

TOOLS,  
valves  
&  
MATERIALS  
For  
Marine use



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Maintenance of machineries has to be carried out regularly. Considering the ships situation, various tools, parts and materials are required to be always available onboard. Clear and good understanding of tools, parts and materials are beneficial to engineers for proper upkeep and inventory of tools.

## 8.1 Maintenance Tools

### 8.1.1 Hand Tools

#### a. Hand Spanner/Wrenches

There are different types of hand spanner and wrenches that are available in the work shop which could be selected depending on the type and condition of maintenance work to be done.

Example usage of hand spanner and wrenches:

- i. Adjustable wrench is used as easy tool for undetermined size of bolt and nut when immediate tightening is required.
- ii. Adjustable pipe wrench is suitable for fastening/loosening small sizes threaded pipes and damage head bolt in an awkward position.
- ii. Slogging spanner is used for loosening and tightening big sizes of bolts using hammer.
- iv. Instead of adjustable pipe wrench, hook spanner is used for threaded cap connection with teeth to avoid damaging the cap.
- v. Offset spanners are used when working in an awkward position jobs.
- vi. Square drive wrench is specially used for square bolts or handle.
- vii. Torque wrenches are used for a specified torque controlled tightening of bolts and nuts.



**Adjustable Wrench**



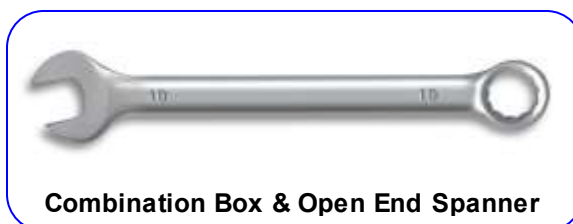
**Adjustable Pipe Wrench**



**Open Ended Slogging Spanner**



**Ring Slogging Spanner**



**Combination Box & Open End Spanner**



**Double Open Ended Spanner**



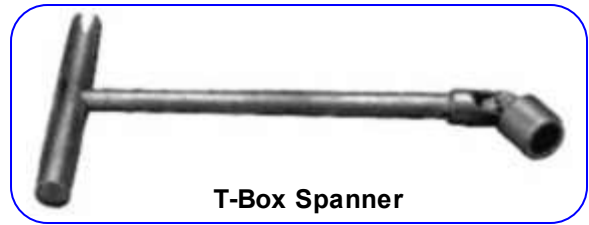
**Single Open Ended Spanner**



**Double Ended Offset Ring Spanner**



**Hook Spanner**



**T-Box Spanner**



**Socket Wrench Ratchet Handle**



**6 & 12 Points Socket Wrench**



**Square Drive Wrench**



**Claw Bar**



**Manual Reading Torque Wrench**



**Automatic Reading Torque Wrench**

## b. Pliers

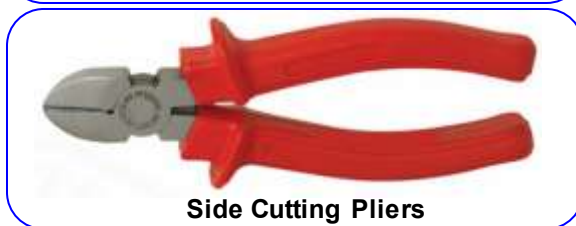
Pliers are designed primarily for gripping objects using leverage. Different types are available which can be also used for cutting wires, crimping of wire connectors, removing of snap wring, etc.,



**Vise Grip**



**Water Pump Pliers**



**Side Cutting Pliers**



**Combination Pliers**



**End Cutting Pliers**



**Long Nose Pliers**



**Snap Ring Pliers**



**Crimping Pliers**

### c. Scissors/ Tin Snips

Scissors are used to cut thin materials with a slight force, while tin snips or metal shears are tools used to cut thin sheet of metal but are able to handle thicker and hard material. Three different types of tin snips are available, the straight, left handed and the right handed tin snips. Basically, cutting with ease will depends on the direction of cut and the tool you are going to use.

Straight snips are for cutting straight line, left cutting snips will cut in curve to the left and right cutting snips will cut curve to the right.



**Cloth Scissors**



**Straight Hand Snip**



**Left Hand Snip**



**Right Hand Snip**

### d. Hammers

Hammer is used to deliver blows to an object such as spanner, straightening metal plates, etc. Different types are available depending on the kind of jobs to do. For example, delivering light blows to machine parts, rubber, plastic, tin and brass hammer is used. For pounding nails and extricating it, the claw hammer is used. For making sound inspection of joints such as bolts and nuts, pin hammer or what commonly called “inspection hammer” is used. Ballpein hammer is very common tool in repairing works anywhere in the ship and in the workshop.



**Ballpein Hammer**



**Claw Hammer**



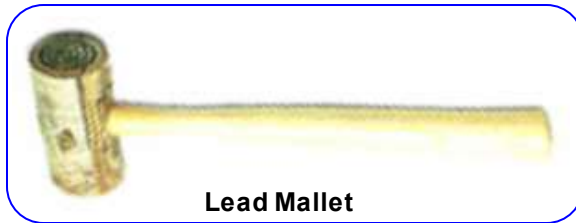
**Sledge Hammer**



**Pin Hammer**



**Rubber Mallet**



**Lead Mallet**



**Rubber/Plastic Mallet**



**Wood Mallet**



**Brass Mallet**

**e. Saw**

Commonly used saw are the cross cut saw for cutting woods in straight line and hack saw for cutting metal rods, plates etc.



**Cross Cut Saw**



**Hack Saw**

**f. Bearing and Gear Puller**

For pulling and removing of gears and bearings, special puller is used such as the 3 jaw and 2 jaw gear/bearing puller. For more balance removal of gear and bearing, the 3 jaw gear puller is more suitable to use.



**3 Jaw Gear Puller**



**2 Jaw Gear Puller**

g. Others

For measuring linear dimensions of an object, the tape measure is used in either cloth ribbon or metal ribbon tape with metric or imperial measurement markings or sometime both are marked in the tape measure.

Surveyor tape is used for linear measuring which is more convenient to use when the dimension has a great length.



**Metric Tape Measure**



**Surveyor Tape Measure**

Screwdrivers are used to insert and tighten or loosen to remove screws, comprises with a head or a tip that engage to the screw. By applying hand rotating forces the screws can be tighten or loosen by the used of these tools. An impact screwdriver is used when the screw required additional force or impact to loose from the base. Different types of screwdriver are available depending on the types of job. Also, different type of head or tip is available for driving screw. The common used screwdriver is the slotted (-) and the Phillips (+) tip.



**Plastic Handle Screwdriver**



**Impact Screwdriver**

For cutting of small diameter pipes, heavy duty pipe cutter is used. For re-tubing of various copper line or aluminum line tube cutter is used.

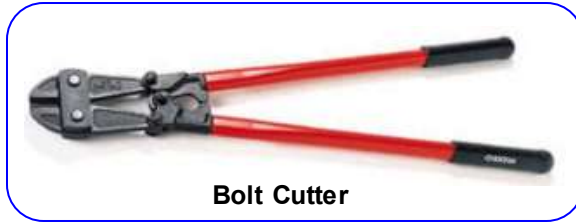


**Heavy Duty Pipe Cutter**



**Tube Cutter**

Bolt cutter is used cutting small diameter rods or bolts with a straight blade and cable or wire rope cutter is used for cutting steel wire ropes with curve blades.



**Bolt Cutter**



**Cable or Wire Rope Cutter**

Portable hydraulic devices such as the hydraulic hand pump and portable cylinders are used for lifting heavy equipment. The portable cylinders are specially used for inching the cylinder liners for facilitation of easy removal from the casing of a diesel engine. The hydraulic hand pump can also be used for torque tightening, manually opening and closing of hydraulically valves in the ballast piping system and other special purposes.



**Hydraulic Hand Pump**



**Portable Jack Cylinders**

Different types of sealant and adhesives are used for maintenance purposes onboard. Some sealant requires special applicator such as the gun applicator and others. The most common used sealant and adhesive is the silicon.



**Gun and Silicon Tube**



**Sealant and Adhesives**

Cold chisels and pin puncher are used for cutting and driving metal pieces at work.



**Cold Chisels**



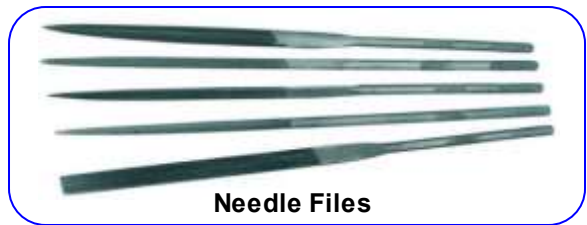
**Pin Puncher**

Allen wrench or sometimes called "hex key" are used to drive screws with inner hexagonal head in different sizes.

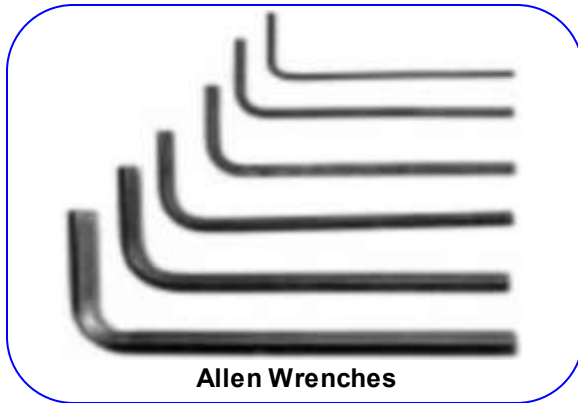
Hand file is use to shape materials by cutting. Different shapes are available such as flat, round, triangle, oval, etc., and file's teeth can range from rough, course and bastard.



**Allen Key Set**



**Needle Files**



**Allen Wrenches**



**Hand Files Set**

Table hand vice is used for holding work material for dismantling, assembling, shaping, etc. It is bolted in the work table and the locking jaw is operated by special square threaded rod that can be rotated by a T-handle.

The anvil is made of hard and massive block and used to support a work material for hammering, chiseling and shaping by hammer.



**Table Hand Vice**



**Anvil**

Gasket holes puncher is used to create hole for gasket and packing materials. When creating holes for hard gasket or packing materials such as compressed fiber, carbon steel, etc., it is best suited to use the table gasket hole puncher than the ordinary hole puncher. The ordinary hole puncher is suitably used for rubber and other soft materials.



**Table Gasket Hole Puncher**



**Gasket Hole Puncher**



## 8.1.2 Power Tools

Power tools onboard are tools powered by electric, pneumatic (air) and sometimes by a gasoline engine. These tools can be classified either stationary or portable.

Stationary tools are commonly fixed in the table or in a base footing in the workshop. Portable tools are hand held tools that can be brought in any work area.

A bench grinder is a machine that drives an abrasive wheel and maybe used for sharpening tools such as for lathe machine and drill bits or shaping work materials. A wire brush or buffing wheels are often mounted in one side in place of the grinding wheel and used to clean or polish work-pieces.

A drill bench press is a stationary machine that is mounted on the floor and used to do fixed style of drilling hole into a work piece. This type of drill has more advantage than a portable drill, as the working lever is driven by a pinion and gear, the work piece is fasten into a vice and the angle of spindle is fixed in relation to the table.



**Electric Bench Grinder**



**Electric Drill Bench Press**

Portable devices are used for cutting, shaping and drilling are also provided in the engine room workshop.



**Portable Electric Angle Grinder**



**Portable Electric Drill**

A pneumatic impact wrench is a socket wrench hand tool and designed to deliver high torque output with minimal exertion by the user. This type of hand power tools is commonly used for loosening bolts and nuts in a fixture. Precaution has to be applied when used in tightening of bolts and nuts as it will impart high amount of torque that can cause deformation to the fastening materials.

A pneumatic jet chisel is used for chipping and de-rusting loose paints, rusts, etc.



**Pneumatic Impact Wrench**



**Pneumatic Jet Chisel**

### 8.1.3 Lathe Machine



**Dainichi Lathe Machine Type DE-1000**



**Head Stock**



**Tool Post**



**Tail Stock**

#### a. Operation of the Lathe Machine

An engine lathe similar to the one shown above is found in every machine shop. It is used mostly for turning, boring, facing, and thread cutting. But it may also be used for drilling, reaming, knurling, grinding, spinning, and spring winding.

The work held in the engine lathe can be revolved at any one of a number of different speeds, and the cutting tool can be accurately controlled by hand or power for longitudinal feed and crossfeed. (Longitudinal feed is the movement of the cutting tool parallel to the axis of the lathe; crossfeed is the movement of the cutting tool perpendicular to the axis of the lathe.)

Lathe size is determined by two measurements:

- i. the diameter of work it will swing (turn) over the ways and;
- ii. the length of the bed. For example, a 14-inch by 6-foot lathe will swing work up to 14 inches in diameter and has a bed that is 6 feet long.

### 8.1.4 Welding and Cutting Equipment

#### a. Hot Work Procedure

S-091000-01FRM

**HOT WORK PERMIT**

This permit is to be completed prior to any welding or burning operation being performed outside of the engine room workshop (and in the room where associated with fuel tank and fuel oil piping).

SHIP'S NAME: \_\_\_\_\_ DATE: \_\_\_\_\_

1. Description of work: \_\_\_\_\_

2. Location of work: \_\_\_\_\_

3. Equipment to be used: \_\_\_\_\_

4. Precaution

a) Working area to be free from combustible materials .....	YES/NO
b) Combustible gas test to be taken and area to be free from gas .....	YES/NO
(Combustible gas % LFL Reading: _____ )	
c) Has the equipment or pipeline been gas freed? .....	YES/NO
d) Has the equipment or pipeline been blanked? .....	YES/NO
e) Is the equipment or pipeline free or liquid? .....	YES/NO
f) Is the equipment isolated electrically? .....	YES/NO
g) Is the surrounding area safe? .....	YES/NO
h) Adjacent area/space to be free from combustible materials .....	YES/NO
i) Ventilation of the working area to be adequate .....	YES/NO
j) Firefighting equipment to be provided at the working location and any other risky area .....	YES/NO
k) Safe access provided .....	YES/NO
l) Special condition/Precaution: _____	

m) Test for combustible gas should be carried out immediately before commencement of hot work and at frequent interval as long as the work is in progress.

5. This permit is valid from: \_\_\_\_\_ Hrs Date: \_\_\_\_\_  
to: \_\_\_\_\_ Hrs Date: \_\_\_\_\_

6. Personnel carrying out work: \_\_\_\_\_

7. Responsible Officer in charge of the work area  
Name: \_\_\_\_\_ Signature: \_\_\_\_\_

8. This permit certifies that safety is secured.

Department Head ( \_\_\_\_\_ )      Master \_\_\_\_\_

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9. The work has been completed and all persons under my supervision, materials and equipment have been withdrawn.

Responsible Officer \_\_\_\_\_      Time and Date \_\_\_\_\_

10. This permit is hereby canceled.

Department Head( \_\_\_\_\_ )      Master \_\_\_\_\_

When carrying out hot work, the PIC on site must ensure the safety of the work by taking the following measures.

- i. The work site and vicinity shall be cleaned and checked to see that it is free of oil, rags and other flammable substances.
- ii. The work site and adjacent areas shall be checked to see that there are no flammable or explosive gases.
- iii. Easily flammable articles shall not be placed in the work site or adjacent areas.
- iv. The work site shall be thoroughly ventilated.
- v. Have portable fire extinguishers, fire hoses and other appropriate fire fighting equipment ready near the work site.
- vi. Safety for approaching the work site shall be ensured.
- vii. The persons engaged in the job shall properly use protective equipment, including goggles and gloves; and ensure to wear protective aprons in welding or flame cutting work.
- viii. Welding and other equipment to be used shall be checked free from abnormalities.
- ix. Post placards or warning signs for the protection of personnel not involves with the job.

- x. Accomplish a "Hot Work Permit" to verify proper hot work procedure and safety on site.
- b. Arc Welding Equipment



Arc welding is the fusion of two pieces of metal by an electric arc between the pieces being joined "the work pieces" and an electrode that is guided along the joint between the pieces. The electrode is either a rod that simply carries current between the tip and the work, or a rod or wire that melts and supplies filler metal to the joint.

How to do a good quality weld?

- i. Current setting:

The correct current, or amperage, setting primarily depends on the diameter and type of electrode selected. For example, a 1/8 in. 6010 rod runs well from 75 to 125 amps, while a 5/32 in. 7018 rod welds at currents up to 220 amps. The side of the electrode box usually indicates operating ranges. Select an amperage based on the material's thickness, welding position (about 15 percent less heat for overhead work compared to a flat weld) and observation of the finished weld. Most new welding machines have a permanent label that recommends amperage settings for a variety of electrodes and material thicknesses.

- ii. Length of arc:

The correct arc length varies with each electrode and application. As a good starting point, arc length should not exceed the diameter of the metal portion (core) of the electrode. Holding the electrode too closely decreases welding voltage. This creates an erratic arc that may extinguish itself or cause the rod to freeze, as well as produces a weld bead with a high crown. Excessively long arcs (too much voltage) produce spatter, low deposition rates, undercuts and maybe porosity.

Many beginners weld with too long of an arc, so they produce rough beads with lots of spatter. A little practice will show you that a tight, controlled arc length improves bead appearance, creates a narrower bead and minimizes spatter.

- iii. Angle of travel:

Stick welding in the flat, horizontal and overhead position uses a "drag" or "backhand" welding technique. Hold the rod perpendicular to the joint and tilt the top of the electrode

in the direction of travel approximately 5 to 15 degrees. For welding vertical up, use a "push" or "forehand" technique and tilt the top of the rod 15 degrees away from the direction of travel.

iv. Manipulation:

Each welder manipulates or weaves the electrode in a unique style. Develop your own style by observing others, practicing and creating a method that produces good results for you. Note that on material 1/4 in. and thinner, weaving the rod typically creates a bead that is wider than necessary. In many instances, plain, straight-ahead travel works fine.

To create a wider bead on thicker material, manipulate the electrode from side to side creating a continuous series of partially overlapping circles, or in a "Z," semi-circle or stutter-step pattern. Limit side-to-side motion to 2-1/2 times the diameter of the electrode core. To cover a wider area, make multiple passes or "stringer beads."

When making a vertical up welding, focus on welding the sides of the joint and the middle will take care of itself. Pause slightly at the side to allow the far side of the bead to cool, the weld puddle to catch up, and to ensure solid "tie-in" to the sidewall. If your weld looks like fish scales, you moved forward too quickly and didn't hold long enough on the sides.

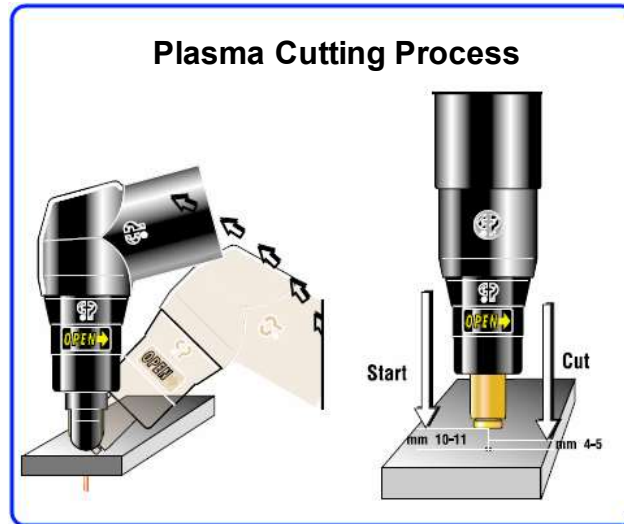
v. Speed of travel:

The proper travel speed produces a weld bead with the desired contour (or "crown"), width and appearance. Adjust travel speed so that the arc stays within the leading one-third of the weld pool. Slow travel speeds produce a wide, convex bead with shallow penetration. Excessively high travel speeds also decrease penetration, create a narrower and/or highly crowned bead, and possibly undercuts.

Always remember that you need a good view of the weld puddle. Otherwise, you can't ensure you're welding in the joint, keeping the arc on the leading edge of the puddle and using the right amount of heat (you can actually see a puddle with too much heat roll out of the joint). For the best view, keep your head off to the side and out of the smoke so you can easily see the puddle.

c. Plasma Cutting Equipment





Plasma Arc Cutting is a process where an open arc can be constricted by passing through a small nozzle, or orifice, from the electrode to the work piece. The gas used is typically air and it combines with an electrical current to create a high temperature plasma arc. When placed in contact with an electrically conductive material, the arc passes through the metal, melting a thin area. The force of the arc pushes the molten metal through the work piece and severs the material.

For the cutting process first a pilot arch between nozzle and cathode is ignited by means of high tension. This low energy pilot arch prepares the distance between plasma burner and work piece by partial ionization. As soon as the pilot arch touches the work piece (flying start of cutting or piercing), the main arch is induced by an automatic increase in performance.

#### d. Oxy-Acetylene Welding and Cutting Equipment

Oxyacetylene welding, commonly referred to as gas welding, is a process which relies on combustion of oxygen and acetylene. When mixed together in correct proportions within a hand-held torch or blowpipe, a relatively hot flame is produced with a temperature of about 3,200 °C. The chemical action of the oxyacetylene flame can be adjusted by changing the ratio of the volume of oxygen to acetylene.

Three distinct flame settings are used, neutral, oxidising and carburizing.



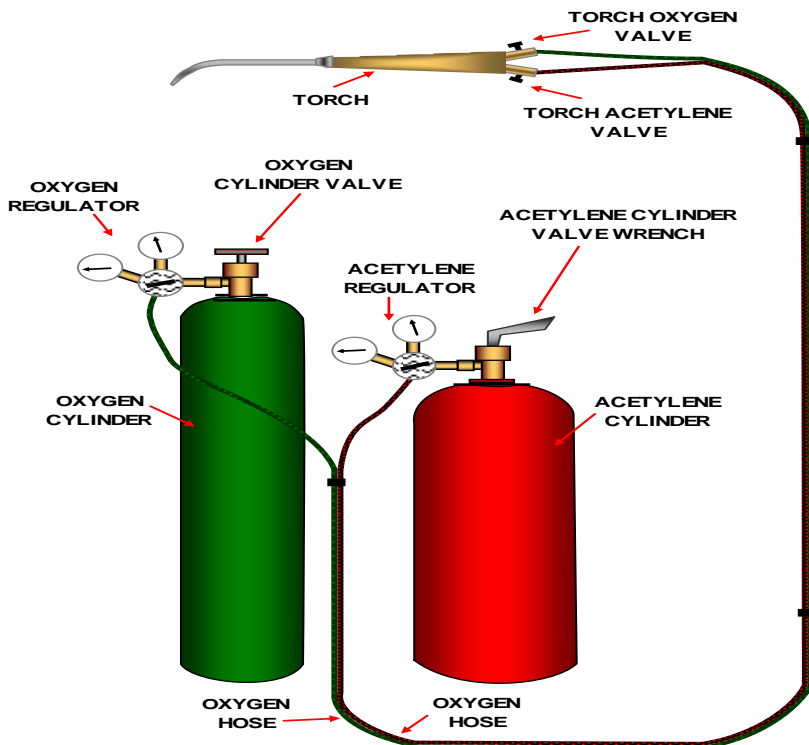


**NEUTRAL FLAME**



**CARBURIZING FLAME**

**OXY-ACETYLENE GAS WELDING OUTFIT**



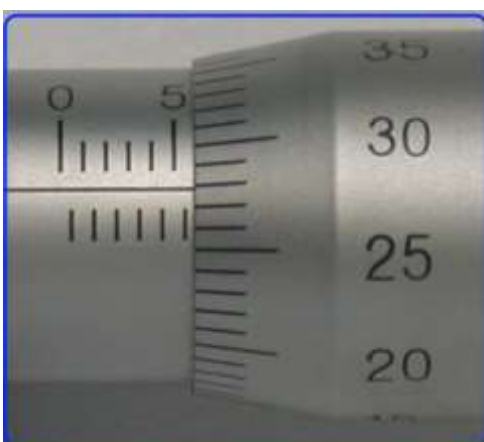
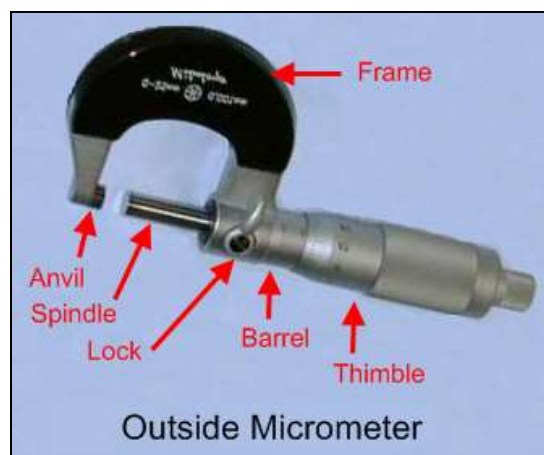
Welding is generally carried out using the neutral flame setting which has equal quantities of oxygen and acetylene. The oxidising flame is obtained by increasing just the oxygen flow rate while the carburising flame is achieved by increasing acetylene flow in relation to oxygen flow. Because steel melts at a temperature above 1,500 deg.C, the mixture of oxygen and acetylene is used as it is the only gas combination with enough heat to weld steel.

### 8.1.5 Measuring Tools

Various measuring tools are available onboard to acquire precise measurements of machinery parts and other materials. These tools are widely used to measure wear of machine parts, dimension, etc.

#### a. Micrometer

A device used for accurate and precise measurements.



#### How to Read Metric Micrometer

Determine the number divisions visible on the scale of the sleeve and add the total to the particular division on the thimble coincided with the axial line on the sleeve.

Thus;

$$\begin{aligned}\text{Micrometer Reading} &= \text{No. on the sleeve} + \text{No. on the thimble} \\ &= 5 + 0.5 + 0.28 \\ &= 5.78 \text{ mm}\end{aligned}$$

Notes:



1. The spindle of an ordinary Metric micrometer has 2 threads per millimeter and thus one complete revolution moves the spindle through a distance of 0.5 millimeter.
2. The longitudinal line on the frame is graduated with 1 millimeter divisions and 0.5 millimeter subdivisions.
3. The thimble has 50 graduations, each being 0.01 millimeter (one-hundredth of a millimeter).

b. Vernier Caliper

Vernier calipers can measure internal dimension using the upper most jaw, external dimension using the lower jaw and depth measurements using the probe that is attached to the movable head and slides along the center of the body.



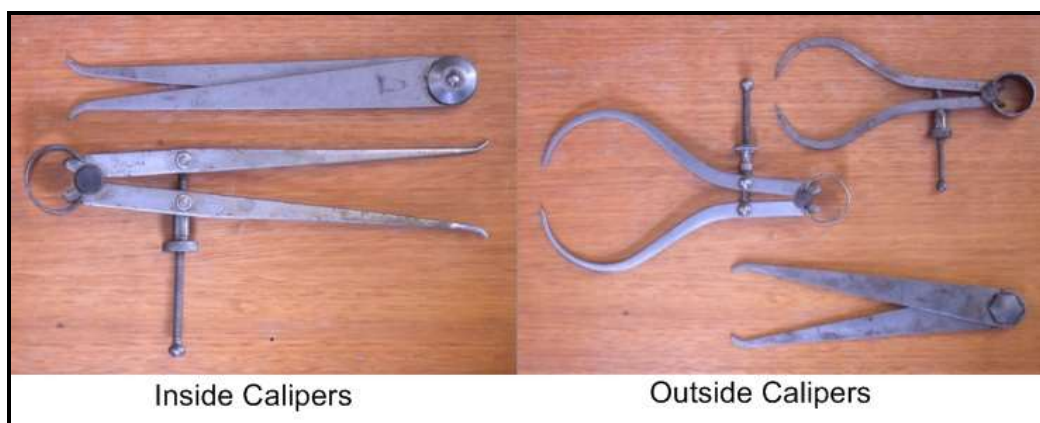
c. Thickness or Feeler Gauge

Use in measuring gaps between two components by sliding the lip of different thickness of the feeler gauge.



d. Calipers

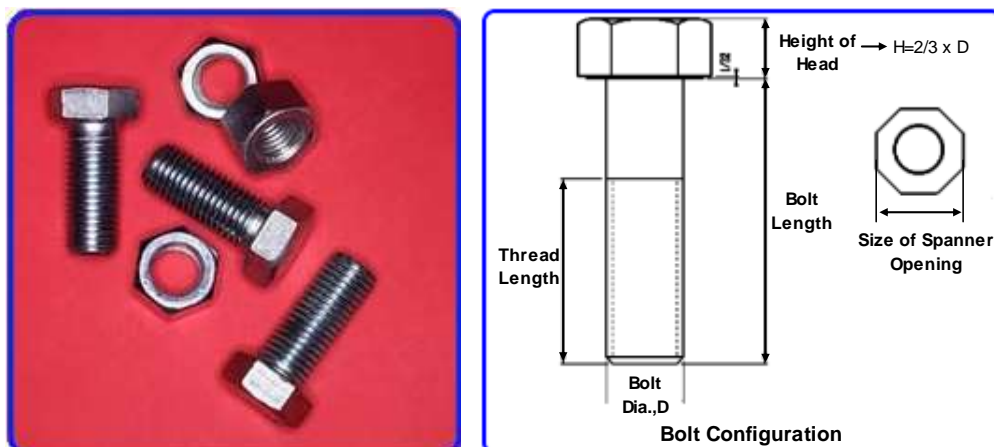
Use to measure internal and external size of an object.



## 8.2 Parts for Maintenance

### 8.2.1 Bolts and Nuts

These are used for fastening machine component parts, piping's, etc. The sizes and dimensions may vary depending on the application but the most common used in maintenance work onboard is listed below.



Nominal Size	Dimension of Spanner			Nominal Size	Dimension of Spanner		
	Hexagon Bolt		Hexagon socket head bolt		Hexagon Bolt		Hexagon socket head bolt
	General	Small-size			General	Small-size	
M3	5.5		2.4	M22	32	30	17
M4	7		3	M24	36	32	19
M5	8		4	M27	41	36	19
M6	10		5	M30	46	41	22
M8	13	12	6	M33	50	46	24
M10	17	14	8	M36	55	50	27
M12	19	17	10	M39	60	55	27
M14	22	19	12	M42	65		32
M16	24	22	14	M45	70		32
M18	27	24	14	M48	75		36
M20	30	27	17				

### 8.2.2 Steel Weld Flanges

Flanges are used to connect pipes of each length, bolted together and inserted with gasket between the faces of both flanges to prevent leakage in the piping systems. The dimensions of flanges in the piping systems are standardized in accordance to the nominal size of the pipes and the pressure rating. Slip on flange of JIS standards are commonly used onboard.

The inside diameter of the slip on flange is slightly larger than the diameter of the matching pipe. The pipe slips into the flange, welding has to be carried out on both side (inside & outside) to prevent leaks.

Flanges can be identified by pressure rating and pipe nominal size.

For example; 5k-32A flange

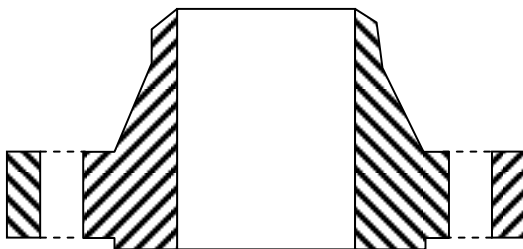
5k is the pressure rating of piping system which is equivalent to maximum 5kgf/cm<sup>2</sup>.

32A is the nominal size of the pipe at which the flange is to be used.



Slip On Flanges

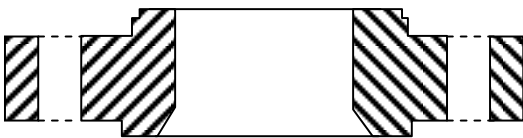
**Type of Flanges:**



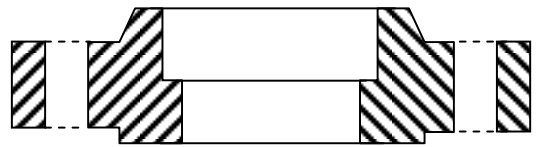
**WELD NECK**



**THREADED**



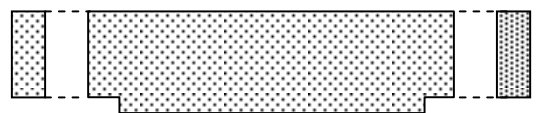
**LAP JOINT**



**SOCKET WELD**

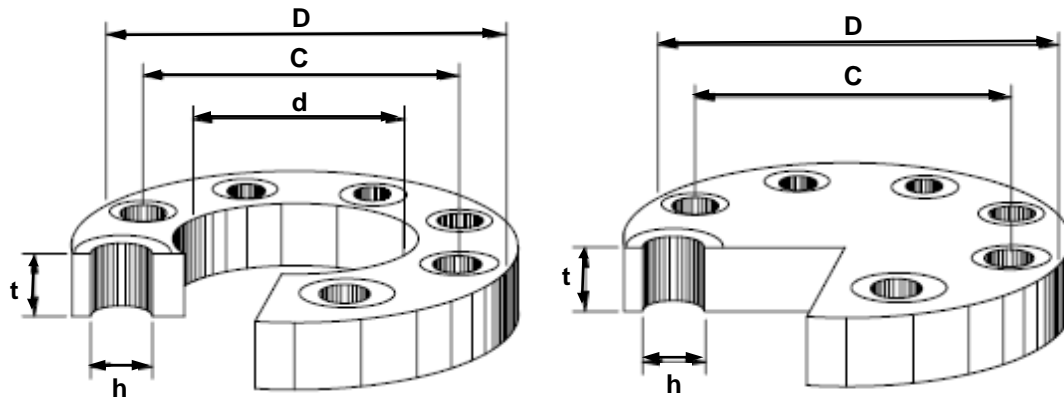


**SLIP- ON**



**BLIND**

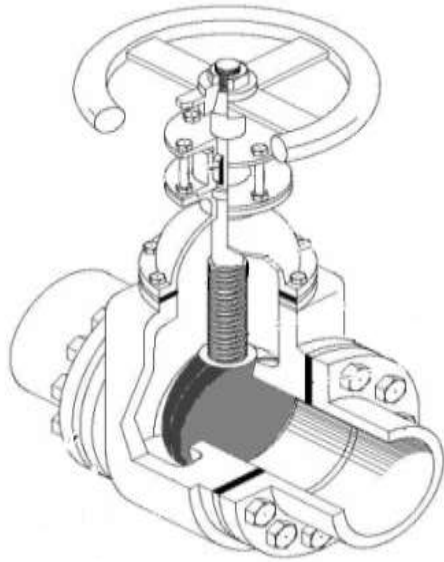
In shipboard maintenance of piping systems, JIS 5K (used for sea water and fresh water piping's, etc.), JIS10K (used for air and steam return line, etc.) and JIS 16K (use for steam and others) standard flanges are commonly used. Attached is the list of flanges sizes and dimensions of up to 300A pipe size (JIS B2220).



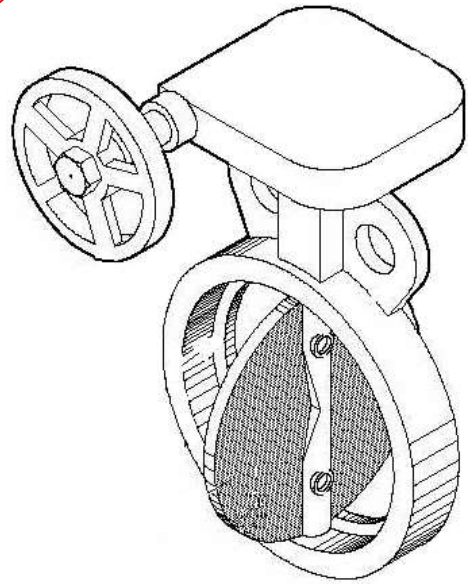
Size	JIS 5K						JIS 10K						JIS 16K					
	d (mm)	D (mm)	C (mm)	No. of bolt hole	Bolt hole dia. (mm)	t (mm)	d (mm)	D (mm)	C (mm)	No. of bolt hole	Bolt hole dia. (mm)	t (mm)	d (mm)	D (mm)	C (mm)	No. of bolt hole	Bolt hole dia. (mm)	t (mm)
10	17.8	75	55	4	12	9	17.8	90	65	4	15	12	17.8	90	65	4	15	12
15	22.2	80	60	4	12	9	22.2	95	70	4	15	12	22.2	95	70	4	15	12
20	22.7	85	65	4	12	10	22.7	100	75	4	15	14	27.7	100	75	4	15	14
25	34.5	95	75	4	12	10	34.5	125	90	4	19	14	34.5	125	90	4	19	14
32	43.2	115	90	4	15	12	43.2	135	100	4	19	16	43.2	135	100	4	19	16
40	49.1	120	95	4	15	12	49.1	140	105	4	19	16	49.1	140	105	4	19	16
50	61.1	130	105	4	15	14	61.1	155	120	4	19	16	61.1	155	120	8	19	16
65	77.1	155	130	4	15	14	77.1	175	140	4	19	18	77.1	175	140	8	19	18
80	90	180	155	4	19	14	90	185	150	8	19	18	90	200	160	8	23	20
90	102.6	190	180	4	19	14	102.6	195	160	8	19	18	102.6	210	170	8	23	20
100	115.4	200	190	8	19	16	115.4	210	175	8	19	18	115.4	225	185	8	23	22
125	141.2	235	200	8	19	16	141.2	250	210	8	23	20	141.2	270	225	8	25	22
150	166.6	265	235	8	19	18	166.6	280	240	8	23	22	166.6	305	260	12	25	24
175	192.1	300	260	8	23	18	192.1	302	265	12	23	22	-	-	-	-	-	-
200	218	320	280	8	23	20	218	330	290	12	23	22	218	350	305	25	25	26
250	269.5	385	345	12	23	22	269.5	400	355	12	25	24	269.5	430	380	27	27	28
300	321	430	390	12	23	22	321	445	400	16	25	24	321	480	430	27	27	30

### 8.2.3 Type of Valves

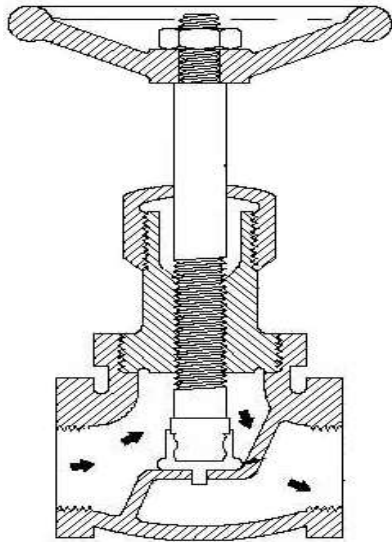
- Gate valves are generally used in systems where low flow resistance for a fully open valve is desired and there is no need to throttle the flow.
- Globe valves are used in systems where good throttling characteristics and low seat leakage are desired and a relatively high head loss in an open valve is acceptable.
- Butterfly valves provide significant advantages over other valve designs in weight, space, and cost for large valve applications.
- Needle valve is used to make relatively fine adjustments in the amount of fluid flow.
- Check valves automatically open to allow flow in one direction and seat to prevent **flow in the reverse direction.**
- A stop check valve is a combination of a lift check valve and a globe valve and incorporates the characteristics of both.
- Plug valves are often used to direct flow between several different ports through use of a single valve.
- Ball valves allow quick, quarter turn on-off operation and have poor throttling characteristics.



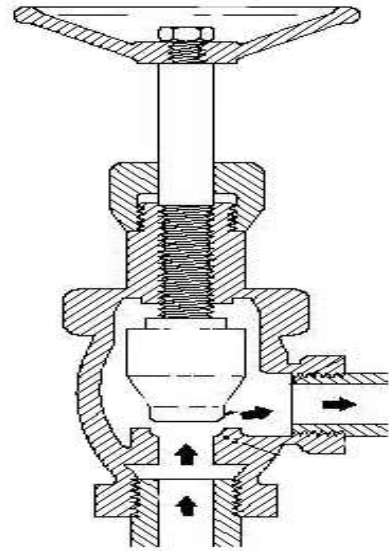
**GATE VALVE**



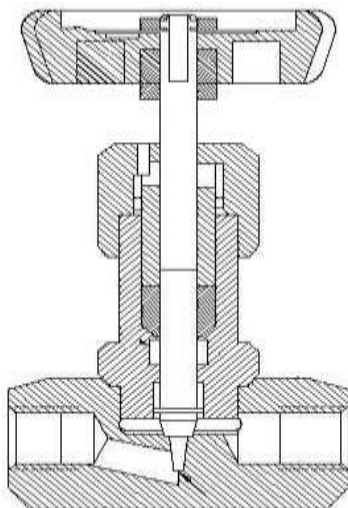
**BUTTERFLY VALVE**



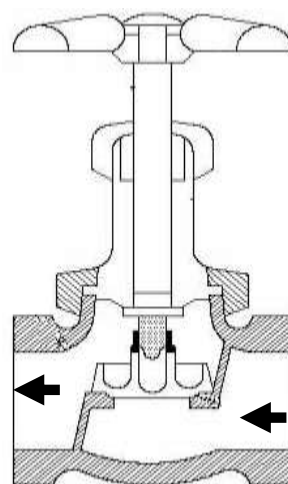
**STRAIGHT GLOBE VALVE**



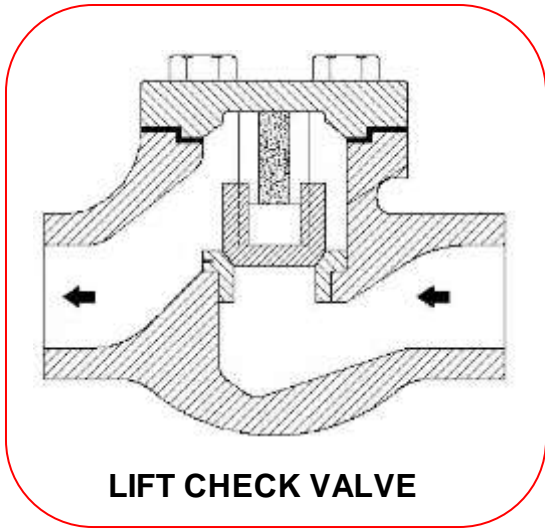
**ANGLE GLOBE VALVE**



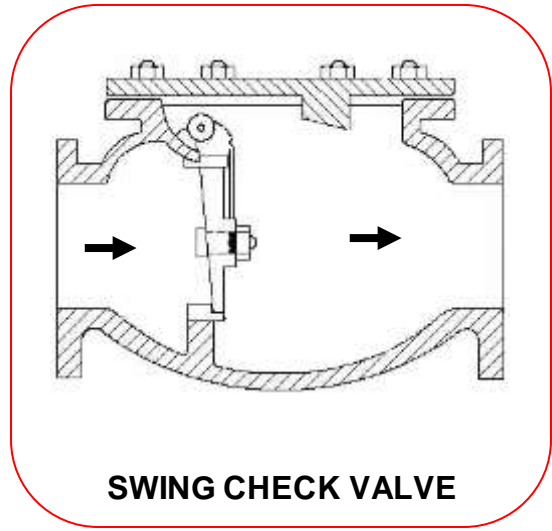
**NEEDLE VALVE**



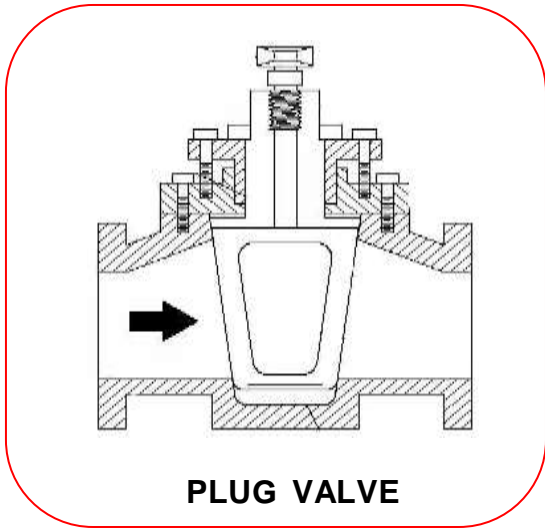
**STOP CHECK VALVE**



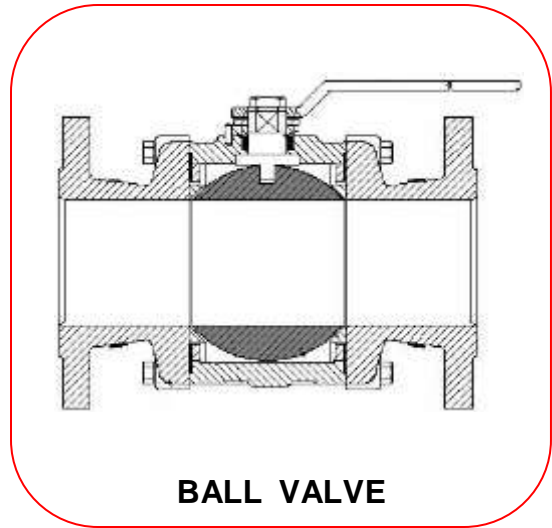
**LIFT CHECK VALVE**



**SWING CHECK VALVE**



**PLUG VALVE**



**BALL VALVE**

#### 8.2.4 Pipe Fittings

Piping system in the engine is not fitted all in straight line; there are bends, crosses, tees and sometimes reducing connections. When piping system requires turns, branches and changes in sizes, there are joints. Joints are accomplished using fitting. There are three broad classifications of fittings and they are; screwed, flanged and welded.

- a. Screwed fittings are generally used in applications requiring small diameter pipe of 2.5 inches or less. The threaded end of the pipe and the internal threads on the fittings are usually coated with a special lubricant to seal the joints. Sample fittings are shown below.



**HEXAGON HEAD PLUG**

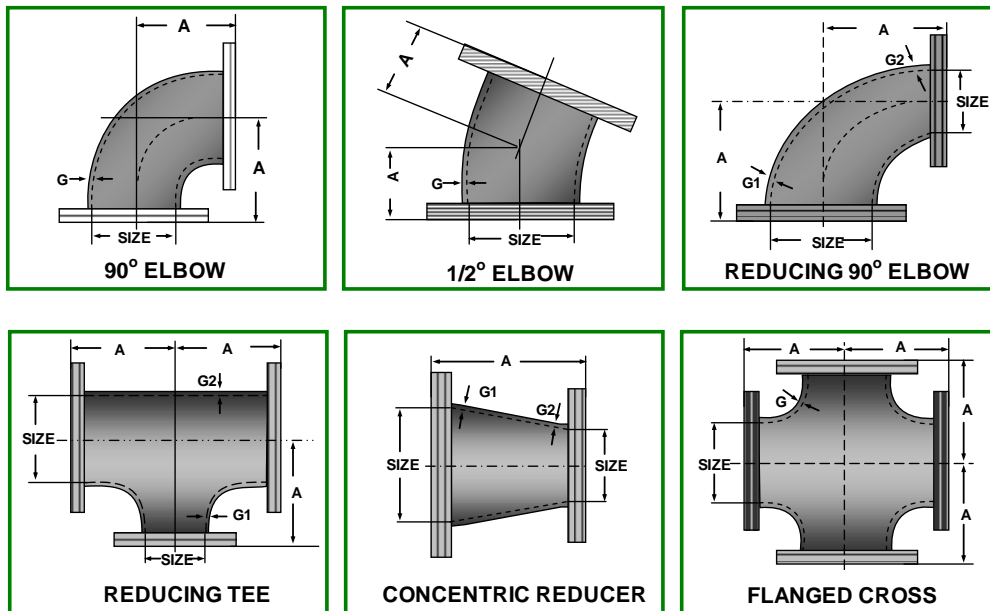


**THREADED CAP**



**THREADED STREET ELBOW**

- b. Flanged fittings and joints are usually used when the pipe connection is occasionally requiring to be disassembled. Shown below are the commonly used flanged fitting in the engine room piping.



**Dimension configurations:**

- A = center to face measurement
- G = wall thickness of the pipe
- Size = nominal size of the pipe

- c. Welded fittings and joints are used in piping system where high pressure and high temperature application is exist and they are permanent connections. Welded fittings are usually less weight than screwed or flanged fittings and they are easier to insulate.



## 8.2.5 Taps and Dies



Taps and Dies are cutting tools used to create screw threads in solid substances such as metals, plastic, etc., and repair screw threads on bolts, nuts, threaded hole etc. Tap is used to cut the female portion of a mating part e.g., nuts and die is used to cut the male part, e.g., bolts. It is more common practice to create a hole into which the bolt is screwed than to create a bolt that screwed into the hole. Thus, taps are more commonly used than dies in any maintenance jobs onboard. The process of cutting a thread in a hole or repairing a thread is called “tapping” the hole.

Taps and dies sizes that are commonly available onboard are in English and Metric system measurement and it follow the sizes of the bolts and nuts.

## 8.2.6 Bearings

Bearing is a device that permits constrained relative motion between two parts either in rotation or in linear movement. Bearings are broadly classified according to the motion they allow and according to their principle of operation. The commonly applied bearings for onboard machineries are the sliding bearings (called “bushes”, journal bearings, sleeve bearings, rifle bearings or plain bearings) and the rolling elements bearings (called ball bearings and roller bearings). The sliding bearings are commonly installed in major machineries and mainly supplied by the engine manufacturers.

The ball bearings and roller bearings are usually installed to motors, purifiers and other equipments with rolling elements and they can be acquired from ordinary ship store suppliers.

Ball bearings are typically used to support axial and radial loads, can tolerate some misalignment of the inner and outer races, and mainly used to a low load capacity application.

Roller bearings are used more satisfactory under shock or impact loading than ball bearing.



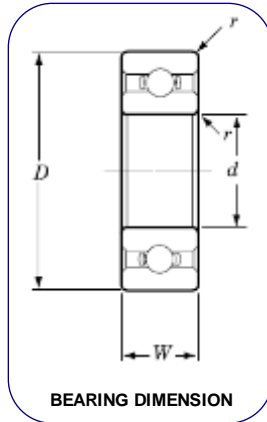


**BALL BEARINGS**

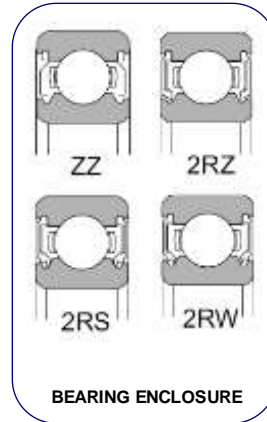


**ROLLER BEARINGS**

Specifications of commonly used ball bearings in the engine room:



**BEARING DIMENSION**

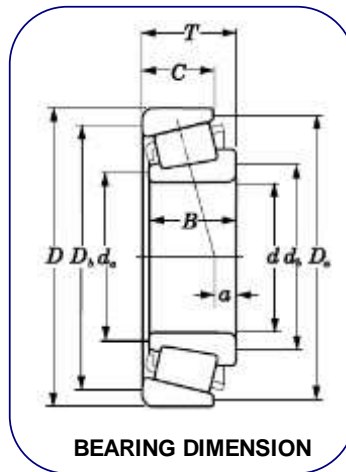


**BEARING ENCLOSURE**

Ball Bearing Dimension and Specification 62-series														
Basic Bearing No.	Bore		Outer Diameter		Width		Radius		Basic Load Rating KN		Ball Complement		Max. Runout Speed	
	d		D		W		r		Dynamic C	Static C <sub>o</sub>	No.	Size mm	Grease r/min	Oil r/min
	mm	inch	mm	inch	mm	inch	mm	inch						
624	4	0.1575	13	0.5118	5	0.1968	0.2	0.007	1.31	0.49	6	2.381	36000	45000
625	5	0.1968	16	0.6299	5	0.1968	0.3	0.012	1.76	0.68	6	3.175	3200	40000
626	6	0.2362	19	0.7480	6	0.2362	0.3	0.012	2.34	0.885	7	3.5	28000	36000
627	7	0.2756	22	0.8661	7	0.2756	0.3	0.012	3.35	1.40	7	3.969	26000	34000
628	8	0.3149	24	0.9448	8	0.3150	0.3	0.012	4.00	1.59	7	3.969	24000	32000
629	9	0.3543	26	1.0236	8	0.3150	0.3	0.012	4.55	1.96	7	4.763	22000	30000
6200	10	0.3937	30	1.1811	9	0.3543	0.6	0.024	5.10	2.39	8	4.763	19000	26000
6201	12	0.4724	32	1.2598	10	0.3937	0.6	0.024	6.10	2.75	7	5.953	18000	24000
6202	15	0.5906	35	1.3780	11	0.4331	0.6	0.024	7.75	3.60	8	5.953	17000	22000
6203	17	0.6693	40	1.5478	12	0.4724	0.6	0.024	9.60	4.60	8	6.747	16000	20000
6204	20	0.7874	47	1.8504	14	0.5512	1.0	0.039	12.80	6.65	8	7.938	14000	18000
6205	25	0.9843	52	2.0470	15	0.5906	1.0	0.039	14.00	7.85	9	7.938	12000	16000
6206	30	1.1811	62	2.4409	16	0.6299	1.0	0.039	19.50	11.30	9	9.525	10000	13000
6207	35	1.378	72	2.8346	17	0.6693	1.1	0.043	25.70	15.30	9	11.112	8800	10000
6208	40	1.5748	80	3.1496	18	0.7087	1.1	0.043	29.10	17.80	9	12	7700	92000
6209	45	1.7717	85	3.3465	19	0.7480	1.1	0.043	32.50	20.40	10	12	6800	8200
6210	50	1.9685	90	3.5433	20	0.7874	1.1	0.043	35.00	23.20	10	12.7	6100	7300
6211	55	2.1654	100	3.9370	21	0.8268	1.5	0.059	43.50	29.20	10	14.288	5500	6600
6212	60	2.3622	110	4.3307	22	0.8661	1.5	0.059	52.50	36.00	10	15.081	5000	6000

Ball Bearing Dimension and Specification 63-series														
Basic Bearing No.	Bore		Outer		Width		Radius		Basic Load		Ball		Max. Runout	
	d		D		W		r		Dynamic C	Static C <sub>o</sub>	No.	Size mm	Grease r/min	Oil r/min
	mm	inch	mm	inch	mm	inch	mm	inch						
635	5	0.1969	18	0.7087	6	0.2362	0.3	0.012	2.34	0.885	9	2.381	34000	40000
6300	10	0.3937	35	1.3780	11	0.4331	0.6	0.024	8.20	3.5	7	6.35	15000	21000
6301	12	0.4724	37	1.4567	12	0.4724	1.0	0.039	9.70	4.2	7	6.35	14000	20000
6302	15	0.5906	42	1.6535	13	0.5118	1.0	0.039	11.40	5.45	7	7.938	13000	18000
6303	17	0.6693	47	1.8504	14	0.5512	1.0	0.039	13.50	6.55	7	8.731	12000	17000
6304	20	0.7874	52	2.0472	15	0.5906	1.1	0.043	15.90	7.9	7	9.525	11000	15000
6305	25	0.9843	62	2.4409	17	0.6693	1.1	0.043	21.20	10.9	7	11.5	10000	13000
6306	30	1.1811	72	2.8346	19	0.7480	1.1	0.043	26.70	15	8	12	8000	10000
6307	35	1.3780	80	3.1496	21	0.8268	1.5	0.059	33.50	19.10	8	13.94	6800	8000
6308	40	1.5748	90	3.5433	23	0.9055	1.5	0.059	40.50	24.00	8	15.081	5800	72000
6309	45	1.7717	100	3.9370	25	0.9843	1.5	0.059	53.00	32	8	17.462	5000	6200
6310	50	1.9685	110	4.3307	27	1.0630	2.0	0.079	62.00	38.5	8	19.05	4400	5500

Specifications of commonly used roller bearings in the engine room:

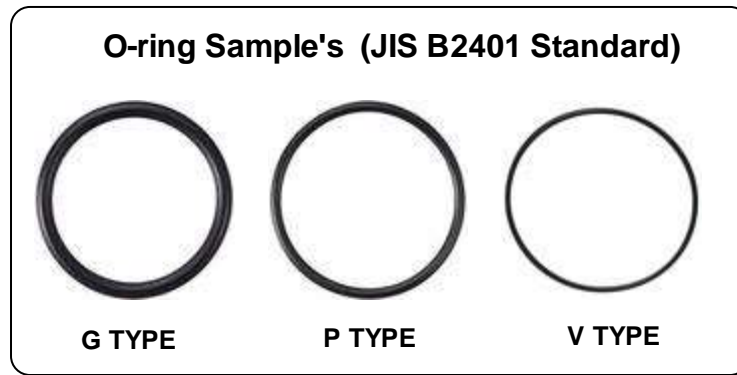


Metric Taper Roller Bearing dimensions and Specifications																	
Bore		Outer		Width		Basic Load		Eff. Load Center	Basic Bearing No.	Minimum Shaft Fillet	Width	Minimum Housing Fillet		Width			
d		D		T		Rating KN						R	B	r	C		
mm	inch	mm	inch	mm	inch	Cr	Cor	a									
17	0.6693	40	1.5748	13.25	0.5217	20.7	21.900	9.90	30203	1.0	0.039	12.0	0.4724	1.0	0.039	11	0.4331
20	0.7874	47	1.8504	15.25	0.6004	28.2	30.600	11.20	30204	1.0	0.039	14.0	0.5512	1.0	0.039	12	0.4724
25	0.9843	52	2.0472	16.25	0.6398	32.2	37.000	12.50	30205	1.0	0.039	15.0	0.5906	1.0	0.039	13	0.5118
30	1.1811	62	2.4409	17.25	0.6791	43.3	50.500	13.80	30206	1.0	0.039	16.0	0.6299	1.0	0.039	14	0.5112
35	1.3780	72	2.8346	18.25	0.7185	54.2	63.500	15.30	30207	1.5	0.059	17.0	0.6693	1.5	0.059	15	0.5906
40	1.5748	80	3.1496	19.75	0.7776	63.0	74.000	16.90	30208	1.5	0.059	18.0	0.7087	1.5	0.059	16	0.6299
45	1.7717	85	3.3465	20.75	0.8169	67.0	83.600	18.60	30209	1.5	0.059	19.0	0.7480	1.5	0.059	16	0.6299
50	1.9685	90	3.5433	21.75	0.8563	73.3	92.100	20.00	30210	1.5	0.059	20.0	0.7874	1.5	0.059	17	0.6693
15	0.5906	42	1.6535	14.25	0.5610	22.0	21.600	9.60	30302	1.0	0.039	13.0	0.5118	1.0	0.039	11	0.4331
17	0.6693	47	1.8504	15.25	0.6004	28.3	27.200	10.40	30303	1.0	0.039	14.0	0.5512	1.0	0.039	12	0.4724
20	0.7874	52	2.0472	16.25	0.6398	33.1	33.200	11.10	30304	1.5	0.059	15.0	0.5906	1.5	0.059	13	0.5118
25	0.9843	62	2.4409	18.25	0.7185	40.0	48.100	13.00	30305	1.5	0.059	17.0	0.6693	1.5	0.059	15	0.5906
30	1.1811	72	2.8346	20.75	0.8169	59.0	63.100	15.30	30306	1.5	0.059	19.0	0.7480	1.5	0.059	16	0.6299
35	1.3780	80	3.1496	22.75	0.8957	75.3	82.600	16.80	30307	2.0	0.079	21.0	0.8268	1.5	0.059	18	0.7087
40	1.5748	90	3.5433	25.25	0.9941	90.9	107.600	19.50	30308	2.0	0.079	23.0	0.9055	1.5	0.059	20	0.7874
45	1.7717	100	3.9370	27.25	1.0728	108.9	129.800	21.30	30309	2.0	0.079	25.0	0.9843	1.5	0.059	20	0.8861

### 8.3 Fabrication Materials

#### 8.3.1 O-rings

O-ring is a loop of elastomer with round (o-shaped) cross section used as a mechanical seal or gasket. They are designed to be seated in a groove and compressed during assembly between two or more parts, creating a seal in the interface.



O-rings are the most common seals used in a machine design because they are inexpensive, easy to make, reliable and have simple mounting requirements. O-rings are available in large number of standard sizes in metric, special and international sizes and various materials.

O-rings are measured in inches or centimeter. The key measurements are inside diameter, outside diameter, and width. Dash numbers are o-rings sizes references and the prefix is the materials used as listed in the table below.

The table below shows the comparison of materials used for manufacturing of o-ring.

Property	Buna-N	Viton	Silicone	PTFE	Kalrez
Part No. Prefix	<b>B-</b>	<b>V-</b>	<b>S-</b>	<b>T-</b>	<b>K-</b>
Tear Resistance	Good	Good	Poor	Excellent	Good
Abrasive Resistance	Good	Good	Poor	Excellent	Good
Ozone Resistance	Poor	Excellent	Excellent	Good	Excellent
Weather Resistance	Fair	Excellent	Excellent	Good	Excellent
Heat Resistance	Fair	Excellent	Excellent	Good	Excellent
Chemical Resistance	Fair	Excellent	Good	Excellent	Excellent
Oil Resistance	Poor	Excellent	Poor	Good	Excellent
Acid Resistance	Fair	Excellent	Good	Excellent	Excellent
Alkali Resistance	Good	Good	Fair	Excellent	Excellent
Steam Resistance	Fair	Fair	Poor	Good	Excellent
Minimum Usable Temperature	-65 deg F	-65 deg F	-120 deg F	-110 deg F	-35 deg F
	-54 deg C	-54 deg C	-85 Deg C	-79 deg C	-37 deg C
Maximum Usable Temperature	300 deg F	500 deg F	450 deg F	500 deg F	550 deg F
	150 deg C	260 deg C	232 deg C	260 deg C	288 deg C
Color	Black	Black	Red	White	Black
Impermeability	Fair	Good	Poor	Excellent	Good
Tensile Strength	Good	Good	Poor	Excellent	Good

Japanese Industrial Standard Designations for O-ring

# JIS B 2401 Class 3 P 400

O-ring Standard

Material

Code	Marking	Material
1A	●	Nitrile 70
1B	●●	Nitrile 90
2	●	Fuel resistant Nitrile 70
3	●	EPR 70
4C	none	Silicone 70
4D	●	Flourcarbon(Viton)

Application

G=static(gasket), P=moving(packaging),  
V=vacuum flange

Nominal Inside Diameter

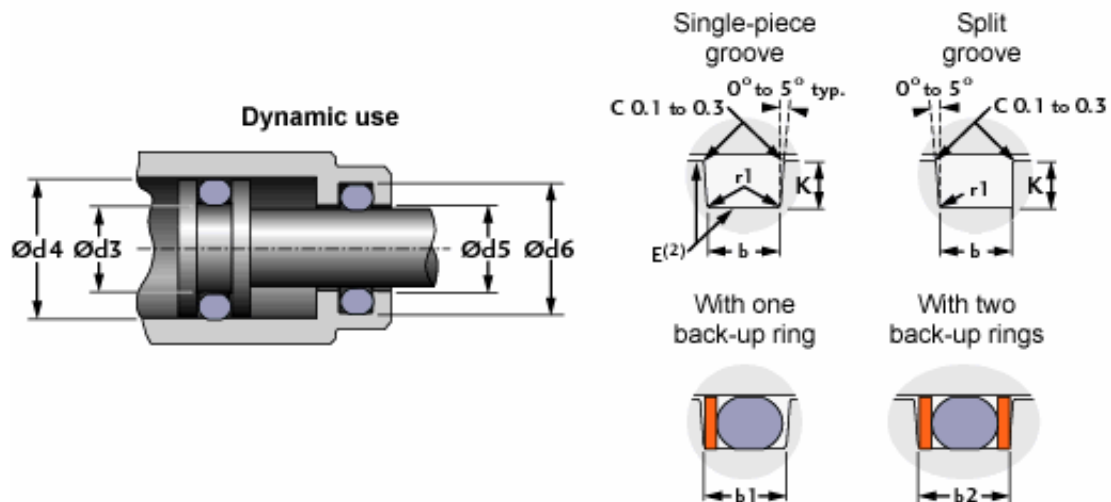
Nominal in mm

Japanese Industrial Standard (JIS) B 2401 classifies O-rings to be used for general-purpose applications. This standard classifies O-rings by material specification and use. The normative reference JIS K 6301 has been abolished in accordance with the international conformity plan of the International Standards Organization (ISO).

a. JIS Standard for O-Ring Applications:

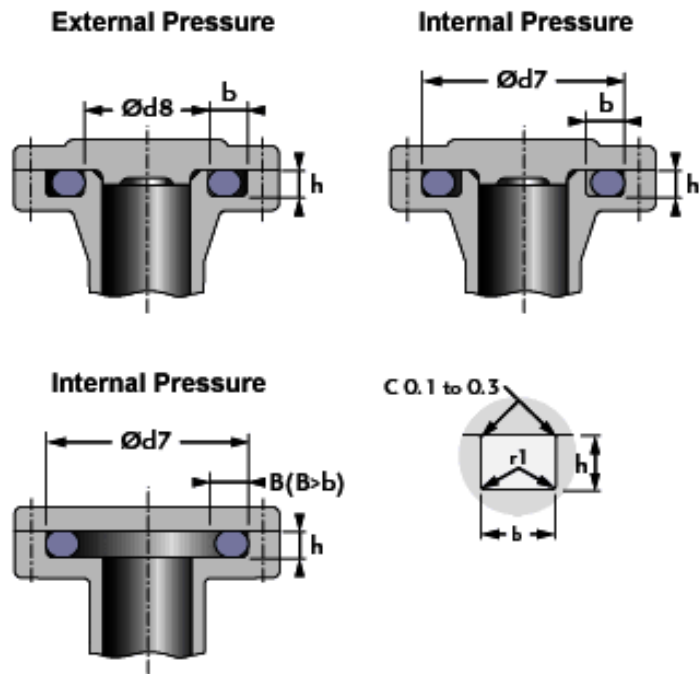
i. For Piston or Rod Sealing Applications (JIS B 2406 O-Ring Housing Dimensions)

P-type o-ring is used for this type of housing (Dynamic use). P stands for moving application.



ii. For Static Face Sealing Applications (JIS B 2406 O-Ring Housing Dimensions)

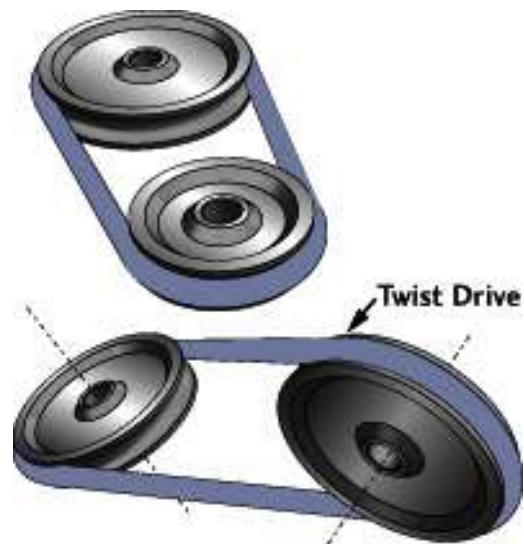
G-type o-ring is used for this application (Static application). G stands for static which means non-moving.



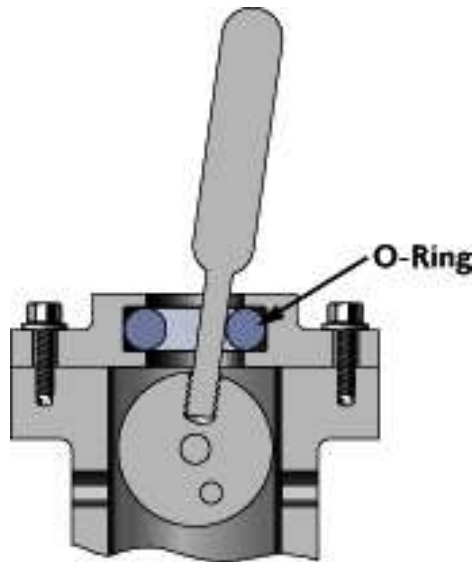
### iii. For Pneumatic and Vacuum Seals

O-rings in pneumatic and vacuum systems are used to seal gases rather than liquids. In application they are identical to the categories of liquid-sealing static and dynamic seals. However, a pneumatic seal is used to control a gas or vapor, and a vacuum seal is used to control a vacuum area or chamber. In either case, the seal should be identified as "pneumatic-reciprocating" or "vacuum-rotary" in specifications.

V-type o-ring is used for this application:



O-ring used in low-power drive belt applications due to their ease of installation, uniform stress distribution, and availability in standard sizes and reliability. Because of their resiliency they don't require belt tensioning devices and pulley locations do not need to be extremely accurate.

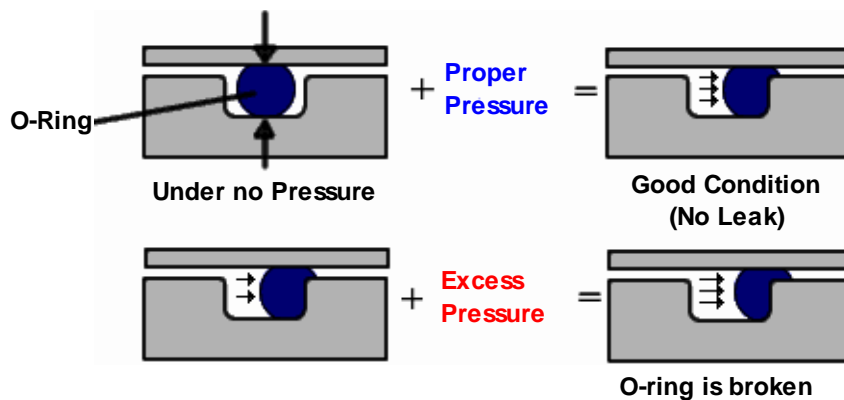
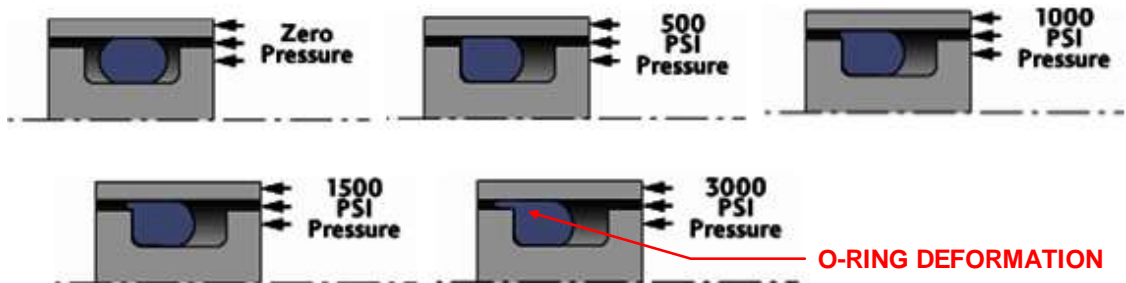


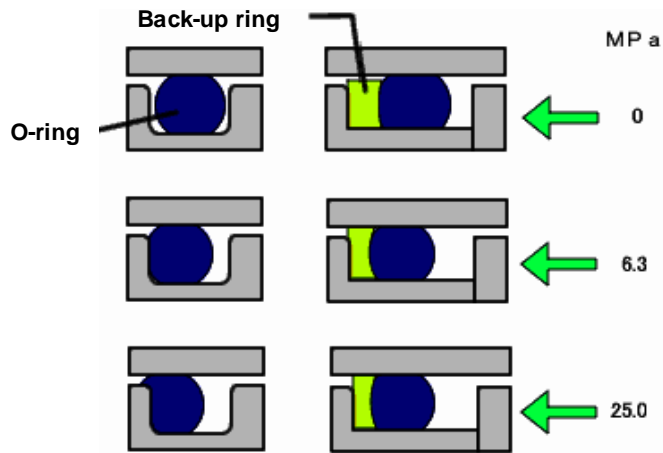
O-rings can be used to soften impact, dampen noise, cushion shock or create rebound in moving or colliding parts.

b. Usage Considerations

i. Pressure

Sealing pressure is created by compression of the seal between the mating surfaces of the gland and external forces such as the pressure exerted by the fluid being sealed. In a low-pressure application (below 100 psi), sealing force is a factor of the o-ring's ability to deform and create a barrier through compression and lower seal hardness and surface finish of the seal and gland become critical considerations. In a high-pressure seal, system pressure activates the seal and compression of the seal and surface finish are not as important as seal material hardness, cross section, diametrical clearance gap and the possible inclusion of backup rings.





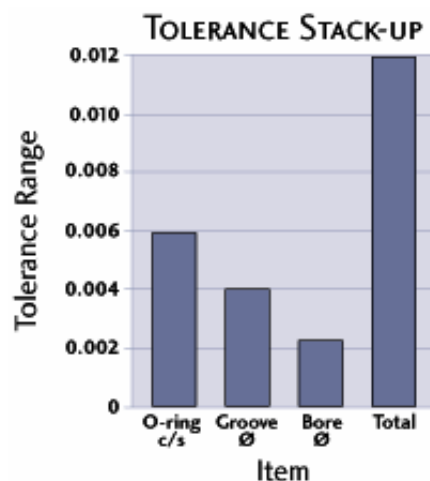
ii. Temperature

O-ring materials working ranges against temperature are shown below.

		Celsius									
		-100°	-50°	0°	50°	100°	150°	200°	250°	Celsius	
AFLAS	FKM	-31°C	23°F	[Bar chart showing range from approx -30 to 200]						204°C	400°F
BUNA-N	NBR	-40°C	-40°F	[Bar chart showing range from approx -40 to 150]						121°C	250°F
ETHYLENE-PROPYLENE	EPDM	-51°C	-60°F	[Bar chart showing range from approx -50 to 150]						121°C	250°F
NEOPRENE	CR	-43°C	-45°F	[Bar chart showing range from approx -45 to 150]						121°C	250°F
HYDRODGENATED NITRILE	HNBR	-34°C	-30°F	[Bar chart showing range from approx -30 to 180]						166°C	330°F
FLUOROCARBON	FKM	-29°C	-20°F	[Bar chart showing range from approx -20 to 200]						204°C	400°F
SILICONE	MQ, PMQ, VMQ, PVMQ	-70°C	-94°F	[Bar chart showing range from approx -70 to 230]						232°C	450°F
FLUOROSILICONE	FVMQ	-60°C	-75°F	[Bar chart showing range from approx -60 to 200]						204°C	400°F
STYRENE BUTADIENE	SBR	-45°C	-50°F	[Bar chart showing range from approx -45 to 120]						100°C	212°F
POLYACRYLATE	ACM	-18°C	0°F	[Bar chart showing range from approx -10 to 180]						175°C	350°F
CAST POLYURETHANE	N/A	-51°C	-60°F	[Bar chart showing range from approx -50 to 100]						107°C	225°F
BUTYL	IIR	-45°C	-50°F	[Bar chart showing range from approx -45 to 150]						121°C	250°F
POLYSULFIDE (THIOLKOL)	T	-45°C	-50°F	[Bar chart showing range from approx -45 to 120]						107°C	225°F
HYPALON	CSM	-45°C	-50°F	[Bar chart showing range from approx -45 to 130]						135°C	275°F
EPICHLOROHYDRIN	CO, ECO	-40°C	-40°F	[Bar chart showing range from approx -40 to 130]						135°C	275°F
NATURAL RUBBER	NA	-51°C	-60°F	[Bar chart showing range from approx -50 to 100]						104°C	220°F
PERFLUOROELASTOMER	FFKM	-32°C	-25°F	[Bar chart showing range from approx -25 to 260]						260°C	500°F
VAMAC	AEM	-40°C	-40°F	[Bar chart showing range from approx -40 to 150]						149°C	300°F
TEFLON	FEP	-184°C	-300°F	[Bar chart showing range from approx -180 to 230]						232°C	450°F

iii. Tolerance Stack-up

In a seal application, the tolerances of all elements in the system are critical to the effectiveness of the seal. Each part is manufactured to its own level of tolerance and the combination of all of these tolerances is designated the tolerance stack-up.



In an application using a standard size O-ring, tolerances are small in relation to the size of the O-ring, and tolerance stack-up may be compensated for by specifying a slightly larger O-ring or by modifying other factors. In applications featuring miniature or micro-miniature O-rings, tolerances are large in relation to the O-ring size, and tolerance stack-up becomes extremely critical.

### 8.3.2 Oil Seal

Oil seal is used for shafting that is rotating inside a housing or bore. Due to friction, some clearance between the shaft and the bore must be established. The function of the oil seal is to stop whatever fluid is inside from leaking out the clearance between the shaft and housing. The seal may also be used to prevent outside materials, such as dirt, from moving in through the clearance.



Oil seals sometimes referred to as “grease seals”, “shaft seals”, etc., have a flexible lip that rubs against a shaft or housing to prevent the leakage or ingress of fluids and dirt. For proper installation, the seal lip should point towards the medium being contained. Some oil seals have a spring to help keep the lip in contact with the shaft. The sealing orientation and direction is important to consider for oil seals.

Common configurations and features of oil seal include single lip, double lip, triple lip, four or more lips, spring loaded, integral wiper, and split seal. Important dimensions to consider when specifying oil seals must include the shaft outer diameter or seal inner diameter, housing bore diameter or seal outer diameter, axial cross section or thickness, and radial cross section. Important service limits parameters to consider include maximum operating speed, maximum operating pressure, vacuum rating, and operating temperature.

Rubber sealing element or lip material choices for oil seals include ethylene acrylic, EDPM, fluoroelastomer, fluorosilicone, nitrile, nylon or polyamide, polychloroprene, polyetheretherkeytone, polyoxymethylene, polytetrafluoroethylene, polyurethane or urethane, and natural rubber. Metallic choices include sintered bronze, cast iron, and stainless steel. Other materials include felt and leather. Many seal manufacturers use their own proprietary material. Consult with manufacturer for proprietary material specifications.

Below are sample tables of oil seal materials and specifications.

Table1 - Oil Seal Materials and Applications:

BASE POLYMER	NITRILE	POLYACRYLATE	SILICONE	FLUROELASTOMER
Material Code	N	P	S	V
Temperature Range *	-40 F ~ 250 F	-20 F ~ 300 F	-80 F ~ 400 F	-30 F ~ 400 F
	(-35 C ~ 120 C)	(-30 C ~ 150 C)	(-60 C ~ 200 C)	(-35 C ~ 200 C)
Oil Resistance	Excellent	E	Good	Excellent
Acid Resistance	Good	Fair	Fair	Excellent



<b>Alkali Resistance</b>	Good	Not recommended	Not recommended	Fair
<b>Water Resistance</b>	Good	F	Good	Good
<b>Heat Resistance</b>	Good	Excellent	Excellent	Excellent
<b>Cold Resistance</b>	Good	F	Excellent	Fair
<b>Wear Resistance</b>	Excellent	Excellent	Good	Excellent
<b>Ozone Resistance</b>	Good	Excellent	Excellent	Excellent
<b>ASTM D2000 Spec.</b>	2BG715B14B34 E014	SDH710A26B16	2GE807A19B37	2HK710A110B38
	EO34EF11EF21	B36EO16EO36	EO16EO36G11	

\* Maximum temperature limits depend on other operating conditions.

Table 2 - Advantages and Disadvantages of Oil Seal Material Applications

<b>MATERIAL</b>	<b>Advantage</b>	<b>Disadvantage</b>
<b>FLUROELASTOMER</b>	Good temperature resistance.	Fair resistance to water, dry running.
	Commonly chosen as high temperature replacement for Nitrile or Polyacrylate.	Low temperature resistance is fair.
<b>POLYACRYLATE</b>	Polymerised acrylic acidesters or PA and ACM.	Poor cold temperature limit, dry running ability, water resistance.
	Good resistance to mineral oil, hypoid gear oil E.P. additive, greases, aging and flex cracking.	Lower mechanical strength.
<b>NITRILE</b>	Commonly referred to as Buna-N or NBR and is copolymer of Butadiene and Acrylonitrile.	Poor resistance to ozone and weather aging.
	Good resistance to petroleum oils, water, silicone oil, greases, glycol base fluids.	
	Good abrasion resistance, cold flow, tear resistance.	
<b>SILICONE</b>	Broad temperature range.	Low resistance to hydrocarbon fluids like gasoline or paraffin fluids or steam above to 50 psi.
	Good ozone resistance	
	Resistant to compression set.	

Table 3- Fluid Compatibility

<b>TYPE OF FLUID TO BE SEALED</b>	<b>LIP MATERIAL</b>			
	<b>NITRILE</b>	<b>POLYACRYLATE</b>	<b>SILICONE</b>	<b>FLUROELASTOMER</b>
<b>Engine Oil</b>	Excellent	Excellent	Good	Excellent
<b>Gear Oil</b>	Good	Good	Not recommended	Excellent
<b>Turbine Oil No.2</b>	Good	Good	Good	Excellent
<b>Machine Oil No.2</b>	Good	Good	Fair	Excellent
<b>Automatic Transmission Fluid</b>	Excellent	Excellent	Fair	Excellent
<b>Petroleum Base Lubricating Oil</b>	Excellent	Excellent	Fair	Excellent
<b>Gasoline</b>	Fair	Not recommended	Not recommended	Excellent
<b>Light Oil / Kerosene</b>	Fair	X	Not recommended	Good
<b>Cutting Oil</b>	Excellent	G	Fair	Excellent
<b>Grease</b>	Excellent	Excellent	Excellent	Excellent

<b>E.P. Lubricants</b>	Good	Excellent	Not recommended	Excellent
<b>Water - Glycol</b>	Excellent	Not recommended	Good	Good
<b>Alcohol</b>	Excellent	Not recommended	Good	Fair
<b>20 % Hydrochloric Acid Solution</b>	Fair	Fair	Fair	Excellent
<b>30% Sulfuric Acid Solution</b>	Fair	Fair	Not recommended	Excellent

### 8.3.3 Packing and Gasket Sheets

Packing or gaskets are used to make fluid or gas resistant seal between two mating surfaces.



The choice of usage of packing and gaskets are decided by the following:

- i. Temperature, pressure and the corrosive nature of the fluid or gas
- ii. Maintenance operations
- iii. Environment requirements (asbestos is banned in many countries)
- iv. Cost of the material

Gasket Material	Used for Products	English			Metric		
		Maximum Temperature (°F)	Maximum Pressure (psi)	Maximum Temperature * Pressure (°F * psi)	Maximum Temperature (°C)	Maximum Pressure (bar)	Maximum Temperature * Pressure (°C * bar)
Synthetic rubbers	water, air	250	60	15 000	121	4	496
Vegetable fiber	oil	250	160	40 000	121	11	1 322
Synthetic rubbers with inserted cloth	water, air	250	500	125 000	121	34	4 130
Solid Teflon	chemicals	500	300	150 000	260	20	5 320
Compressed Asbestos <sup>1)</sup>	most	750	333	250 000	399	23	9 068
Carbon Steel	high pressure fluids	750	2 133	1 600 000	399	145	58 036
Stainless Steel	high pressure or corrosive fluids	1200	2 500	3 000 000	649	171	110 636
Spiral wound	-	-	-	-	-	-	-
SS/Teflon	chemicals	500	500	250 000	260	34	8 866
CS/Asbestos <sup>1)</sup>	most	750	333	250 000	399	23	9 068
SS/Asbestos <sup>1)</sup>	corrosive	1200	208	250 000	649	14	9 220
SS/Ceramic	hot gases	1900	132	250 000	1038	9	9 313

<sup>1)</sup> Note! Asbestos is not legal in many countries

The table above can be used as an indication of some common gasket materials and their limitations.

### 8.3.4 Packing Glands

Packing glands are used to [seal](#) around a reciprocating or rotating shaft or spindle. A malleable packing compound is forced into place by an adjustable packing nut, or similar arrangement. This enables the [seal](#) or packing to be tightened to suit the operating conditions and allows subsequent adjustment to account for wear.



Packing glands are widely used for valves, i.e,soot blower, pump sealing arrangement etc. Different types of materials are available that suited best to the kind of working condition applicable such as the temperature and pressure. When selecting the type of packing glands to be used, it should be suited with the working application of the device. The table below as sample shows the type of packing glands and its suitability.

Pillar Packing Performance and Application:

Pillar style No.	Main materials	Performance					Main Application				Color
		Temp (°C)	Press (Mpa)		Velocity (m/s)	PV value (MPa · m/s)	Pump (MPa · m/s)	Recipro-Pump	Valve	Others	
			pump	Valves & Reciprocating pump							
No.6710(N)	Pillar foil & Inconel wore	600	-	43.1	-	-			●		Black
No.6710CL	Pillar foil & Inconel wore	400	-	77.6	-	-			●		Black
No.6710CH	Pillar foil & Inconel wore	600	-	77.6	-	-			●		Black
No.6711(N)	Pillar foil & Inconel wore	600	-	25.9	-	-			●	Soot blowers	Black
No.6720(N)	Pillar foil & PTFE fiber	400	-	15.5	-	-			●		Black
No.6722	Pillar foil & Aramid fiber	350	-	10.3	-	-			●	Soot blowers	Black
No.6733	Pillar foil & Aramid fiber	350	2.0	-	20	19.6	●	○	○		Black
No.6766	Pillar foil & stainless wire	400	-	-	-	-			●		Black
No.6315	Pillar foil & stainless wire	450	-	15.5	-	-			●	Soot blowers	Black
No.6315CL	Pillar foil & stainless wire	400	-	15.5	-	-			●		Black
No.6315CH	Pillar foil & stainless wire	600	-	25.9	-	-			●		Black
No.6114	Pillar foil & organicfiber	400	-	5.2	-	-			●	Man hole	Black
No.6118	Pillarfoil & Stainless wire	350	-	10.3	-	-			●		Black
No.6610(N)	Pillar foil(Pure graphite)	600	-	43.1	-	-			●		Black
No.6610CL	Pillar foil(Pure graphite)	400	-	77.6	-	-			●		Black
No.6610CH	Pillar foil(Pure graphite)	600	-	77.6	-	-			●		Black
No.6615	Pillar foil(Pure graphite)	350	2.0	-	20	24.5	○				Black
No.6616(N)	Pillar foil(Pure graphite)	600	-	43.1	-	-			●		Black
No.6616CL	Pillar foil(Pure graphite)	400	-	77.6	-	-			●		Black
No.6616CH	Pillar foil(Pure graphite)	600	-	77.6	-	-			●		Black
No. 6617	Pillar foil(Pure graphite)	(注2) 600	-	43.1	-	-			●		Black
No.6501L	Carbonized fiber	200	1.0	5.2	20	9.8	●	○	○	Stern tube	Black
No.6502L	Carbonized fiber	200	1.2	5.2	10	9.8	●				Black
No.6507	Carbon fiber	260	1.0	10.3	10	7.8	○		○		B&W
No.6521L	Carbonized fiber	200	1.2	-	20	9.8	●	○	○		Black
No.6527	Carbon fiber	350	1.0	10.3	10	7.8	○	○	○	Stern tube	Black
No.6527L	Carbon fiber	350	1.6	-	10	9.8	●	○			Black
No.6527S	Carbon fiber	300	-	29.4	1.2	24.5		●			Black
No.6528	Carbon fiber	500	-	43.1	-	-			●		Black
No.4500	Pillar exclusive white fiber	100	1.0	-	10	4.9	●				white
No.4504	P.T.F.E fiber	200	0.8	10.3	8	3.4	○		●		white
No.4505L	P.T.F.E fiber	260	1.0	10.3	10	4.9	○	○	○		white
No.4506L	Special aramid fiber	120	1.0	-	10	4.9	●				Light yellow
No.4507L	Special P.T.F.E fiber	260	1.6	10.3	16	12.3	●	●	●		Dark grey
No.4508L	Special organic fiber	200	1.2	10.3	20	12.3	●	○	○		Brown
No.4516L	Special aramid fiber	200	1.0	10.3	10	6.4	●		●		Light yellow
No.4519	P.T.F.E & carbon fiber	260	-	10.3	-	-			●		B&W
No.4525	P.T.F.E fiber	260	-	10.3	-	-			○		white
No.4525L	P.T.F.E fiber	200	1.0	10.3	10	4.9	●	●	●		white
No.4526	Aramid fiber	260	1.6	10.3	10	9.8	○	○	○		Ye & Wh
No.4526L	Aramid fiber	260	1.6	10.3	16	14.7	●	○	●		Yellow
No.4527L	Special P.T.F.E fiber	260	1.2	-	20	12.3	●				Dark grey
No.4529L	Aramid & P.T.F.E fiber	260	2.0	10.3	16	14.7	○	●	○		Ye&Bl
No.4536	Special aramid fiber	200	-	10.3	-	-	○	○	○	Kneeder Low-speed. Dry	Light Yellow
No.4545	P.T.F.E fiber	260	-	15.5	-	-	○	○	○	Big-size Rotary machine	white
No.420	Ramie fiber	80	0.6	-	10	3.4	○			Stern tubes	Black
No.426	Ramie fiber	80	0.5	-	10	2.5	○			Stern tubes	Ivory
No.426F	Ramie fiber	80	0.6	-	10	3.4	○			Stern tubes	white
No.428F	Ramie & Aramid fiber	80	1.0	-	10	4.9	○			Stern tubes	Light Yellow
No.436	Lead alloy foil	210	1.6	-	20	14.7	●				Black
No.385(N)	Ceramic fiber & stainless fiber	600	-	43.1	-	-			●		Black
No.633	Aluminum alloy foil	350	1.6	-	16	7.8	●				Grey

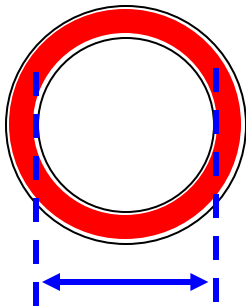
### 8.3.5 Pipes and Tubes

Carbon steel pipes are commonly used in engine room piping system and tubes



Difference between pipes and tubes:

- a. Pipes (Carbon pipes, Stainless pipes, Galvanized pipes, etc.)



**Nominal Diameter**

The most important property of the pipe is the capacity and the size is related to the inside diameter. Thus, the nominal diameter measurement of the pipe is related to the inside diameter.

Regardless of [schedule number](#), pipes of a particular size all have the same outside diameter (not withstanding manufacturing tolerances). As the schedule number increases, the wall thickness increases, and the actual bore is reduced.

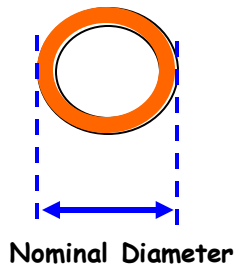
For example:

- a. A 4 inches (100 mm) Schedule 40 pipe has an outside diameter of 4.500 inches (114.30 mm), a wall thickness of 0.237 inches (6.02 mm), giving a bore of 4.026 inches (102.26 mm)
- b. A 4 inches (100 mm) Schedule 80 pipe has an outside diameter of 4.500 inches (114.30 mm), a wall thickness of 0.337 inches (8.56 mm), giving a bore of 3.826 inches (97.18 mm)

Pipes are identified by "nominal" or "trade" names that are loosely related to the actual dimensions. It is common to identify pipes by inches using NPS or "Nominal Pipe Size". The metric equivalent is called DN or "diametre nominel". The metric designations conform to International Standards Organization (ISO) usage and most commonly applied to the piping system in the engine room. Shown on the chart below are the pipe sizes in metric and English measurements.

Diameter Nominal - DN - (mm)	Nominal Pipe Size - NPS - (inches)	Diameter Nominal - DN - (mm)	Nominal Pipe Size - NPS - (inches)	Diameter Nominal - DN - (mm)	Nominal Pipe Size - NPS - (inches)
6	1/8	150	6	750	30
8	1/4	200	8	800	32
10	3/8	250	10	900	36
15	1/2	300	12	1000	40
20	3/4	350	14	1100	42
25	1	400	16	1200	48
32	1 1/4	450	18	1400	54
40	1 1/2	500	20	1500	60
50	2	550	22	1600	64
65	2 1/2	600	24	1800	72
80	3	650	26	2000	80
100	4	700	28	2200	88

b. Tubes (Copper, Aluminum, etc.)



The nominal diameter of the tube is the outside diameter and the inside diameter of the tube is depending on the thickness.

8.3.6 Other Materials

There are other materials that are widely used in the shipboard maintenance procedure that must be always kept on hand. These are the steel plates, steel bars, i.e., angle, flat, etc., proper inventory and stocking is a must at all times.



STEEL PLATES

STEEL BARS

STEEL ANGLE BARS

Standard sizes are available from the manufacturers but dimensions are in reference to the length by width and thickness measurements.

Thank you!