars.

**12. SHELL PLATING**

Outer plating of ships. The shell is set in rows of plating called strakes.

**13. WEB FRAME (King Frame)**

A larger frame that provides additional strength and is placed usually on placed several frames apart depending on the ship.

**14. STIFFENER**

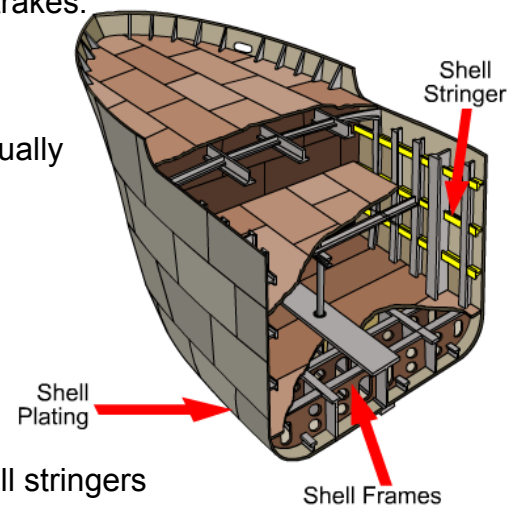
An angle bar, T-bar, etc. used to stiffen plating of a bulkhead.

**15. DECK BEAM**

Any *deck stiffeners* running transversely or longitudinally also call stringers (longitudinal), girders, longitudinal frames, etc.

**16. FOUNDATIONS**

Supports for equipment of all types, computers, engines, files, etc. Usually built out of plate and angle iron.



## **17. SUPERSTRUCTURE**

A structure built above the uppermost complete deck such as on an aircraft carrier. The island of an aircraft carrier is the superstructure.

## **18. STANCHION**

An upright bar, post, or support. To brace or secure.

## **19. LONGITUDINAL**

Fore and aft structural member running parallel or nearly parallel to the center vertical keel, along the inner bottom, shell, or deck.

## **20. BILGE**

Curved section between the bottom ends of a ship; recess into which all water drains.

## **21. BULWARK**

Strake of shell plating above the weather deck.

## **22. LIGHTENING HOLE**

Hole cut in a structural member to reduce its weight.

## **23. TRANSOM**

After end of a vessel.

## **24. TRANSOM FRAME**

Aftermost transverse frame. Last transverse frame of a ship's structure.

## **25. SCUPPERS**

Scuppers are drains from weather decks.

## **26. DAVIT**

A crane used in handling small boats, stores, lifeboats, gear, etc.

**27. ATHWARTSHIP**

At right angles to the centerline of ship from side to side. Also referred to as transverse. To go from one side of the ship to the other side.

**28. TRANSVERSE**

Crosswise. Runs from port to starboard or starboard to port.

**29. STERN POST (Rudder Post)**

After part of stern frame to which rudder is attached.

**30. RUDDER**

Device located near after perpendicular and used in steering or maneuvering a ship.

**31. GO ABOVE**

Go up ladder.

**32. GO BELOW**

Go down ladder.

**33. BALLAST**

Any weight or weights (usually sea water or lead) used to keep the ship from becoming top heavy or to change her trim.

**34. BALLAST TANK**

Watertight compartment used to hold ballast.

**35. COMPARTMENT**

A subdivision of space or room in a ship.

**36. DAVIT**

Crane on ship used to handle small boats.

**37. GALLEY**

Dining hall below decks; A cook room or kitchen.

**38. HOLD**

The inside of a hull; cargo space.

**39. TANKS**

Voids used to hold fluids (oil, water) or ballast.

**40. OFFICERS COUNTRY**

Area restricted to naval officers.

**41. PROPELLER (Screws)**

A rotating device which drives a ship through the water.

**42. QUARTERDECK**

Not actually a deck. This is the ships watchstanders duty station; Access by brow.

**43. DISPLACEMENT**

The word displacement refers to the mass of the water that the ship displaces (moves out of the way) while floating. A floating ship always displaces an amount of water of the same mass as the ship. This is the basis of buoyancy and how the ship is kept afloat.

**44. SCUPPER**

Drain from the weather deck.

**45. SHAFT ALLEY**

Area at aft end of ship where shaft runs

**46. TRUNK**

A small casing passing through a deck, such as is used for ladders or ventilation.

**47. WATERTIGHT**

Riveted, caulked or welded as to prevent the passage of water.



## 48. BOAT

A smaller vessel able to be carried on the deck of a larger one.

## II. SHIPS LINES

### 1. CENTER LINE

The exact center between the two sides.

### 2. BASE LINE

It is a horizontal plane at the bottom of the ship.

### 3. FRAME LINE

Frames – Term generally used to designate one of the transverse ribs that make up the skeleton of a ship.

### 4. LOAD WATER LINE

The water line at which the ship will float when loaded to its designed draft.

### 5. BEAM

Extreme width of ship.

### 6. LENGTH OVERALL (LOA)

The length of a ship measured from the extreme forward end to the aftermost point of the stern.

### 7. FORWARD PERPENDICULAR

A line perpendicular to the baseline, intersecting the forward edge of the stem at the designed water line.

### 8. AFT PERPENDICULAR

A line perpendicular to the baseline, intersecting the after edge of the sternpost at the designed water line

### 9. FREEBOARD

The vertical distance from the waterline to the top of the weather deck at the side.

## **10. DRAFT (Molded Draft)**

Depth of the lowest point of ship below surface of water when she is afloat.

## **11. MOLDED DEPTH**

The vertical distance from the molded base line to the top of the uppermost strength deck beam at side, measured at mid length of the vessel. Addition of the Draft & Freeboard.

## **12. SHEAR**

Forward and aft curvature of a deck.

## **13. CAMBER**

Rise or crown of a deck from side to side. (athwartship)

## **14. TUMBLE HOME**

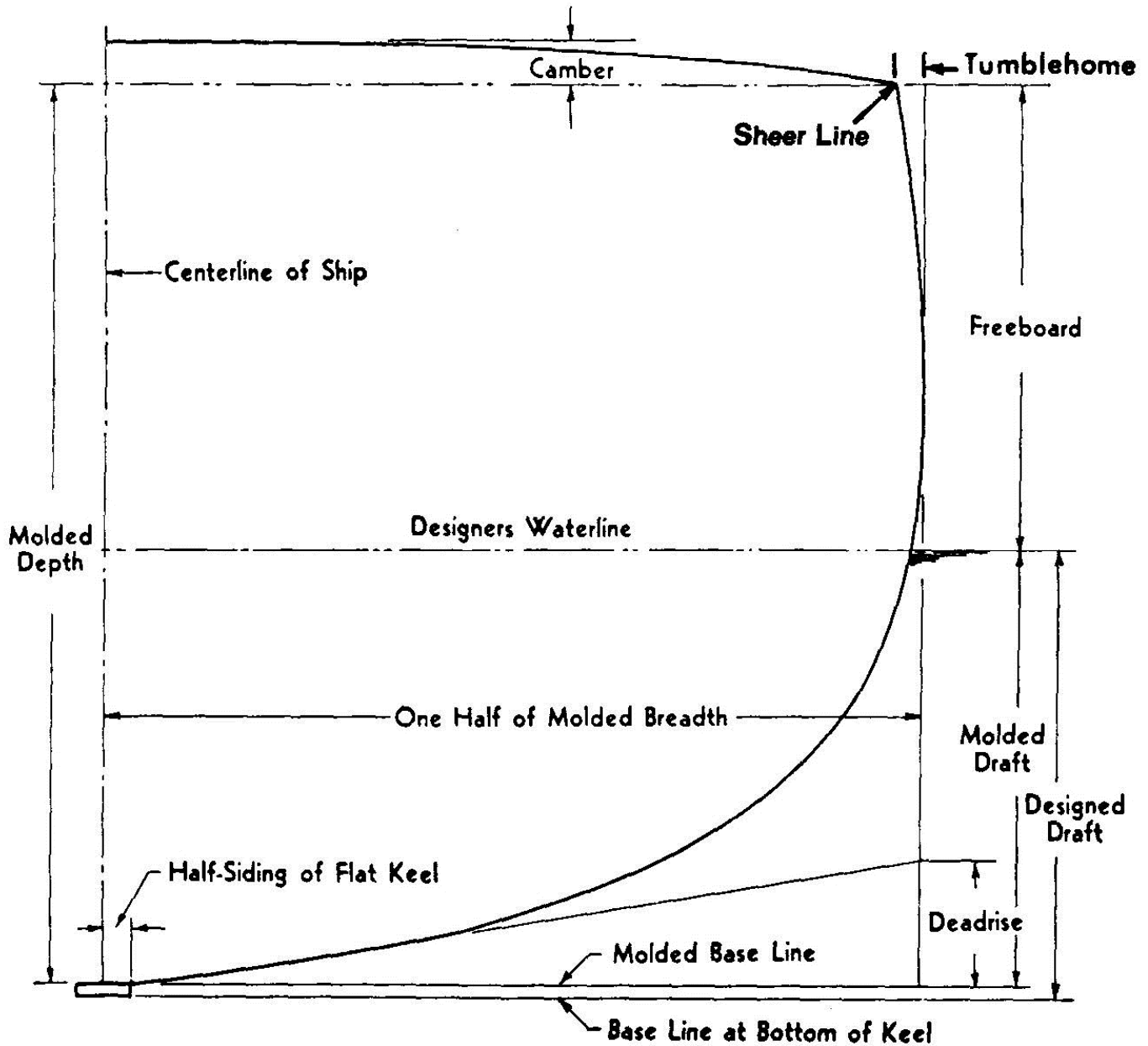
The decreasing of a vessel's beam above the waterline as it approaches the rail. Slant inboard of a ship's side above the bilge.

## **15. DEAD RISE**

Slant up athwartship of the bottom of a ship from keel to bilge.

## 16. KEELS

Backbone of the ship, usually built in the form of an I-beam, which runs the full length of the ship. The keel is made up of the Flat Keel, Center Vertical Keel (CVK) and a rider plate. Also see Bilge Keel.



**Figure 3-5.** Midship-section molded-form definitions

### **III. SHIP CONSTRUCTION**

#### **1. HULL**

The shell or plating of a ship.

#### **2. GUNWALE**

The upper edge of the sides of the ship; the point at which the sides of the ship meet the main deck.

#### **3. LIFELINES**

Light wire ropes erected around the edges of weather decks to prevent personnel and equipment from being swept overboard.

#### **4. FRAMES**

The members of a ship's hull extend from the keel to the sides of the ship. This makes up the ribs of the ship. Frame spacing is the fore and aft distance between adjacent frames.

**5. BULKHEAD** - interior walls of a ship which subdivide the interior of a ship into compartments or rooms. There are several named bulkheads, but the general groups are:

- A. **Structural Bulkheads** - divide the ship into watertight compartments.
- B. **Metal Joiner Bulkheads** - serve as partitions; they are not watertight.

#### **6. BRIDGE**

Area from which the ship is controlled by the captain or the officer of the deck.

#### **7. MASTS**

Used to support radio and radar antennas, signal lights and booms. A ship may have more than one mast.

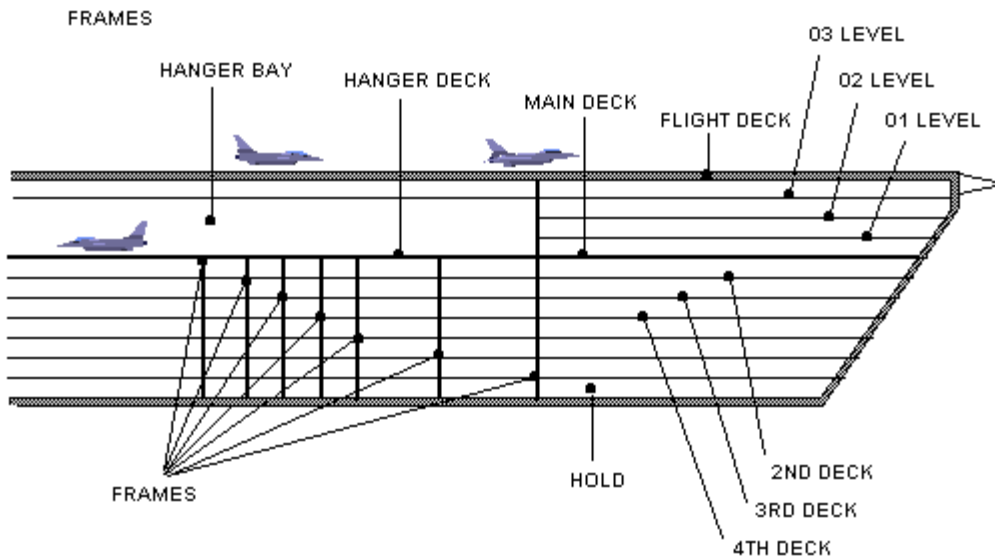
#### **8. YARDARMS**

Spars (Long steel pole) mounted athwartship near the top of the masts.

#### **9. STACK**

Serves to carry off smoke and hot gases from boilers and exhaust from the diesel engines in non-nuclear powered ships.

## **IV. DECKS**



### **1. DECKS**

Decks are the "floors" of the ship. A deck in a ship corresponds to a floor in a building. It is the plating or covering of any tier of beams above the inner bottom, forming a floor, either in the hull or superstructure of a ship. Decks are designated by their location as upper deck, main deck, etc.

### **2. WEATHER DECK**

The uppermost complete decks exposed to the weather.

### **3. MAIN DECK**

Uppermost complete deck on most ships.

### **4. SECOND DECK**

The first complete deck below the main deck.

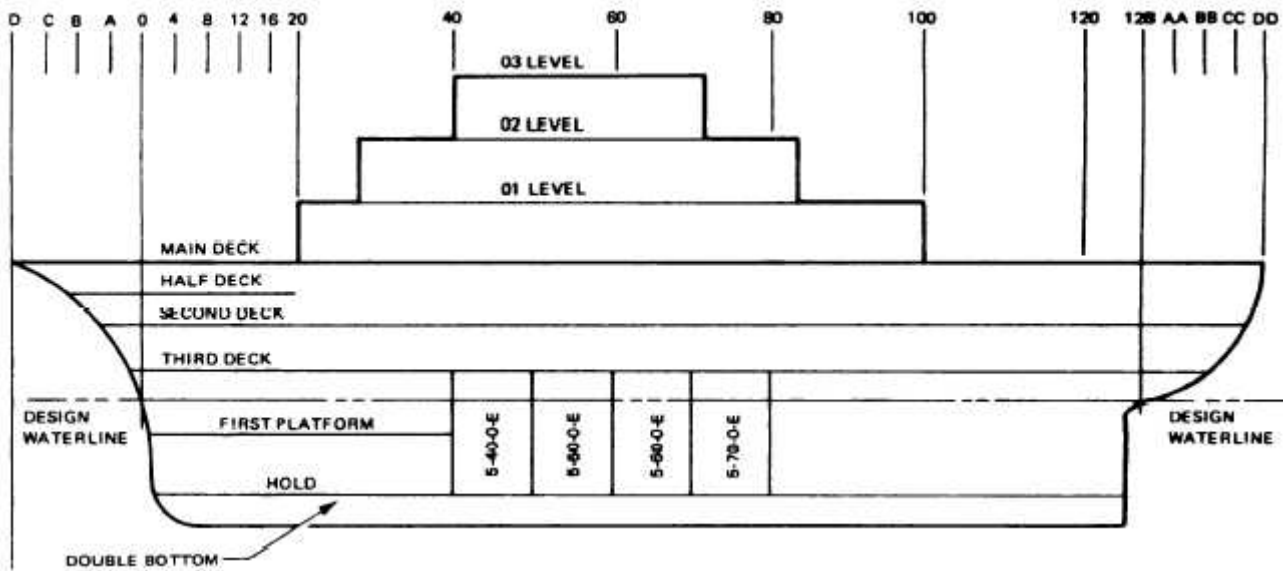
### **5. THIRD DECK**

The second complete deck below the main deck.

### **6. LEVELS**

Term used to designate deck heights above the main deck:

ex. - 01 level, 02 level, etc. Also used on submarines. Decks are called Upper Level, Mid Level & Lower Level on a 688 class submarine.



## 7. FANTAIL (*Poop Deck*)

After end section of the upper weather deck; opposite the forecastle, also referred to as the "poop deck".

## 8. FORECASTLE (*fōk'sul*)

Forward most section of the upper weather deck.

## 9. HANGER DECK

Main deck on aircraft carrier; used to store aircraft when not on flight deck.

## 10. FLIGHT DECK

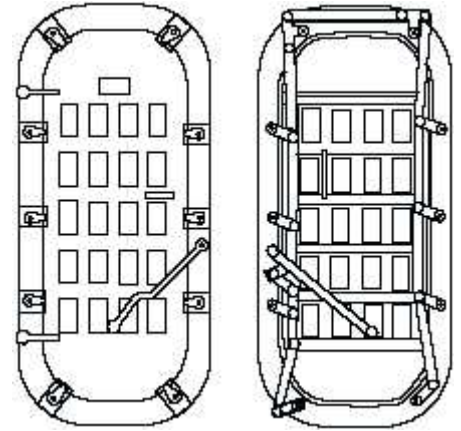
Upper weather deck on an aircraft carrier used to launch aircraft.

## V. Access Ways

### 1. DOOR

Provides access through a bulkhead.

- A. Watertight (WT) - to weather decks/structural bulkheads.
- B. Non-watertight (NWT) - to spaces within a watertight compartment.
- C. Air-Tight (AT) – Not as stringent controls as watertight. Typically used above the main deck.



### 2. HATCH

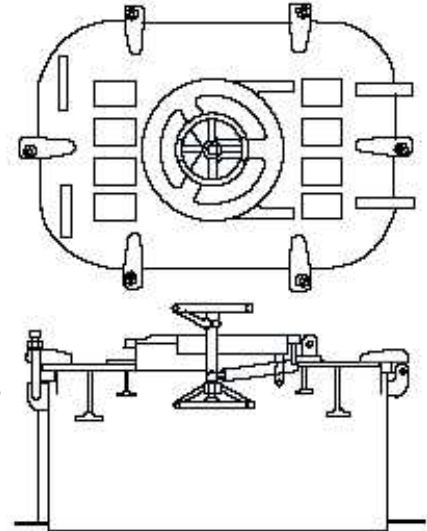
Provides access through a deck.

### 3. SCUTTLE

A small opening through a hatch or deck to provide access to other areas of the ship. For passing ammo or personnel passage.

### 4. QUICK ACTING DOOR

Door with linkage on back side connected to single throw rod. This is used in high traffic areas. Requires more maintenance.



### 5. INDIVIDUALLY DOGGED DOOR

Door with several different separate dogs. This is used where there is minimal traffic.

### 6. DOG

A small bent metal fitting used to close doors, hatch cover, manhole covers, etc.

### 7. LADDERS

Lead from one deck level to another. Similar to a stairway in a building. May be vertical or angled.

## **RIGGING**

**1. BITT**

A vertical post used in making fast lines; a bollard.

**2. BOLLARD**

A single tie post.

**3. CHOCK**

A heavy fitting through which ropes or hawsers may be led.

**4. DERRICK**

A device for hoisting heavy weights, cargo, etc.

## **DOCKING TERMS**

**1. DRY-DOCK**

Permanently installed area used to bring ship down to keel block level.

**2. FLOATING DRY-DOCK**

Floating dock that sinks to allow ship in and then is raised up to lift ship.

**3. PIER**

Waterborne areas to tie ships up.

**4. BERTH**

A place for a ship; or a place to sleep or bunk.

**5. CAISSON**

Used at the opening of a dry-dock to prevent water from entering the dock.

**6. BROW**

A moveable ladder or ramp used for boarding a vessel from the dock.

**7. KEEL BLOCK**



Heavy blocks, usually concrete and wood which support the keel of the ship in dry-dock during construction / repair.

## 8. **SAW HORSE**

Portable wooden device, used to stand. Should be used when there is no staging.

## 9. **STAGING**

Permanent assembly of pipes and clamps. Makes up a stable work environment where there is nothing to stand on. May be made portable with wheels at bottom of staging.

# **SUBMARINES ONLY**

## 1. **HATCH**

Point of entry / exit on board submarines.

- A. **WEAPONS SHIPPING HATCH** – Primarily used for weapons loading.
- B. **BRIDGE TRUNK** – Access to the bridge through the sail.
- C. **FORWARD ESCAPE HATCH** – Most forward personnel hatch.
- D. **AFT ESCAPE HATCH** – Farthest aft hatch.

## 2. **BOW PLANE**

On a submarine, large fairwater used to steer the ship vertically. either attached to the sail or may be retractable forward of the sail.

## 3. **DIVING PLANE**

Used to steer the ship vertically. There are two diving planes located perpendicular to the rudders on a submarine.

## 4. **LEVELS**

Decks of a submarine. Labeled U/L – Upper Level, M/L – Mid Level, and L/L – Lower Level.

## 5. **MANEUVERING**

Reactor plant operations control room on submarines; You must ask and be given “permission to enter” prior to entering space. Similar to EOS on a surface craft.

## 6. **BALLAST TANK**

Groups of tanks designed to allow the submarine to dive and re-surface.

## 7. **SAIL**

The superstructure of a submarine. Antennas, periscope, radar, snorkel, etc go through top of sail.

## **8. TORPEDO TUBE**

A tube fixed below or near the water line through which a torpedo is fired.

# **NUCLEAR SHIPS ONLY**

## **SPECIAL QUALIFICATIONS ARE REQUIRED!**

### **1. RC**

Reactor Compartment; You need special qualifications and a TLD to enter.

### **2. RAR**

Reactor Access Room

### **3. RadCon**

Radiation Control Technicians; Rad. techs. control all aspects of radioactive & contaminated material.

### **4. RADIOACTIVE MATERIAL STORAGE AREA**

Area that is used to store radioactive and contaminated material.

### **5. EOS**

Reactor plant operations control room on surface craft; you must ask and be given "permission to enter" prior to entering space. Similar to Maneuvering on a submarine.

# ABBREVIATIONS

**ABV** – Above  
**AE** – After End  
**AMR** – Auxiliary Machinery Room  
**AT** – Airtight  
**AUX** – Auxiliary  
**BET** – Between  
**BEV** – Bevel  
**BHD** – Bulkhead  
**BL** – Baseline  
**B/M** – Bill of Materials  
**BOT** – Bottom  
**CHAM** – Chamfer  
**C (CL)** – Center Line  
**CONT** – Continuous  
**COMPT** – Compartment  
**C-C** – Center to Center  
**CTR** – Center  
**DIA (or D)** – Diameter  
**DIM** – Dimension  
**DK** – Deck  
**DN** – Down  
**EL** – Elevation  
**ER** – Engine Room  
**FE** – Forward End  
**FDN** – Foundation  
**FO** – Fuel Oil  
**FP** – Forward Perpendicular  
**FR** – Frame  
**FT** – Fume Tight  
**FW** – Fresh Water  
**FWD** – Forward  
**GT** – Gas Tight  
**ID** – Inside Diameter  
**INBD** – Inboard

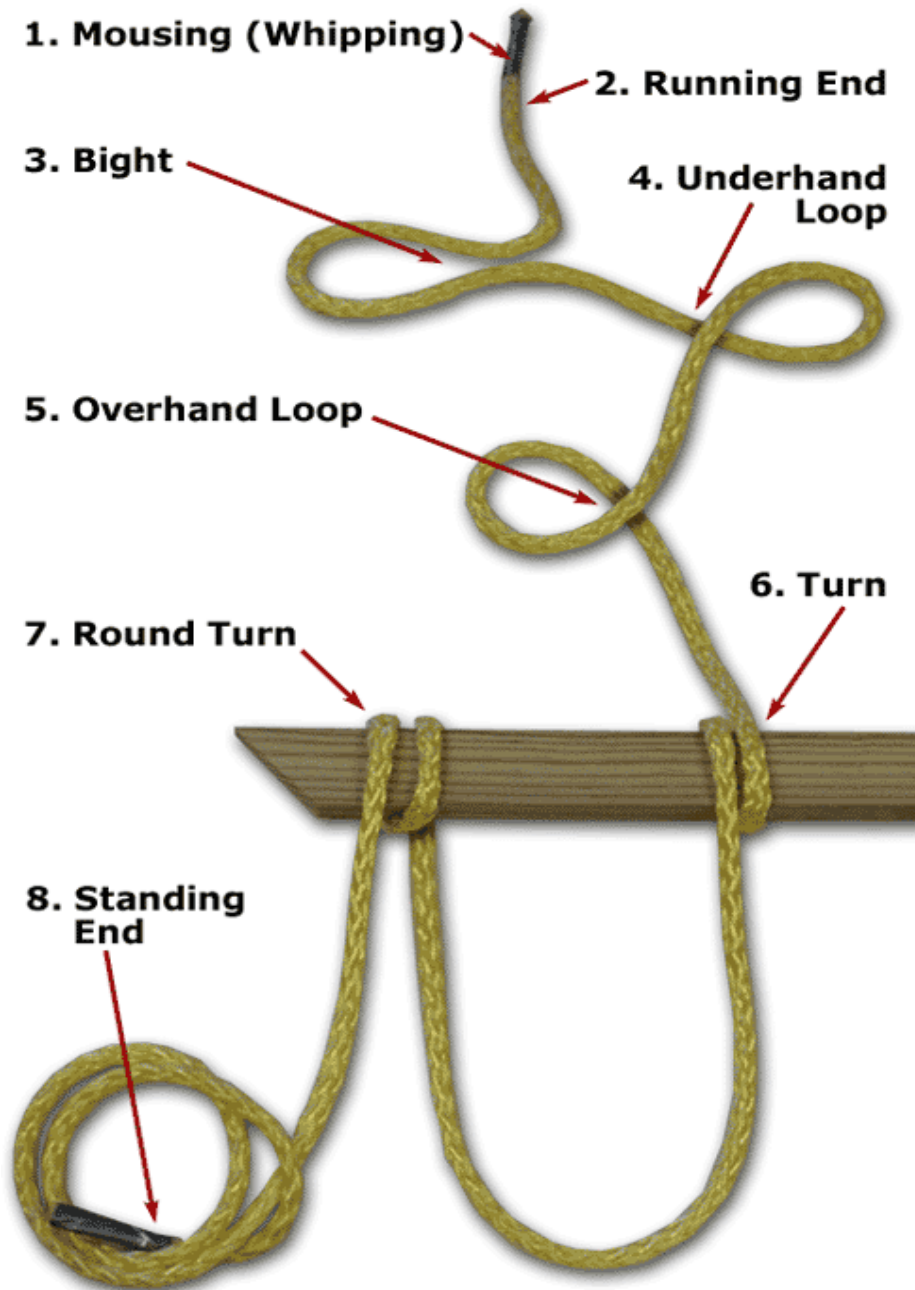
**IWO** – In Way Of  
**K** – Keel  
**LB (or #)** – Pounds  
**LBP** – Length Between Perpendiculars  
**LG** – Length  
**LOA** – Length Over All  
**LWL** – Load Waterline  
**MACH** – Machinery  
**MAX** – Maximum  
**MH** – Man Hole  
**MIN** – Minimum  
**MMR** – Main Machinery Room  
**ND** – Non Deviation  
**NO.** – Number  
**NT** – Non Tight  
**OD** – Outside Diameter  
**OOD** – Officer of the Deck;  
usually posted at the quarterdeck.  
**OT** – Oil Tight  
**P** – Port  
**R (or Rad)** – Radius  
**REQD** – Required  
**RPM** – Revolutions Per Minute  
**SR** – Stateroom  
**STBD** – Starboard  
**STIFF** – Stiffener  
**THD** – Thread  
**THK** – Thick or Thickness  
**TT** – Tank Top  
**VL** – Vertical Ladder  
**VLS** – Vertical Launch System  
**WT** – Water Tight  
**∩** – Midship

# BASIC KNOT TYING

## LESSON 5

# KNOT TYING GUIDE

Tying on tools and materials can be tricky, and cutting ropes to get them loose is expensive.



Learning a few simple, secure and easily untied knots can save you a lot of headaches, time and money.

## A Little About Rope

Knot tying and rigging has its own special language. To give a better understanding of the instructions for the knots in this guide, spend a few minutes familiarizing yourself with some of the lingo.

1. **Mousing** or **whipping** is a method of using tape or twine to secure the strands at the end of a rope. Mousing prevents the rope from unraveling.
2. The **running end** of a rope is the moving or workable end of the rope. In rigging, the running end is usually the leading end of a rope.
3. A **bight** is an unclosed loop in a rope that turns back on itself. Bights are often used to take up slack or add strength to ropes.
4. An **underhand loop** is created when a rope is looped back on itself with the running end passing under the standing end.
5. An **overhand loop** is created when a rope is looped back on itself with the running end passing over the standing end.
6. A **turn** is formed when a rope is wrapped 360 degrees (1 time) around a stationary object. Turns add holding power in rigging and maintain the direction of the running end of a rope.
7. A **round turn** is formed when a rope is wrapped 1 1/2 times around a stationary object. Round turns add holding power in rigging and reverse the direction of the running end of a rope.
8. The **standing end** of a rope is any portion of the rope secured to a fixed object or otherwise located behind the running end of the rope. In rigging, the standing end is usually any stationary portion of a rope.
9. **Seizing** is a technique where the running end of a rope is secured to the standing end with a half hitch or double half hitch. Seizing prevents the knot from loosening when rope tension changes.
10. A **tail** is the running end of a rope left over after a knot is tied. The tail of a knot should be long enough to allow you to seize it to the standing end of the rope, usually 6" to 8".

# Common Knots

Following are simplified instructions for tying a few commonly used knots.

## Two Half Hitches

This reliable knot is quickly tied and is the hitch most often used in mooring. To tie:

1. Pass end of rope around post or other object.
2. Wrap short end of rope under and over long part of rope, pushing the end down through the loop. This is a half hitch.
3. Repeat on long rope below first half hitch and draw up tight.



## Bowline

This knot doesn't jam or slip when tied properly. To tie:

1. Make the overhand loop with the end held toward you, then pass end through loop.
2. Now pass end up behind the standing part, then down through the loop again.
3. Draw up tight.





## Square Knot

This knot is used at sea in reefing and furling sails. To tie:

1. Pass left and over and under right end. Curve what is now the left end toward the right and cross what is now the right end over and under the left.
2. Draw up tight.
3. This knot is easily confused with the Granny Knot.



## Clove Hitch

This knot is the "general utility" hitch for when you need a quick, simple method of fastening a rope around a post, spar or stake. To tie:

1. Make a turn with the rope around the object and over itself.
2. Take a second turn with the rope around the object.
3. Pull the end up under the second turn so it is between the rope and the object. Tighten by pulling on both ends.



## Figure Eight

This knot is ideal for keeping the end of a rope from running out of tackle or pulley. To tie:

1. Make underhand loop, bringing end around and over the standing part.
2. Pass end under, then up through the loop.
3. Draw up tight.



## Anchor Bend

This knot is used to secure a rope or a line to an anchor. To tie:

1. Pass two loops through ring.
2. Place free end around standing line.
3. Pass free end through loops.
4. Complete by making half hitch.



Sources –  
[www.lowes.com](http://www.lowes.com)  
[www.onwater.com](http://www.onwater.com)

# BASIC HAND TOOLS FOR ALL TRADES

## LESSON 6

## TOOL SAFETY RULES

1. Always inspect your tool prior to use and after finishing work. Look for damage that may have occurred. Keep tools in good condition.
2. Advise your supervisor of any unsafe conditions or practices, which may exist.
3. Always obey safety rules
4. Always read and follow the safety guidelines for the tools that you are using. Always be familiar with the tool prior to using it on the job site.
5. Do not allow horseplay in the work area.
6. Always use the proper tool for the job. Do not attempt to make due with the incorrect tool. Many people are injured doing this.
7. Return broken tools to the tool room. They are a hazard. Workers are more efficient with a tool in good condition and safety is greatly improved.
8. Report injuries to your supervisor immediately.
9. Always keep tools in their proper storage box or rack. Punches & chisels that have a mushroomed shaft must be ground down or turned in.
10. Always wear PPE – Personal Protective Equipment. Safety glasses, hard hat, ear plugs, leather gloves, safety shoes are all part of the standard safety gear required shipboard. Additional PPE may be required, depending on the job.
11. All PPE must be in good repair. A hard hat without the liner is not acceptable. Leather gloves with holes in them will not protect your hands. Safety glasses that are seriously scratched can make it harder to see the job site. Safety shoes that are worn could be a hazard to you.
12. Safety belts are no longer acceptable per OSHA guidelines. Safety harnesses must be worn if working in an area requiring this.
13. Special care must be taken if you are working around open electrical circuits. Special clothing and tools must be used along with special precautions. Treat electricity with RESPECT!
14. Keep your mind on the job at hand. Do not allow distractions to increase your chances of injury.
15. Be aware of your surroundings. Before cutting near electrical cables or cords, have them tied back to prevent damage.
16. When using a tool, be sure to look where you are stepping; such as when measuring, it is easy to forget about your surroundings and make a step in the wrong direction.
17. Always protect ships equipment. It is the workers responsibility to prevent damage.

## I. DIVIDERS

Dividers are instruments used for checking distances between two points, scribing arcs or circles, transferring measurements to other parts.

### Types:

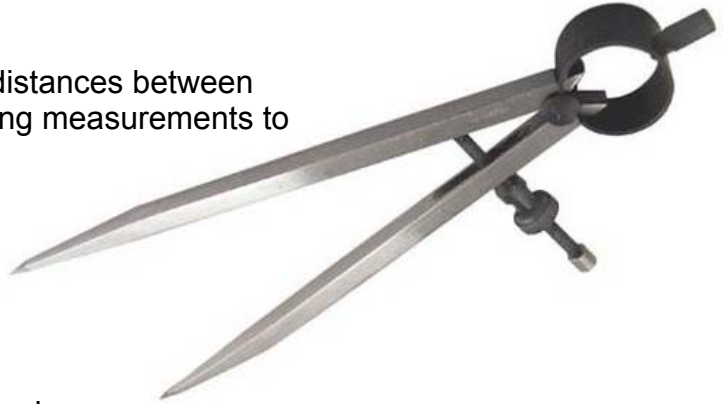
Spring Divider  
Wing Divider

### Usage:

1. Set the radius on the dividers using a ruler.
2. Place one point of the divider in the center of the arc to be drawn.
3. Lean the dividers in the direction of movement and scribe the circle by revolving the dividers.

### Care/Safety:

Keep dividers clean & dry. Protect the points against damage. Store where they will not become bent or broken.



## II. RULERS

### Types:

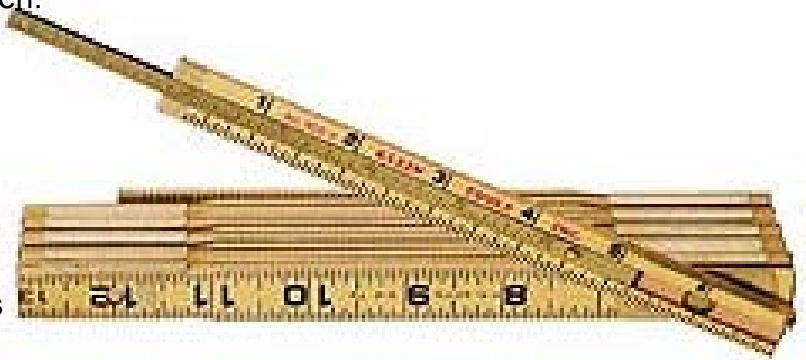
Folding Ruler – 6'  
Steel Tape – 6', 12', 25', 30', 50', 100' & others  
Steel Rule – 6", 12", 2' & others

### Usage:

1. Measuring lengths of stock.
2. Measuring outside diameter of pipe.
3. Measuring inside diameter of pipe.
4. Measuring the circumference of pipe.
5. Measuring inside dimensions.
6. Measuring the thickness of stock through a hole.
7. Measuring outside dimension with a tape.

### Care/Safety:

Keep ruler and tape clean & dry. Store where they will not become bent or damaged.



### III. LEVELS

Levels are used to check whether an object is in a true vertical or horizontal position. All levels consist of a liquid filled vial supported in a metal or wooden frame.

#### Basic Types:

- Carpenters Level
- Machinist Level
- Torpedo Level
- Line Level

#### Usage:

A level may be checked for accuracy by placing it on a known level surface and noting the position of the bubble. Reverse the level end for end. Observe the position of the bubble. If the relative position of the bubble was the same for both readings, the level is accurate.

The level may have more than one leveling vial. Some levels include vials for checking horizontal, angled and vertical surfaces. Make sure you are using the correct level vial for the surface you are checking. The bubble should be between the two etched lines on the vial. If it is not, the surface is not level.

#### Care/Safety:

Extreme care should be taken when storing the level. It can be very sensitive to rough handling. Store in a clean, dry environment away from other tools that could damage the level.



### IV. SQUARES

#### Types:

- Carpenters Square
- Combination Square
- Try Square
- Sliding T-Bevel



**Usage:**

A square is used to transfer perpendicular lines. Squares may have graduations that are used for measuring. Combination squares can be used for laying out 45-degree angles and may include a protractor head for measuring different angles and a centering head for laying off the center of pipe & round stock. The sliding T-bevel square is used to transfer a known angle to other material and checking known angles or bevels.

**Care/Safety:**

Squares should be kept in a clean dry environment. As with all measuring tools, the square should be kept away from other tools that could damage the square.

**V. PLIERS****Types:**

- Slip Joint Pliers
- Lineman's Pliers
- Diagonal Cutting Pliers
- End Cutting Pliers
- Needle Nose Pliers
- Wire Strippers

**Usage:**

Pliers come in many different shapes with pivoting jaws. The jaws may have a serrated edge for holding or a cutting edge. Slip joint pliers have a pivot joint that allows the jaws to handle large or small objects. Use the correct type of pliers for the job.

**Care/Safety:**

- Clean with a rag. Apply a light coat of oil after use.
- Store pliers in a toolbox or hang on a rack.
- Do not remove insulation on handles that have insulation.
- Do not use for prying.



## VI. CLAMPS

### Types:

C-Clamps  
Sliding Bar Clamps  
Hand Screw Clamps

### Usage:

Clamps are used to hold work, which is not held in a vise. They come in a variety of sizes and types.

C-clamps are excellent for holding work to a flat surface near the edge of a plate. It is measured by the opening between the swivel pads.

Sliding bar clamps are faster alternatives to C-clamps. There is one fixed jaw and one-jaw slides into position to clamp down on the work piece.

Hand screw clamps are used extensively in woodworking. They are excellent at holding pieces at odd angles.

### Care/Safety:

Clean threads & swivel with a rag and lubricate with a light coat of oil.

Store on a rack to prevent damage.



## VII: HAMMERS

### Types:

Carpenters Hammer  
Machinist's Ball Peen Hammer  
Blacksmith's Hammer (Sledge Hammer)  
Soft-Faced Hammer



### Usage:

Hammer handles may be either wood, fiberglass or steel. The face (striking surface) may be flat or bell shaped. Hammer faces are usually smooth; some have a milled surface to prevent slipping. Care should be taken to prevent damage to the work surface when using a milled face hammer, as it will mar the work surface should it come in contact with it.

Hammers come in different weights. Depending on the type of work and the hammer being used, the weight could be from 7 ounces up to 10 pounds or more.

All hammers come with one primary striking face and opposite that may include a claw, peening head, or other surface.





Hold the hammer firmly near the end of the handle. This provides the best control and striking power with the least effort. Be sure to strike the surface squarely to prevent damaging the surface.

**Care/Safety:**

Make sure the head is attached firmly to the handle and the handle is in good condition. If it should become loose, replace it. Make sure the face is clean and free of oil to prevent slipping. Replace the hammer if it has a worn or chipped face or claw.

## VIII. SCREWDRIVERS

### Blade Types:

Standard (Flat)  
Phillips  
Square Drive

### Usage:

Screwdrivers come in many shapes & sizes. Types of screwdrivers include common screwdrivers, stubby screwdrivers, cabinet screwdrivers, offset screwdrivers & ratcheting screwdrivers. Each is intended for a specific use.

The tip of the blade should be straight & square with sides being parallel to each other.

Make sure the tip is sized properly for the slot size of the screw. Too narrow or too wide of a tip will cause slippage and possibly damage the work surface.

Standard screwdrivers are identified by the length of the blade, such as 3", 6" and 10". Phillips screwdrivers are identified by tip size, ranging from 0 to 4. Square drive screwdrivers are identified by tip size also, which include #1, #2 and #3.

Hold the screwdriver properly. Slipping can mar the work surface and injure the worker.

*TIP* - When driving screws into hard woods, rub the screw into wax or soap prior to driving into a pre-drilled hole. This extra lubrication makes driving easier.

### Care/Safety:






Do not use the screwdriver as a pry bar or chisel. Use the proper tool for the job.

Always use the proper size screwdriver for the job.

Make sure the screwdriver tip is in good condition. If not, the screwdriver will slip and damage the work piece.



### Screwdriver Tip Configurations

	Slotted: Standard or flat for driving single slotted screws. Tip width range from 1/6" to 1/2".
	Phillips®: Designed specifically for use with Phillips® head screw, which has two recessed slots at right angles to each other. Sizes range from 0 point (small) to 4 point (large).
	Pozidriv®: Similar to the Phillips® style, the screw can be identified by additional lines on the face. Sizes range from 1 point (small) to 4 point (large).
	Square head: Square tip, used in mobile homes, recreational vehicles and industrial applications. Sizes range from 1 point (small) to 3 point (large).
	Torx®: Star shaped, used in the automotive industry. Sizes range from T-10 (small) to T-30 (large).

## IX. WRENCHES

Wrenches are designed for tightening & loosening nuts, bolts, studs & pipes. They are forged from steel alloys to prevent breakage. Each type of wrench is intended for a specific use and should be used correctly for ultimate efficiency

### Types:

Open End Wrench  
Box Wrench  
Combination Wrench  
Adjustable Wrench (Crescent)  
Socket Wrench  
Hex Key Wrench  
Clamp Pliers (Vise Grip)  
Pipe Wrench  
Torque Wrench



### Usage:

Ensure you have the correct type and size of wrench to perform the task. Longer wrenches provide additional torque but can also damage a nut or bolt. Short wrenches will not provide the required torque and may slip from the work piece easier.

Adjustable wrenches should be tightly adjusted and pulled so that the force is on the side of the fixed jaw.

Clamping Pliers should be used with caution. They are excellent for removing rounded nuts, but will cause damage if not used correctly.

Torque wrenches are precision instruments and should only be used for final torquing of nuts or bolts. Prior to torquing, all nuts & bolts should be installed with another wrench.



### Care/Safety:

Check for worn, cracked or sprung jaws on the wrench.

Avoid using extensions on wrenches for additional leverage.

Never use a wrench as a hammer. Use the right tool for the job!

Always pull the wrench to protect your knuckles in case the wrench slips.

Wrenches should fit the nuts and bolts snugly to prevent slippage.

Use penetrating oil on rusted nuts and bolts. Allow time for the oil to penetrate prior to turning the wrench.

Keep the wrench in good condition in a clean, dry environment.

## X. CHISELS

### Types:

Woodworker's Chisel  
Machinist's Chisel

### Usage:

For Woodworker's Chisel, secure the work piece in a vise or clamp. Always cut with the grain of the wood. Rough-cuts are made with the bevel down. Smooth cuts are made with the bevel up. Use short, rapid mallet blows to control depth and length of cut.

For machinist's chisel, place work piece on firm surface. Place chisel and lightly strike with a hammer. Check chisel mark to make sure cut is in desired location. Continue striking until the chisel has cut through the work piece.



## XI. PUNCHES & PINS

Two common types of punches include the solid and the hollow. Hollow punches are for cutting holes in leather, paper and other material. Solid punches are used for marking metal, aligning parts, driving pins and similar tasks.

### Types:

Center Punch  
Hole Cutting Punch  
Drift Pin  
Alignment Pin

### Usage:



For marking centers of holes, hold the center punch on a pre-determined spot. Strike the punch firmly with one blow to create a divot, which will be used as a starting point for dividers or a drill bit. For cutting holes, place the material on a piece of wood. Position the punch over the desired spot. Punch firmly with a hammer. The material should have a hole punched cleanly in the correct spot. Drift and alignment pins are used to bring drilled holes into alignment for bolt insertion.

**Care/Safety:**

Always wear safety glasses when using a punch.  
Store punches in a rack so that the edges are not damaged.  
Mushroomed edges should be ground down smooth.  
Clean punches and apply a light coat of oil before storing.

## XII. FILES

Files are used for cutting, smoothing or removing small amounts of metal, wood, plastic or other material. Files come in different shapes, lengths and surface cuts. The file has five parts: 1. Point 2. Edge 3. Face or Cutting Teeth 4. Heel or Shoulder 5. Tang

**Types:**

- Mill File
- Pillar File
- Round File
- Square File
- Taper File
- Three Square File
- Warding File
- Swiss Pattern File

**Usage:**

Files come in grades of coarseness. They are the:

1. Bastard cut for heavy work
2. Second cut for finish work
3. Smooth cut for finish work
4. Dead smooth cut for an extra fine finish



Clamp the work in a vise.

When filing hard metals, apply pressure in the forward stroke only.

When filing soft metals, apply pressure on the return strokes also to keep the file clean.

**Care/Safety:**

A new file should be broken in by using it on brass, bronze or smooth iron.

Use a file brush cleaner to keep the file clean.

Store clean files in its holder or a rack away from other files.

Use a handle on file to prevent injuring your hands.

Do not use a file as a pry bar.

Do not hammer on the file.

## XIII. TAP AND DIES

Taps & dies are used to cut threads in metal, plastic or hard rubber. Taps are used to cut internal threads. Die nuts are used to cut external threads.

### Tap Types:

Taper (Starting) Tap

Plug Tap

Bottom Tap

### Usage:

Apply cutting oil to the taps and the hole. The threaded hole should be started with the taper tap. Ensure the tap is perpendicular to the surface being tapped. Do not apply pressure, the threads will pull the tap into the work piece. While tapping, it may become necessary to bring the tap out to clean the hole. Remove the tap and check the new threads. For a bottom tapped hole, the bottom tap will need to be run through the hole.

To use a die nut, the die nut should be positioned in a diestock (handle). Apply cutting oil to the die and the work. Position the die over the work piece. Turn the die forward one turn and then turn backward one-quarter turn. Repeat this method until the desired cut length has been accomplished. Ensure the die is square to the work piece. Back off the die nut and remove.



### Care/Safety:

Do not sharpen taps or dies.

Keep cutting edges lightly oiled.

Store taps & dies in a protective case to prevent damage.

## XIV. SAWS

Saws are tools with thin, flat steel blades with a row of spaced teeth along the edge. The blade is attached to a handle. They are available in various sizes depending on the material to be cut. Typically, there are two categories of handsaws: ripsaw and crosscut. Ripsaw is designed to cut



with the grain of the wood. Crosscut is designed to cut across the grain of the wood.

**Common Types:**

- Handsaw
- Hacksaw
- Backsaw
- Keyhole Saw

**Usage:**

Place the workplace on a level surface with material braced near the line of the cut. Make sure the saw is perpendicular to the work surface and angled about 45 degrees along the cut line. Sawing is done on the downward stroke only while applying even pressure. Make sure to support the work piece when nearing the end of the cut to prevent it breaking unevenly.

Hacksaws are designed to cut metal objects. The appropriate blade can be attached depending on the hardness of the metal. Hard metals will require more teeth; softer metals require fewer teeth in the saw blade.

**Care/Safety**

- Always inspect the saw for damage prior to use.
- Store in a toolbox or hanging to prevent damage.
- Wear eye protection when using a saw.
- Clamp or hold firmly material prior to cutting.
- Be careful of hand placement while sawing.

## XV. CHALK LINE

The chalk line is a common tool used to strike perfectly straight lines onto material. The case holds a length of string with a hook on the end. Chalk is poured into the case which will transfer to the deck. The chalk is commonly found in white and blue. The chalk line can also be used as a plumb bob if one is not available. Although it is usually not the best choice.

**Usage:**

One person should hold the case with the turning knob turned out 90° to the case. Another worker should pull the string out to the desired length. The worker with the case should put his string down on the desired mark while the 2<sup>nd</sup> worker pulls the string taut and places his string down on the appropriate mark. One of





the workers or an 3<sup>rd</sup> worker lifts the middle of the string a few inches off the deck and drops it. The string snaps back to the straight line leaving a perfectly straight chalk line.

### Care/Safety

Be sure to reel the string back in after use. Oil the knob lightly as required. Keep the chalk well furnished with chalk for sharp lines. Using a center punch, punch the lines on the deck after use, **if allowed**.

## XVI. PLUMB BOB

The plumb bob is the correct tool to use to transfer a point or to find a perfectly plumb line from the overhead. The plumb bob is attached to a length of string.

### Usage:

Layout a crosshair of a measurement in the overhead. Have one worker hold the string on that crosshair while lowering the plumb bob down to the deck. The second worker should bring the plumb bob to within about 1/16" of the deck. Steady the plumb bob. Mark where the point is. Rotate your line of sight 90° and make another mark. This will transfer a crosshair down below. Punch the mark, **if allowed**.

### Care/Safety:

Protect the point of the plumb bob from damage. Also protect the point so that it does not stab a worker. It is sharp. Roll the string up to prevent cutting it.

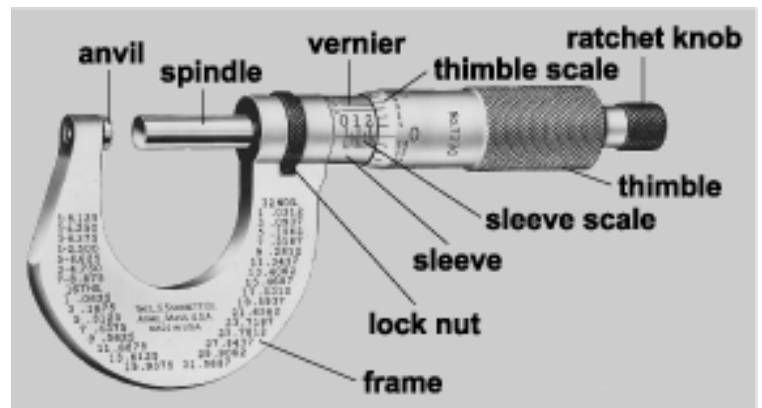


## XVII. MICROMETER

A micrometer is a c-clamp shaped tool that is capable of measuring within the frame to within 1/1000 of an inch or .0001".

### Usage:

The piece is placed between the anvil and the spindle. Tighten the thimble until light contact is made. Then the measurement should be taken. You may need to be qualified to use this tool to such fine measurements.



### Carrying tool bags while climbing ladders OSHA 1915.131(a)

Hand lines, slings, tackles of adequate strength, or carriers such as tool bags with shoulder straps shall be provided and used to handle tools, materials, and equipment so that employees will have their hands free when using ship's ladders and access ladders. The use of hose or electric cords for this purpose is prohibited.

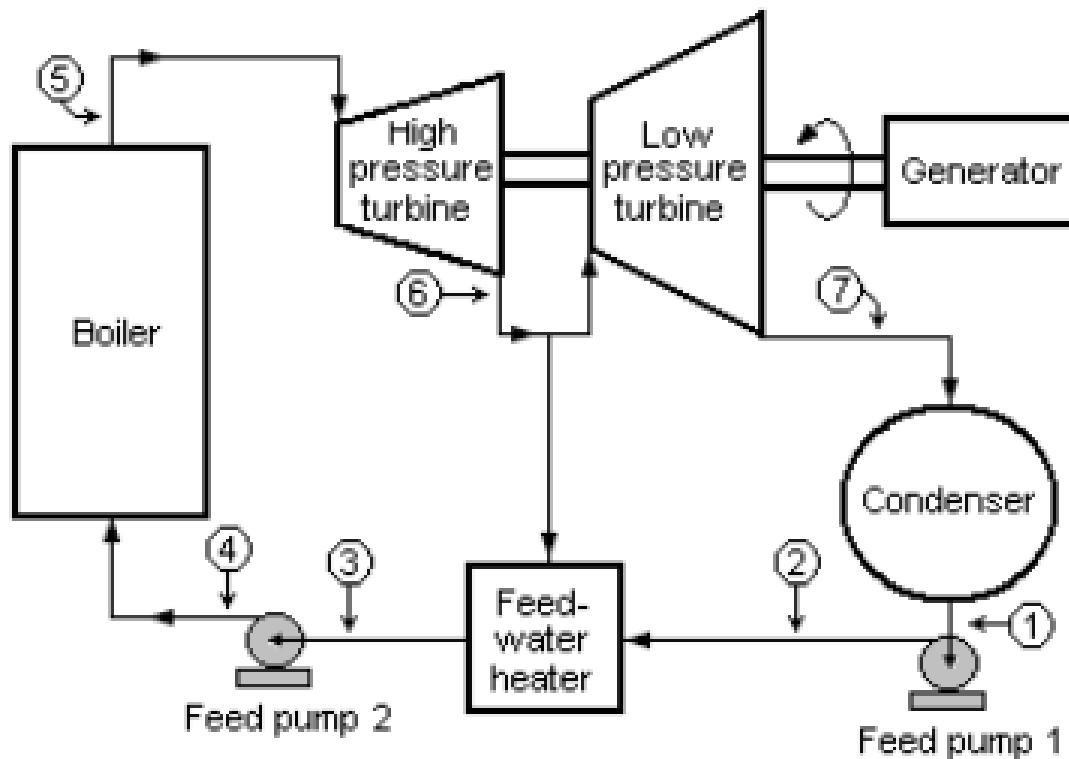
The tools described in this handout are common shipboard tools. Other tools are used but may not be listed here.

# BASIC POWER PLANT DESIGN

## LESSON 7

# Basics of Power Plant Design

**A Thermal Power Plant** – is a power plant where the “prime mover” is steam driven. In a nutshell, water is heated, turns into steam and is used to spin a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled back to the point where it was heated. This is also known as the Rankine Cycle. The greatest variation in the design of naval power plants is the difference in fuels sources, whether it be traditional boilers using coal / fuel oils or Nuclear Reactors. These systems are also used to create clean water for the ship’s crew and equipment through use of Distilling Units.



## Feed water heating and deaeration

The feed water used in the steam boiler is a means of transferring heat energy from the burning fuel to the mechanical energy of the spinning steam turbine. The total feed water consists of recirculated condensate water and purified makeup water. Because the metallic materials it contacts are subject to corrosion at high temperatures and pressures, the makeup water is highly purified before use. A system of water softeners and ion exchange demineralizers produces water so pure that it coincidentally becomes an electrical insulator! Makeup water sources are in place to offset the small losses from steam leaks in the system.

The feed water cycle begins with condensate water being pumped out of the condenser after traveling through the steam turbines.

### **Boiler operation**

A boiler is a closed vessel in which water or other fluid is heated. The heated or vaporized fluid exits the boiler for use in various processes or heating applications.

In commercial applications, the boiler is a rectangular furnace about 50 feet (15 m) on a side and 130 feet (40 m) tall. Its walls are made of a web of high pressure steel tubes about 2.3 inches (58 mm) in diameter.

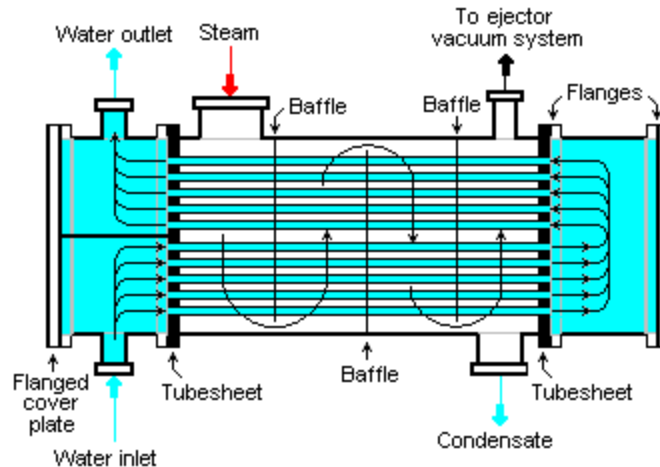
Pulverized coal is air-blown into the furnace from fuel nozzles at the four corners and it rapidly burns, forming a large fireball at the center. The thermal radiation of the fireball heats the water that circulates through the boiler tubes near the boiler perimeter. The water circulation rate in the boiler is three to four times the throughput and is typically driven by pumps. As the water in the boiler circulates it absorbs heat and changes into steam at 700 °F (371 °C) and 3,200 psi (Template:Convert/MP). It is separated from the water inside a drum at the top of the furnace. The saturated steam is introduced into superheat pendant tubes that hang in the hottest part of the combustion gases as they exit the furnace. Here the steam is superheated to 1,000 °F (500 °C) to prepare it for the turbine.

Plants that use gas turbines to heat the water for conversion into steam use boilers known as heat recovery steam generators (HRSG). The exhaust heat from the gas turbines is used to make superheated steam that is then used in a conventional water-steam generation cycle, as described in gas turbine combined-cycle plants section below

### **Steam condensing**

The condenser condenses the steam from the exhaust of the turbine into liquid to allow it to be pumped. If the condenser can be made cooler, the pressure of the exhaust steam is reduced and efficiency of the cycle increases.

*Diagram of a typical water-cooled surface condenser*



The surface condenser is a shell and tube heat exchanger in which cooling water is circulated through the tubes. The exhaust steam from the low pressure turbine enters the shell where it is cooled and converted to condensate (water) by flowing over the tubes as shown in the adjacent diagram. Such condensers use steam ejectors or rotary motor-driven exhausters for continuous removal of air and gases from the steam side to maintain vacuum.

For best efficiency, the temperature in the condenser must be kept as low as practical in order to achieve the lowest possible pressure in the condensing steam. Since the condenser temperature can almost always be kept significantly below 100 °C where the vapor pressure of water is much less than atmospheric pressure, the condenser generally works under vacuum. Thus leaks of non-condensable air into the closed loop must be prevented.

The limiting factor is the temperature of the cooling water and that, in turn, is limited by the prevailing average climatic conditions at the power plant's location (it may be possible to lower the temperature beyond the turbine limits during winter, causing excessive condensation in the turbine). Plants operating in hot climates may have to reduce output if their source of condenser cooling water becomes warmer; unfortunately this usually coincides with periods of high electrical demand for air conditioning.

### **Steam turbine generator**

The turbine generator consists of a series of steam turbines interconnected to each other and a generator on a common shaft. There is a high pressure turbine at one end, followed by an intermediate pressure turbine, two low pressure turbines, and the generator. As steam moves through the system and loses pressure and thermal energy it expands in volume, requiring increasing diameter and longer blades at each succeeding stage to extract the remaining energy. The entire rotating mass may be over 200 metric tons and

100 feet (30 m) long. It is so heavy that it must be kept turning slowly even when shut down (at 3 rpm) so that the shaft will not bow even slightly and become unbalanced. This is so important that it is one of only five functions of blackout emergency power batteries on site. Other functions are emergency lighting, communication, station alarms and turbogenerator lube oil.

Superheated steam from the boiler is delivered through 14–16-inch (360–410 mm) diameter piping to the high pressure turbine where it falls in pressure to 600 psi (4.1 MPa) and to 600 °F (320 °C) in temperature through the stage. It exits via 24–26-inch (610–660 mm) diameter cold reheat lines and passes back into the boiler where the steam is reheated in special reheat pendant tubes back to 1,000 °F (500 °C). The hot reheat steam is conducted to the intermediate pressure turbine where it falls in both temperature and pressure and exits directly to the long-bladed low pressure turbines and finally exits to the condenser.

The generator, 30 feet (9 m) long and 12 feet (3.7 m) in diameter, contains a stationary stator and a spinning rotor, each containing miles of heavy copper conductor—no permanent magnets here. In operation it generates up to 21,000 amperes at 24,000 volts AC (504 MWe) as it spins at either 3,000 or 3,600 rpm, synchronized to the power grid. The rotor spins in a sealed chamber cooled with hydrogen gas, selected because it has the highest known heat transfer coefficient of any gas and for its low viscosity which reduces windage losses. This system requires special handling during startup, with air in the chamber first displaced by carbon dioxide before filling with hydrogen. This ensures that the highly explosive hydrogen–oxygen environment is not created.

The electricity flows to a distribution center where transformers increase the voltage for transmission to its destination.

The steam turbine-driven generators have auxiliary systems enabling them to work satisfactorily and safely. The steam turbine generator being rotating equipment generally has a heavy, large diameter shaft. The shaft therefore requires not only supports but also has to be kept in position while running. To minimize the frictional resistance to the rotation, the shaft has a number of bearings. The bearing shells, in which the shaft rotates, are lined with a low friction material like Babbitt metal. Oil lubrication is provided to further reduce the friction between shaft and bearing surface and to limit the heat generated.

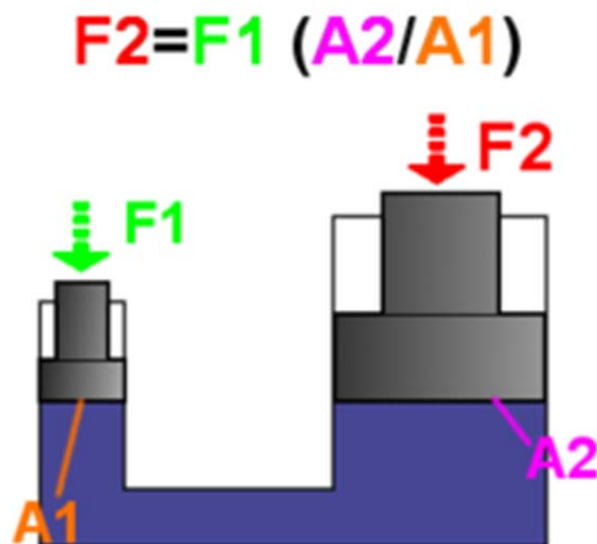


# HYDRAULICS, PNEUMATICS AND WELDING

## LESSON 8



**Hydraulics** is a topic in applied science and engineering dealing with the mechanical properties of liquids. Fluid mechanics provides the theoretical foundation for hydraulics, which focuses on the engineering uses of fluid properties. In fluid power, hydraulics is used for the generation, control, and transmission of power by the use of pressurized liquids. Hydraulic topics range through most science and engineering disciplines, and cover concepts such as pipe flow, dam design, fluidics and fluid control circuitry, pumps, turbines, hydropower, computational fluid dynamics, flow measurement, river channel behavior and erosion.



A **hydraulic press** is a machine (see machine press) using a hydraulic cylinder to generate a compressive force. It uses the hydraulic equivalent of a mechanical lever, and was also known as a Bramah press after the inventor, Joseph Bramah, of England. He invented and was issued a patent on this press in 1795. As Bramah (who is also known for his development of the flush toilet) installed toilets, he studied the existing literature on the motion of fluids and put this knowledge into the development of the press. The hydraulic press depends on Pascal's principle: the pressure throughout a closed system is constant. One part of the system is a piston acting as a pump, with a modest mechanical force acting on a small cross-sectional area; the other part is a piston with a larger area which generates a correspondingly large mechanical force. Only small-diameter tubing (which more easily resists pressure) is needed if the pump is separated from the press cylinder.

**Pascal's law:** Pressure on a confined fluid is transmitted undiminished and acts with equal force on equal areas and at 90 degrees to the container wall.

A fluid, such as oil, is displaced when either piston is pushed inward. The small piston, for a given distance of movement, displaces a smaller amount of volume than the large piston, which is proportional to the ratio of areas of the heads of the pistons. Therefore, the small piston must be moved a large distance to get the large piston to move significantly. The distance the large piston will move is the distance that the small piston is moved divided by the ratio of the areas of the heads of the pistons. This is how energy, in the form of work in this case, is conserved and the Law of Conservation of Energy is satisfied. Work is force times distance, and since the force is increased on the larger piston, the distance the force is applied over must be decreased.

The pressurized fluid used, if not generated locally by a hand or mechanically-powered pump, can be obtained by opening a valve which is connected to a hydraulic accumulator or a continuously-running pump whose pressure is regulated by a relief valve. When it is desired to generate more force than the available pressure would allow, or use smaller, higher-pressure cylinders to save size and weight, a hydraulic intensifier can be used to increase the pressure acting on the press cylinder.

When the pressure on the press cylinder is released (the fluid returning to a reservoir), the force created in the press is reduced to a low value (which depends on the friction of the cylinder's seals). The main piston does not retract to its original position unless an additional mechanism is employed.



## **Pneumatics**

Pneumatics is a branch of technology, which deals with the study and application of use of pressurized gas to effect mechanical motion.

Pneumatic systems are extensively used in industry, where factories are commonly plumbed with compressed air or compressed inert gases. This is because a centrally located and electrically powered compressor that powers cylinders and other pneumatic devices through solenoid valves is often able to provide motive power in a cheaper, safer, more flexible, and more reliable way than a large number of electric motors and actuators..

## **Gases used in pneumatic systems**

Pneumatic systems in fixed installations such as factories use compressed air because a sustainable supply can be made by compressing atmospheric air. The air usually has moisture removed and a small quantity of oil added at the compressor, to avoid corrosion of mechanical components and to lubricate them.

Any compressed gas other than air is an asphyxiation hazard - including nitrogen, which makes up 77% of air. Compressed oxygen (approx. 23% of air) would not asphyxiate, but it would be an extreme fire hazard, so is never used in pneumatically powered devices.

Portable pneumatic tools and small vehicles such as Robot Wars machines and other hobbyist applications are often powered by compressed carbon dioxide because containers designed to hold it such as soda stream canisters and fire extinguishers are readily available, and the phase change between liquid and gas makes it possible to obtain a larger volume of compressed gas from a lighter container than compressed air would allow. Carbon dioxide is an asphyxiant and can also be a freezing hazard when vented inappropriately.

## **Comparison to hydraulics**

Both pneumatics and hydraulics are applications of fluid power. Pneumatics uses an easily compressible gas such as air or a suitable pure gas, while hydraulics uses relatively incompressible liquid media such as oil. Most industrial pneumatic applications use pressures of about 80 to 100 psi. Hydraulics applications commonly use from 1,000 to 5,000 psi, but specialized applications may exceed 10,000 psi.

## **Advantages of pneumatics**

- Simplicity of Design And Control .
  - Machines are easily designed using standard cylinders & other components. Control is as easy as it is simple ON - OFF type control.
- Reliability

- Pneumatic systems tend to have long operating lives and require very little maintenance.
- Because gas is compressible, the equipment is less likely to be damaged by shock. The gas in pneumatics absorbs excessive force, whereas the fluid of hydraulics directly transfers force.
- Storage
  - Compressed gas can be stored, allowing the use of machines when electrical power is lost.
- Safety
  - Very low chance of fire (compared to hydraulic oil).
  - Machines can be designed to be overload safe.

### **Advantages of hydraulics**

- Liquid (as a gas is also a 'fluid') does not absorb any of the supplied energy.
- Capable of moving much higher loads and providing much higher forces due to the incompressibility.
- The hydraulic working fluid is basically incompressible, leading to a minimum of spring action. When hydraulic fluid flow is stopped, the slightest motion of the load releases the pressure on the load; there is no need to "bleed off" pressurized air to release the pressure on the load.

## Welding

Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the workpieces and adding a filler material to form a pool of molten material (the weld pool) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the workpieces to form a bond between them, without melting the workpieces.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including open air, under water and in outer space. Welding is a potentially hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation.

Until the end of the 19th century, the only welding process was forge welding, which blacksmiths had used for centuries to join iron and steel by heating and hammering. Arc welding and oxyfuel welding were among the first processes to develop late in the century, and electric resistance welding followed soon after. Welding technology advanced quickly during the early 20th century as World War I and World War II drove the demand for reliable and inexpensive joining methods. Following the wars, several modern welding techniques were developed, including manual methods like shielded metal arc welding, now one of the most popular welding methods, as well as semi-automatic and automatic processes such as gas metal arc welding, submerged arc welding, flux-cored arc welding and electroslag welding. Developments continued with the invention of laser beam welding, electron beam welding, electromagnetic pulse welding and friction stir welding in the latter half of the century. Today, the science continues to advance. Robot welding is commonplace in industrial settings, and researchers continue to develop new welding methods and gain greater understanding of weld quality and properties.

### Key Welding Processes

One of the most common types of arc welding is shielded metal arc welding (SMAW); it is also known as manual metal arc welding (MMA) or stick welding. Electric current is used to strike an arc between the base material and consumable electrode rod, which is made of steel and is covered with a flux that protects the weld area from oxidation and contamination by producing carbon dioxide (CO<sub>2</sub>) gas during the welding process. The electrode core itself acts as filler material, making a separate filler unnecessary.

**Shielded metal arc welding:** The process is versatile and can be performed with relatively inexpensive equipment, making it well suited to shop jobs and field work. An operator can become reasonably proficient with a modest amount of training and can achieve mastery with experience. Weld times are rather slow, since the consumable electrodes must be frequently replaced and because slag, the residue from the flux, must be chipped away after welding. Furthermore, the process is generally limited to welding ferrous materials, though special electrodes have made possible the welding of cast iron, nickel, aluminum, copper, and other metals.

**Gas metal arc welding (GMAW),** also known as **metal inert gas or MIG welding**, is a semi-automatic or automatic process that uses a continuous wire feed as an electrode and an inert or semi-inert gas mixture to protect the weld from contamination. Since the electrodeOne of the most common types of arc welding is shielded metal arc welding (SMAW);[19] it is also known as manual metal arc welding (MMA) or stick welding. Electric current is used to strike an arc between the base material and consumable electrode rod, which is made of steel and is covered with a flux that protects the weld area from oxidation and contamination by producing carbon dioxide (CO<sub>2</sub>) gas during the welding process. The electrode core itself acts as filler material, making a separate filler unnecessary.



A related process, **flux-cored arc welding (FCAW)**, uses similar equipment but uses wire consisting of a steel electrode surrounding a powder fill material. This cored wire is more expensive than the standard solid wire and can generate fumes and/or slag, but it permits even higher welding speed and greater metal penetration.

**Gas tungsten arc welding (GTAW),** or **tungsten inert gas (TIG) welding**, is a manual welding process that uses a nonconsumable tungsten electrode, an inert or semi-inert

gas mixture, and a separate filler material.[23] Especially useful for welding thin materials, this method is characterized by a stable arc and high quality welds, but it requires significant operator skill and can only be accomplished at relatively low speeds.[23]

GTAW can be used on nearly all weldable metals, though it is most often applied to stainless steel and light metals. It is often used when quality welds are extremely important, such as in bicycle, aircraft and naval applications. A related process, plasma arc welding, also uses a tungsten electrode but uses plasma gas to make the arc. The arc is more concentrated than the GTAW arc, making transverse control more critical and thus generally restricting the technique to a mechanized process. Because of its stable current, the method can be used on a wider range of material thicknesses than can the GTAW process and it is much faster. It can be applied to all of the same materials as GTAW except magnesium, and automated welding of stainless steel is one important application of the process. A variation of the process is plasma cutting, an efficient steel cutting process.

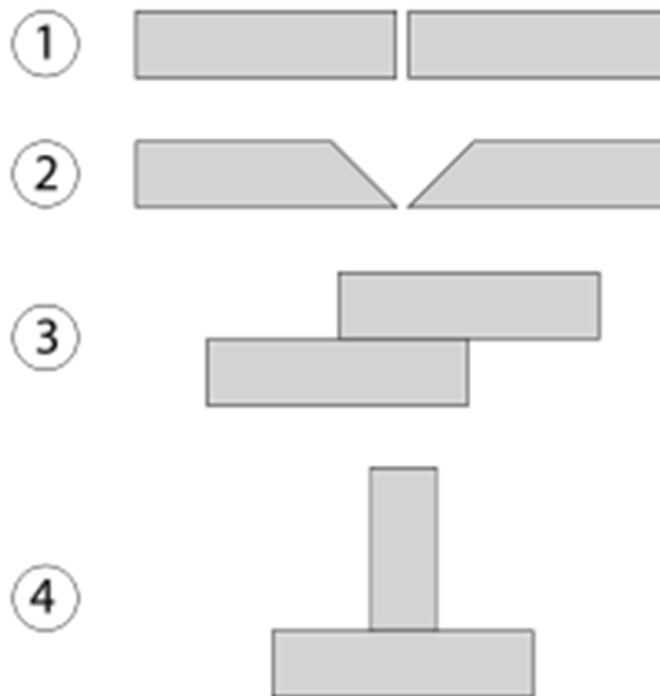
**Submerged arc welding (SAW)** is a high-productivity welding method in which the arc is struck beneath a covering layer of flux. This increases arc quality, since contaminants in the atmosphere are blocked by the flux. The slag that forms on the weld generally comes off by itself, and combined with the use of a continuous wire feed, the weld deposition rate is high. Working conditions are much improved over other arc welding processes, since the flux hides the arc and almost no smoke is produced. The process is commonly used in industry, especially for large products and in the manufacture of welded pressure vessels. Other arc welding processes include atomic hydrogen welding, electroslag welding, electrogas welding, and stud arc welding.

A related process, **flux-cored arc welding (FCAW)**, uses similar equipment but uses wire consisting of a steel electrode surrounding a powder fill material. This cored wire is more expensive than the standard solid wire and can generate fumes and/or slag, but it permits even higher welding speed and greater metal penetration.



## Geometry

Welds can be geometrically prepared in many different ways. The five basic types of weld joints are the butt joint, lap joint, corner joint, edge joint, and T-joint (a variant of this last is the cruciform joint). Other variations exist as well—for example, double-V preparation joints are characterized by the two pieces of material each tapering to a single center point at one-half their height. Single-U and double-U preparation joints are also fairly common—instead of having straight edges like the single-V and double-V preparation joints, they are curved, forming the shape of a U. Lap joints are also commonly more than two pieces thick—depending on the process used and the thickness of the material, many pieces can be welded together in a lap joint geometry.



Many welding processes require the use of a particular joint designs; for example, resistance spot welding, laser beam welding, and electron beam welding are most frequently performed on lap joints. Other welding methods, like shielded metal arc welding, are extremely versatile and can weld virtually any type of joint. Some processes can also be used to make multipass welds, in which one weld is allowed to cool, and then another weld is performed on top of it. This allows for the welding of thick sections arranged in a single-V preparation joint, for example.



*The cross-section of a welded butt joint, with the darkest gray representing the weld or fusion zone, the medium gray the heat-affected zone, and the lightest gray the base material.*

After welding, a number of distinct regions can be identified in the weld area. The weld itself is called the fusion zone—more specifically, it is where the filler metal was laid during the welding process. The properties of the fusion zone depend primarily on the filler metal used, and its compatibility with the base materials. It is surrounded by the heat-affected zone, the area that had its microstructure and properties altered by the weld. These properties depend on the base material's behavior when subjected to heat. The metal in this area is often weaker than both the base material and the fusion zone, and is also where residual stresses are found.

## Quality

Many distinct factors influence the strength of welds and the material around them, including the welding method, the amount and concentration of energy input, the weldability of the base material, filler material, and flux material, the design of the joint, and the interactions between all these factors.[36] To test the quality of a weld, either destructive or nondestructive testing methods are commonly used to verify that welds are free of defects, have acceptable levels of residual stresses and distortion, and have acceptable heat-affected zone (HAZ) properties. Types of welding defects include cracks, distortion, gas inclusions (porosity), non-metallic inclusions, lack of fusion, incomplete penetration, lamellar tearing, and undercutting. Welding codes and specifications exist to guide welders in proper welding technique and in how to judge the quality of welds.[36] Methods such as visual inspection, radiography, ultrasonic testing, dye penetrant inspection, Magnetic-particle inspection or industrial CT scanning can help with detection and analysis of certain defects.

## Heat-affected zone

The effects of welding on the material surrounding the weld can be detrimental—depending on the materials used and the heat input of the welding process used, the HAZ can be of varying size and strength. The thermal diffusivity of the base material plays a large role—if the diffusivity is high, the material cooling rate is high and the HAZ is relatively small. Conversely, a low diffusivity leads to slower cooling and a larger HAZ. The amount of heat injected by the welding process plays an important role as well, as processes like oxyacetylene welding have an unconcentrated heat input and increase the size of the HAZ. Processes like laser beam welding give a highly concentrated, limited amount of heat, resulting in a small HAZ. Arc welding falls between these two extremes, with the individual processes varying somewhat in heat input.



*The blue area results from oxidation at a corresponding temperature of 600 °F (316 °C). This is an accurate way to identify temperature, but does not represent the HAZ width. The HAZ is the narrow area that immediately surrounds the welded base metal.*

## Safety issues

Welding, without the proper precautions, can be a dangerous and unhealthy practice. However, with the use of new technology and proper protection, risks of injury and death associated with welding can be greatly reduced. Because many common welding procedures involve an open electric arc or flame, the risk of burns and fire is significant; this is why it is classified as a hot work process. To prevent them, welders wear personal protective equipment in the form of heavy leather gloves and protective long sleeve jackets to avoid exposure to extreme heat and flames. Additionally, the brightness of the weld area leads to a condition called arc eye or flash burns in which ultraviolet light causes inflammation of the cornea and can burn the retinas of the eyes. Goggles and welding helmets with dark face plates are worn to prevent this exposure, and in recent years, new helmet models have been produced that feature a face plate that self-darkens upon exposure to high amounts

*Arc welding with a welding helmet, gloves, and other protective clothing*



of UV light. To protect bystanders, translucent welding curtains often surround the welding area. These curtains, made of a polyvinyl chloride plastic film, shield nearby workers from exposure to the UV light from the electric arc, but should not be used to replace the filter glass used in helmets.

Welders are also often exposed to dangerous gases and particulate matter. Processes like flux-cored arc welding and shielded metal arc welding produce smoke containing particles of various types of oxides. The size of the particles in question tends to influence the toxicity of the fumes, with smaller particles presenting a greater danger. This is due to the fact that smaller particles have the ability to cross the blood brain barrier. Additionally, many processes produce fumes and various gases, most commonly carbon dioxide, ozone and heavy metals, that can prove dangerous without proper ventilation and training. Exposure to manganese welding fumes, for example, even at low levels (<0.2 mg/m<sup>3</sup>), may lead to neurological problems or to damage to the lungs, liver, kidneys, or central nervous system. Furthermore, because the use of compressed gases and flames in many welding processes poses an explosion and fire risk, some common precautions include limiting the amount of oxygen in the air and keeping combustible materials away from the workplace.

# PUMPS, GEARS AND PULLEYS

## LESSON 9

## Pumps

A pump is a device used to move fluids, such as liquids, gases or slurries.

A pump displaces a volume by physical or mechanical action. Pumps fall into three major groups: direct lift, displacement, and gravity pumps. Their names describe the method for moving a fluid:

### Positive Displacement

A positive displacement pump causes a fluid to move trapping a fixed amount of it then forcing (displacing) that trapped volume into the discharge pipe. Some positive displacement pumps work using an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pump as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant given each cycle of operation.

The positive displacement principle applies in the following types of pumps:

- Rotary lobe pump
- Progressive cavity pump
- Rotary gear pump
- Piston pump
- Diaphragm pump
- Screw pump
- Gear pump
- Hydraulic pump
- Vane pump

### Velocity pumps

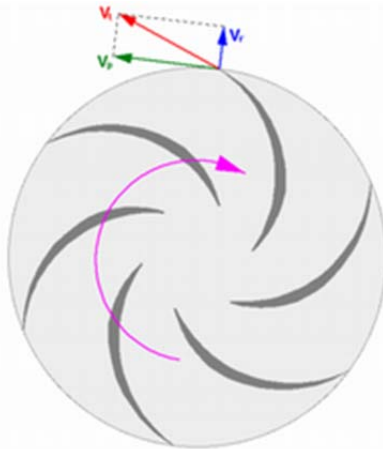
Rotodynamic pumps (or dynamic pumps) are a type of velocity pump in which kinetic energy is added to the fluid by increasing the flow velocity. This increase in energy is converted to a gain in potential energy (pressure) when the velocity is reduced prior to or as the flow exits the pump into the discharge pipe. This conversion of kinetic energy to pressure can be explained by the First law of thermodynamics or more specifically by Bernoulli's principle. Dynamic pumps can be further subdivided according to the means in which the velocity gain is achieved.

These types of pumps have a number of characteristics:

1. Continuous energy
2. Conversion of added energy to increase in kinetic energy (increase in velocity)

### 3. Conversion of increased velocity (kinetic energy) to an increase in pressure head

One practical difference between dynamic and positive displacement pumps is their ability to operate under closed valve conditions. Positive displacement pumps physically displace the fluid; hence closing a valve downstream of a positive displacement pump will result in a continual build up in pressure resulting in mechanical failure of either pipeline or pump. Dynamic pumps differ in that they can be safely operated under closed valve conditions (for short periods of time).



*A centrifugal pump uses a spinning "impeller" which has backward-swept arms*

## Gears

A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque. Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, torque, and direction of a power source. The most common situation is for a gear to mesh with another gear, however a gear can also mesh a non-rotating toothed part, called a rack, thereby producing translation instead of rotation.

The gears in a transmission are analogous to the wheels in a pulley. An advantage of gears is that the teeth of a gear prevent slipping.

When two gears of unequal number of teeth are combined a mechanical advantage is produced, with both the rotational speeds and the torques of the two gears differing in a simple relationship.

In transmissions which offer multiple gear ratios, such as bicycles and cars, the term gear, as in first gear, refers to a gear ratio rather than an actual physical gear. The term is used to describe similar devices even when gear ratio is continuous rather than discrete, or when the device does not actually contain any gears, as in a continuously variable transmission.

The earliest known reference to gears was circa A.D. 50 by Hero of Alexandria, but they can be traced back to the Greek mechanics of the Alexandrian school in the 3rd century B.C. and were greatly developed by the Greek polymath Archimedes (287–212 B.C.). The Antikythera mechanism is an example of a very early and intricate geared device, designed to calculate astronomical positions. Its time of construction is now estimated between 150 and 100 BC



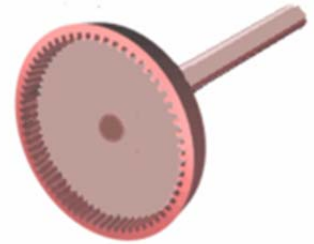
*Two meshing gears transmitting rotational motion. Note that the smaller gear is rotating faster. Although the larger gear is rotating less quickly, its torque is proportionally greater.*



## Types

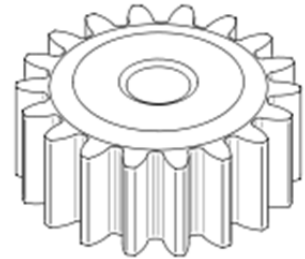
### External vs Internal gears

An external gear is one with the teeth formed on the outer surface of a cylinder or cone. Conversely, an internal gear is one with the teeth formed on the inner surface of a cylinder or cone. For bevel gears, an internal gear is one with the pitch angle exceeding 90 degrees. Internal gears do not cause direction reversal.[5]



### Spur

Spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radially, and although they are not straight-sided in form, the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears can be meshed together correctly only if they are fitted to parallel shafts.



### Helical

Helical or "dry fixed" gears offer a refinement over spur gears. The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling causes the tooth shape to be a segment of a helix. Helical gears can be meshed in a parallel or crossed orientations. The former refers to when the shafts are parallel to each other; this is the most common orientation. In the latter, the shafts are non-parallel, and in this configuration are sometimes known as "skew gears".

The angled teeth engage more gradually than do spur gear teeth causing them to run more smoothly and quietly. With parallel helical gears, each pair of teeth first make contact at a single point at one side of the gear wheel; a moving curve of contact then grows gradually across the tooth face to a maximum then recedes until the teeth break contact at a single point on the opposite side. In spur gears teeth suddenly meet at a line contact across their entire width causing stress and noise. Spur gears make a characteristic whine at high speeds. Whereas spur gears are used for low speed applications and those situations where noise control is not a problem, the use of helical gears is indicated when the application involves high speeds, large power transmission, or where noise abatement is important.



A disadvantage of helical gears is a resultant thrust along the axis of the gear, which needs to be accommodated by appropriate thrust bearings, and a greater degree of sliding friction between the meshing teeth, often addressed with additives in the lubricant.

## Double Helical

Double helical gears, or herringbone gear, overcome the problem of axial thrust presented by "single" helical gears by having two sets of teeth that are set in a V shape. Each gear in a double helical gear can be thought of as two standard mirror image helical gears stacked. This cancels out the thrust since each half of the gear thrusts in the opposite direction. Double helical gears are more difficult to manufacture due to their more complicated shape.



For each possible direction of rotation, there are two possible arrangements of two oppositely-oriented helical gears or gear faces. In one possible orientation, the helical gear faces are oriented so that the axial force generated by each is in the axial direction away from the center of the gear; this arrangement is unstable. In the second possible orientation, which is stable, the helical gear faces are oriented so that each axial force is toward the mid-line of the gear. In both arrangements, when the gears are aligned correctly, the total (or net) axial force on each gear is zero. If the gears become misaligned in the axial direction, the unstable arrangement generates a net force for disassembly of the gear train, while the stable arrangement generates a net corrective force. If the direction of rotation is reversed, the direction of the axial thrusts is reversed, a stable configuration becomes unstable, and vice versa.

Stable double helical gears can be directly interchanged with spur gears without any need for different bearings.

## Bevel

A bevel gear is shaped like a right circular cone with most of its tip cut off. When two bevel gears mesh their imaginary vertices must occupy the same point. Their shaft axes also intersect at this point, forming an arbitrary non-straight angle between the shafts. The angle between the shafts can be anything except zero or 180 degrees. Bevel gears with equal numbers of teeth and shaft axes at 90 degrees are called miter gears.



Spiral bevel gears have the same advantages and disadvantages relative to their straight-cut cousins as helical gears do to spur gears. Straight bevel gears are generally used only at speeds below 5 m/s (1000 ft/min), or, for small gears, 1000 r.p.m.

## Worm

Worm gears resemble screws. A worm gear is usually meshed with a spur gear or a helical gear, which is called the gear, wheel, or worm wheel.

Worm-and-gear sets are a simple and compact way to achieve a high torque, low speed gear ratio. For example, helical gears are normally limited to gear ratios of less than 10:1 while worm-and-gear sets vary from 10:1 to 500:1. A disadvantage is the potential for considerable sliding action, leading to low efficiency.

Worm gears can be considered a species of helical gear, but its helix angle is usually somewhat large (close to 90 degrees) and its body is usually fairly long in the axial direction; and it is these attributes which give it screw like qualities. The distinction between a worm and a helical gear is made when at least one tooth persists for a full rotation around the helix. If this occurs, it is a 'worm'; if not, it is a 'helical gear'. A worm may have as few as one tooth. If that tooth persists for several turns around the helix, the worm will appear, superficially, to have more than one tooth, but what one in fact sees is the same tooth reappearing at intervals along the length of the worm. The usual screw nomenclature applies: a one-toothed worm is called single thread or single start; a worm with more than one tooth is called multiple thread or multiple start. The helix angle of a worm is not usually specified. Instead, the lead angle, which is equal to 90 degrees minus the helix angle, is given.



In a worm-and-gear set, the worm can always drive the gear. However, if the gear attempts to drive the worm, it may or may not succeed. Particularly if the lead angle is small, the gear's teeth may simply lock against the worm's teeth, because the force component circumferential to the worm is not sufficient to overcome friction. Worm-and-gear sets that do lock are called self locking, which can be used to advantage, as for instance when it is desired to set the position of a mechanism by turning the worm and then have the mechanism hold that position. An example is the machine head found on some types of stringed instruments.

Worm gears can be right or left-handed following the long established practice for screw threads.

## **Rack and Pinion**

A rack is a toothed bar or rod that can be thought of as a sector gear with an infinitely large radius of curvature. Torque can be converted to linear force by meshing a rack with a pinion: the pinion turns; the rack moves in a straight line. Such a mechanism is used in automobiles to convert the rotation of the steering wheel into the left-to-right motion of the tie rod(s). Racks also feature in the theory of gear geometry, where, for instance, the tooth shape of an interchangeable set of gears may be specified for the rack (infinite radius), and the tooth shapes for gears of particular actual radii then derived from that. The rack and pinion gear type is employed in a rack railway.



## **Pulleys**

A pulley, also called a sheave or a drum, is a mechanism composed of a wheel on an axle or shaft that may have a groove between two flanges around its circumference. A rope, cable, belt, or chain usually runs over the wheel and inside the groove, if present. Pulleys are used to change the direction of an applied force, transmit rotational motion, or realize a mechanical advantage in either a linear or rotational system of motion. It is one of the six simple machines. Two or more pulleys together are called a block and tackle.

## **Belt and pulley systems**

A belt and pulley system is characterized by two or more pulleys in common to a belt. This allows for mechanical power, torque, and speed to be transmitted across axles. If the pulleys are of differing diameters, a mechanical advantage is realized.

A belt drive is analogous to that of a chain drive, however a belt sheave may be smooth (devoid of discrete interlocking members as would be found on a chain sprocket, spur gear, or timing belt) so that the mechanical advantage is approximately given by the ratio of the pitch diameter of the sheaves only, not fixed exactly by the ratio of teeth as with gears and sprockets.

In the case of a drum-style pulley, without a groove or flanges, the pulley often is slightly convex to keep the flat belt centered. It is sometimes referred to as a crowned pulley. Though once widely used in factory line shafts, this type of pulley is still found driving the rotating brush in upright vacuum cleaners.

## **Rope and pulley systems**

Also called block and tackles, rope and pulley systems (the rope may be a light line or a strong cable) are characterized by the use of one rope transmitting a linear motive force (in tension) to a load through one or more pulleys for the purpose of pulling the load (often against gravity.) They are often included in lists of simple machines.

In a system of a single rope and pulleys, when friction is neglected, the mechanical advantage gained can be calculated by counting the number of rope lengths exerting force on the load. Since the tension in each rope length is equal to the force exerted on the free end of the rope, the mechanical advantage is simply equal to the number of ropes pulling on the load. For example, in Diagram 3 below, there is one rope attached to the load, and 2 rope lengths extending from the pulley attached to the load, for a total of 3 ropes supporting it. If the force applied to the free end of the rope is 10 lb, each of these rope lengths will exert a force of 10 lb. on the load, for a total of 30 lb. So the mechanical advantage is 3.

The force on the load is increased by the mechanical advantage; however the distance the load moves, compared to the length the free end of the rope moves, is decreased in the same proportion. Since a slender cable is more easily managed than a fat one (albeit shorter and stronger), pulley systems are often the preferred method of applying mechanical advantage to the pulling force of a winch (as can be found in a lift crane).

Pulley systems are the only simple machines in which the possible values of mechanical advantage are limited to whole numbers.

In practice, the more pulleys there are, the less efficient a system is. This is due to sliding friction in the system where cable meets pulley and in the rotational mechanism of each pulley.

It is not recorded when or by whom the pulley was first developed. It is believed however that Archimedes developed the first documented block and tackle pulley system, as recorded by Plutarch. Plutarch reported that Archimedes moved an entire warship, laden with men, using compound pulleys and his own strength.

The simplest theory of operation for a pulley system assumes that the pulleys and lines are weightless, and that there is no energy loss due to friction. It is also assumed that the lines do not stretch.

A hoist using the compound pulley system yielding an advantage of 4. The single fixed pulley is installed on the hoist (device). The two movable pulleys (joined together) are attached to the hook. One end of the rope is attached to the crane frame, another to the winch.

In equilibrium, the total force on the pulley must be zero. This means that the force on the axle of the pulley is shared equally by the two lines looping through the pulley. The situation is schematically illustrated in diagram 1. For the case where the lines are not parallel, the tensions in each line are still equal, but now the vector sum of all forces is zero.

A second basic equation for the pulley follows from the conservation of energy: The product of the weight lifted times the distance it is moved is equal to the product of the lifting force (the tension in the lifting line) times the distance the lifting line is moved. The weight lifted divided by the lifting force is defined as the advantage of the pulley system.

It is important to notice that a system of pulleys does not change the amount of work done. The work is given by the force times the distance moved. The pulley simply allows trading force for distance: you pull with less force, but over a longer distance.

In diagram 2, a single movable pulley allows weight  $W$  to be lifted with only half the force needed to lift the weight without assistance. The total force needed is divided between the lifting force (red arrow) and the "ceiling" which is some immovable object (such as the earth). In this simple system, the lifting force is directed in the same direction as the movement of the weight. The advantage of this system is 2. Although the force needed to lift the weight is only  $W/2$ , we will need to draw a length of rope that is twice the distance that the weight is lifted, so that the total amount of work done (Force x distance) remains the same.

A second pulley may be added as in diagram 2a, which simply serves to redirect the lifting force downward; it does not change the advantage of the system.

## How it works

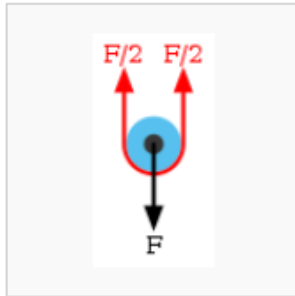


Diagram 1: A basic equation for a pulley. In equilibrium, the force  $F$  on the pulley axle is equal and opposite to the sum of the tensions in each line leaving the pulley, and these tensions are equal.

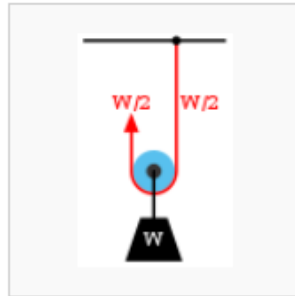


Diagram 2: A simple pulley system—a single movable pulley lifting weight  $W$ . The tension in each line is  $W/2$ , yielding an advantage of 2.

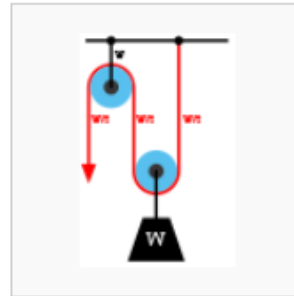
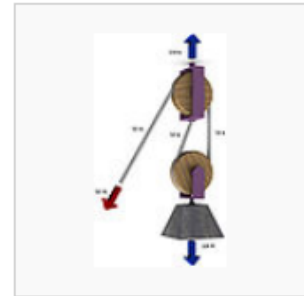


Diagram 2a: Another simple pulley system similar to diagram 2, but in which the lifting force is redirected downward



A practical compound pulley corresponding to diagram 2a

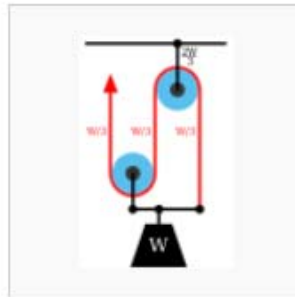


Diagram 3: A simple compound pulley system—a movable pulley and a fixed pulley lifting weight  $W$ . The tension in each line is  $W/3$ , yielding an advantage of 3.

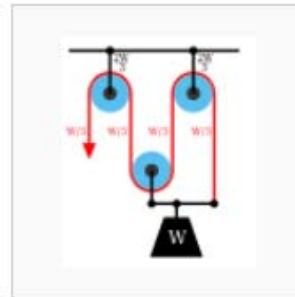


Diagram 3a: A simple compound pulley system—a movable pulley and a fixed pulley lifting weight  $W$ , with an additional pulley redirecting the lifting force downward. The tension in each line is  $W/3$ , yielding an advantage of 3.

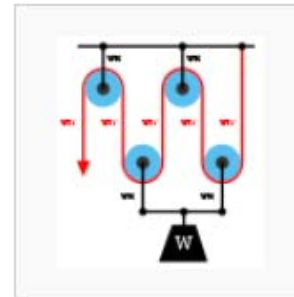


Diagram 4a: A more complicated compound pulley system. The tension in each line is  $W/4$ , yielding an advantage of 4. An additional pulley redirecting the lifting force has been added.

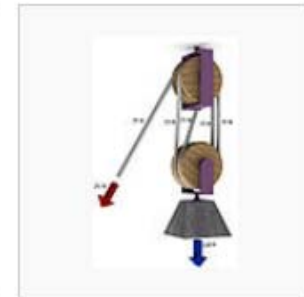


Figure 4b: A practical block and tackle pulley system corresponding to diagram 4a. Note that the axes of the fixed and movable pulleys have been combined.