Antwerp Maritime Academy

Navale Engineering

Marine Electrical Knowledge

Author:
Willem Maes

February 19, 2013

Contents

List of Figures

List of Tables

Chapter 1

Electrical Distribution.

1.1 Power Distribution

The function of a ship's electrical distribution system is to safely convey electrical power to every item of equipment connected to it. The most obvious element in the system is the main switchboard. The main board supplies bulk power to motor starter groups (often part of the main board), section boards and distribution boards. Transformers interconnect the HV and LV distribution sections of the system. Circuit breakers and fuses strategically placed troughout the system automatically disconnects a faulty circuit within the network. The main switchboard is placed in the engine controlroom and from there engineroom staf monitor and control the generation and distribution of electrical power. It is very important that every engineer has a profound knowledge of the electrical distribution of the ship's power. The only way to aquire this knowledge is to study the ship's power diagrams. Almost all oceangoing ships have an A.C. distribution system in preference to a direct current D.C. system. Usally a ship's electrical distribution scheme follows shore pratice. This allows normal industrial equipment to be used after being adapted and certified where and if necessary, so it can withstand the conditions on board of a ship (e.g. vibration, freezing and tropical temperatures, humidity, the salty atmosphere, etc. encountered in various parts of the ship). Most ships have a 3-phase A.C., 3-wire, 440V insulated-neutral system. This means that the neutral point of star connected-generators is not earthed to the ship's hull. Ship's with very large electrical loads have generators operating at high voltages (HV) of 3.3KV, 6.6KV, and even 11KV. By using these high voltages we can reduce the size of cables and equipment. High voltage systems are becoming more common as ship size and complexity increase. The frequency of an A.C. power system can be 50 Hz or 60Hz. The most common power frequency adopted for use on board ships is 60Hz. This higher frequency means that generators and motors run at higher speeds with a consequent reduction in size for a given power rating. Lighting and low power single-phase supplies usually operate at 220 V. This voltage is derived from a step down transformer connected to the 440 V system.

1.2 Grounding systems in shipboard electrical networks.

In electrical engineeering, the ground means reference in electrical circuits from which other voltages are measured. The earth point means a solid connection to the earth, which due to its massive section and mass has almost no resistance for electrical current. If the reference for your voltage mea-

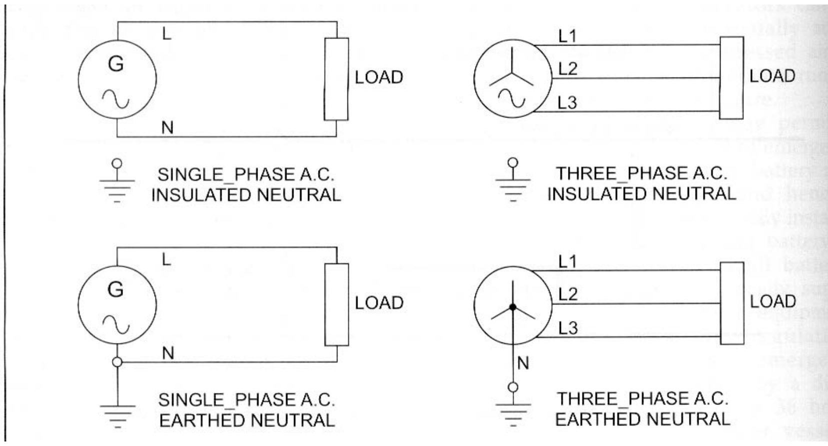

Figure 1.1: Insulated and earthed neutral systems.

surements is the earth the earth becomes your ground. By absense of the earth on board of a ship, the ship's hull can be used as a substitute for the earth. Depending on the construction of the electrical networks they may ar may not be connected to earth potential. In general we can have solidly grounded, reactance grounded, resistance grounded and isolated networks. In isolated networks there is the challenge to detect earth faults. Ships distribution systems are typically isolated in low voltage systems (¿1000V AC) and high resistance grounded in high voltage systems. High resistance grounding ensures the trip action in case of an earth fault and prevents short circuit faults in the network. High resistance grounding can therefore not guarantee continuity of service.

Characteristics	Solid	Isolated	High resistance
High ground fault current	**Yes**	No	No
Possibility of multi-phase fault	**High**	Low	Low
Arc flash hazard risk level	**High**	Very low	Very low
Relative safety level (equipment			
and personnel)	**Low**	High	Very high
Fault location	**Yes**	No	Yes
Continuity of service	**No**	Yes	Yes
Possible selective tripping	**Yes**	No	Yes
Alarming without tripping	**No**	Yes	Yes
Cable insulation level (IEC 60502-2)	**1.0**	1.73	1.73
Surge protection level	**1.0**	1.73	1.73
Transient overvoltage level	**2.5x**	6x	2.7x

1.3 Electrical faults

There are three different kind of electrical faults.

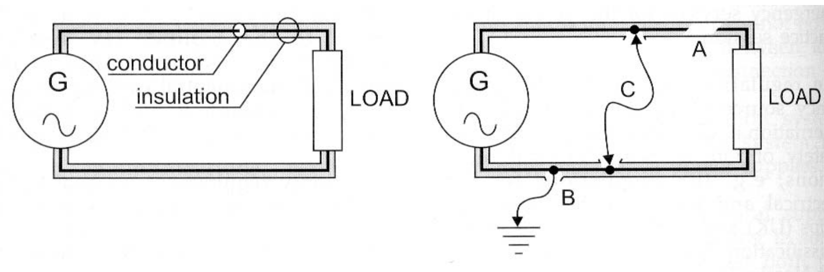

Figure 1.2: circuit faults

1.3.1 Earth fault

An earth fault is caused by loss of insulation allowing the current to flow to earth potential. Causes of earth faults are typically breakdown or wear of insulation. The majority of earth faults occur within electrical equipment due to an insulation failure or a loose wire, wich allows a live conductor to come into contact with its earthed metal enclosure.
To protect against the dangers of electric shock and fire that may result from earth faults, the metal enclosures and other non-current carrying metal parts of electrical equipment must be earthed. The earthing connector connects the metal enclosure to earth (the schip's hull) to prevent it from attaining a

dangerous voltage with respect to earth. Such earth bonding of equipment ensures that its voltage in reference to earth always remains at zero.

1.3.2 Open circuit fault

An open circuit fault occurs when a phase conductor is completely or even partialy interupted. Causes of open circuit faults are bad connections or a break in the wire. Open circuit faults when intermittent can cause flashes. Open circuit faults when not completely open (bad connection) can cause a lot of heat and are a fire hazzard. Open circuits in three phase circuits can cause motors to run on only two phases and create a motor overload.

Short circuit fault

Short circuit faults occurs where two different phase conductors are connected together. This can be caused by double break loss of insulation, human error or another abnormal situation. A large amount of current is released in a short circuit, often accompanied by an explosion.

1.3.3 Significance of Earth Faults

If a single earth fault occurs on the live line of an earthed distribution system it would be the equivalent to a schort-circuit fault across the generator trough the schip's hull. The resulting large current would immediatly cause the line protective device (fuse or circuit breaker) to trip out the faulty circuit. The faulted electric equipment would be immediately isolated from the supply and so rendered safe. However, the loss of power supply, could create a hazardous situation, especialy if the equipment was classed essential(ABS part 4 chapter 8 table 1 and 2), e.g. steering gear. The large fault current could also cause arcing damage at the fault location. In contrast a single earth fault occuring on one line of an insulated distribution system will not cause any protective trip to operate and the system would continue to function normally. This is the important point: equipment continues to operate with a single earth fault as it does not provide a closed circuit so no earth fault current will flow. More important is that if a second earth fault occurs on another line of the insulated system, the two faults together would be equivalent to a short- circuit fault (via the ship's hull) and the resulting large current would operate protection devices and cause disconnection of perhaps essential services creating a risk to the safety of the ship.
An insulated distribution system therefore requires two earth faults on two

different lines to cause an earth fault current to flow.
In contrast, an earthed distribution system requires only one earth fault to cause an earth fault current to flow.
An insulated system is, therefore more effective than an earthed system in maintenance continuity of supply to essential services. Hence its adoption for most marine electrical systems.
Note: Double-pole switches with fuses in both lines are necessary in an insulated single-phase circuit.

1.3.4 An Electric Power System's Reliability

Reliability of an electric system is obtained by sectioning of the distribution system and providing multiple power sources, by providing an emergency power system, subsectioning of the circuits, the choice of the earthing system and the selectivity of the protections.

1.3.5 Sectioning of the distribution system and providing multiple power sources

Providing multiple transformators can protect certain users against particular problems. An example can be computer systems wich are sensitive to harmonics.

1.3.6 Emergency power systems

Two independant high to low voltage power stations, emergency generators, UPS, independant emergency lighting a.o. have to be placed in well protected area's enabling them to function in case of an emergency and or accident.

1.3.7 Sectioning of circuits

Essential equipment can take there power from the main or emergency switchboard. This way a fault wich affects a secondary circuit doesn't influence a circuit with high priority. Sectioning of circuits is done as demanded by *The Rules* and the demands of exploitation, providing at least two power sources for all essential equipment.

1.3.8 Selectivity

If a fault occurs at any point in an electrical distribution circuit, it is essential that it does not interrupt the supply to essential services. This obvious

requirement leads to the necessity of rapidly isolating the defective section without depriving the other users of electrical energy; this is in fact the principle of selective tripping.
The protective element (circuit breaker or fuses) wich is placed immediately up-stream from the part of the circuit where the fault has occured, and this alone element, must then operate; the other protecting elements must not trip. Conventional selectivity processes (overcurrent and time lag) fullfil these requirements to a more or less satisfactory degree.

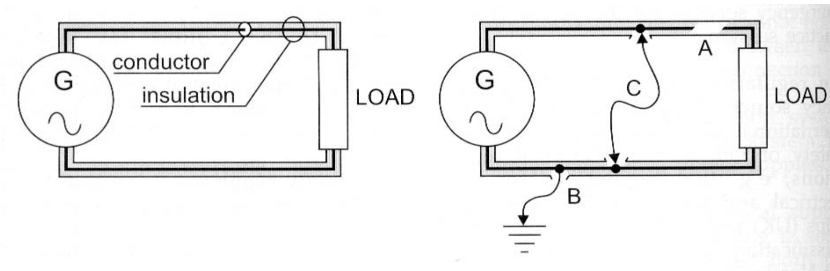

Figure 1.3: circuit faults

1.3.9 Overcurrent Selectivity

This makes use of protective equipment operating instantaneously (rapid circuit breakers or fuses). The selectivity is based on the fact that the short-circuit current decreases with increasing distance from the power source. It is thus especially for low voltages where the connecting impedances are not negligible.

1.3.10 Time lag selectivity

This can make complete selectivity by delaying the tripping of each circuit-breaker for durations all the higher as the circuit-breaker is nearer the source of energy.

Chapter 2

A Ship's Electrical System.

2.1 Overview

2.2 Generators

In marine applications generators are always synchronous machines. Synchronous machines are excited by direct current. In all but very small generators the rotor is the exiter of the generator. The direct current can be supplied to the rotor from an external exciting device via slip rings (brushed excitation) or via a small AC generator and rectifier on the rotor shaft (brushless excitation). An automatic voltage regulator (AVR) controls de exciting current. The AVR keeps the generators voltage in the set value, regardless of changes in load, temperature and frequency.

2.3 Electric motors

Nowadays the most widely used electric motors in marine applications are 3-phase alternating current asynchronous motors with a squirrel cage rotor.

2.4 Starting devices

A starting device is the general term for a piece of equipment that allows the connection of a consumer to its main power supply. Starting devices can also be used to limit inrush current of a consumer to an acceptable value. An acceptable value is one that does not disturb the proper functioning of the power supply as this would also disturb other consumers on this supply. Limiting the starting current will also limit the starting torque of an electric

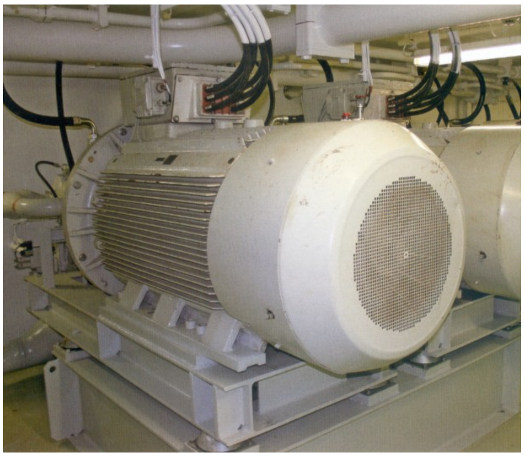

Figure 2.1: asynchronous motor

motor. This may be nescessary to protect for instance a gear box or other mechanical devices.

2.4.1 Direct-on-line starters

The simplest and cheapest way of starting an electric load is direct-on-line starting. The starting time will be minimal, the starting torque will be maximum but the voltage drop while starting will be maximal also for the other consumers. In general, a generator is able to supply a sudden overload of 50 percent of its KVA rating, resulting in a voltage drop at the generator terminals of less than 15 percent. This allows for another 5 percent voltage drop in the distribution network, in order to stay under the maximum allowed voltage drop of 20 percent during starting of a large consumer. The voltage drop is mostly a result of the capabilities of the generator (and AVR) as the power factor of a starting motor is almost always less then 0,4. A diesel engine should be capable of handling a load step of 20 percent or more without a frequency dip of more than 10 percent, wich should be recovered within 15 seconds. Modern commonrail and constant pressure electronic injected diesel engines have some difficulty handling step loads.

2.4.2 Reduced voltage starting

In some applications a motor cannot be directly connected to the line because the starting current is to high. In these cases we have to reduce the voltage applied to the motor either by connecting resistors (or reactors) in series

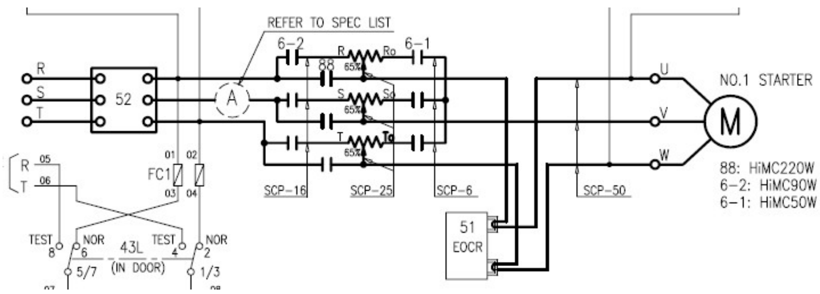

Figure 2.2: autotransformer starter main circuit

with the line or by employing an autotransformer. In reducing the voltage we recall the following:

- The locked-rotor current is proportional to the voltage: reducing the voltage by half reduces the current by half.
- The locked-rotor torque is proportional to the square of the voltage: reducing the voltage by half reduces the voltage by a factor of four.

2.4.3 Primary resistance starting

Primary resistance starting consists of placing three resistors in series with the motor during the start-up period. Suppose we chose the resistors so that the locked-rotor voltage across the stator is 65 percent of the total voltage. The locked rotor current is therefore 65 percent of the normal starting current and the locked rotor torque is $0,65^2 = 0,42$ or 42 percent of the full load torque. This means that the motor must be started at a very light load. After starting, when the motor reaches its maximum torque for this reduced voltage the resistors are shorted and the current jumps to its nominal value and maximum torque will be available.

2.4.4 Autotransformer starters

Compared to a resistance starter, the advantage of an autotransformer starter is that for a given torque it draws a much lower line current. The disadvantage is that autotransformers cost more, and the transition from reduced-voltage to full-voltage is not quite as smooth. Autotransformers usually have taps to give output voltages of 0,8, 0,65, and 0,5 times nominal. The corresponding starting torques are respectively 0,64, 0,42 and 0,25 off the full voltage starting torque. Furthermore the starting currents on the line side are also reduced to 0,64, 0,42 and 0,25 of the full voltage locked-rotor current.

2.4.5 Star-delta starters

Star-delta starting is also a way of reduced voltage starting. Star-delta starting was a much used method ashore, as it is cost effective, uses proven technologies and is widely available. This starting method gives the same results as an autotransformer starter having a 58 percent tap. The reason is that the voltage across each star-connected winding is only $\frac{1}{\sqrt{3}} = 0,58$ of its rated value.

- starting current will be reduced to 58 percent
- starting torque will be reduced to $0,58^2 = 0,33$ or only 33 percent.

The fact that marine generators are capable of accepting big step loads and the big reduction in torque while starting is propably the reason that star-delta starting is almost never used in a marine environment.

2.4.6 High voltage choke starter

Another way to limit motor starting current is a series reactor. If an air core is used for the series reactor then a very efficient and reliable soft starter can be designed which is suitable for all type of 3 phase induction motor [synchronous / asynchronous] ranging from 25 KW 415 V to 30 MW 11 KV. Using an air core series reactor soft starter is very common practice for applications like pump, compressor, fan etc. Usually high starting torque applications do not use this method.

2.4.7 Electronic softstarters

Electrical soft starters can use solid state devices to control the current flow and therefore the voltage applied to the motor. They can be connected in series with the line voltage applied to the motor, or can be connected inside the delta () loop of a delta-connected motor, controlling the voltage applied to each winding. Solid state soft starters can control one or more phases of the voltage applied to the induction motor with the best results achieved by three-phase control. Typically, the voltage is controlled by reverse-parallel-connected silicon-controlled rectifiers (thyristors), but in some circumstances with three-phase control, the control elements can be a reverse-parallel-connected SCR and diode. A soft starter continuously controls the three-phase motors voltage supply during the start-up phase. This way, the motor is adjusted to the machines load behavior. Mechanical operating equipment is accelerated in a gentle manner. Service life, operating behavior and work flows are positively influenced.

Chapter 3

Auxilliary Electrical services.

3.1 Introduction

todo

3.2 Lighting

3.2.1 Incandescent lighting.

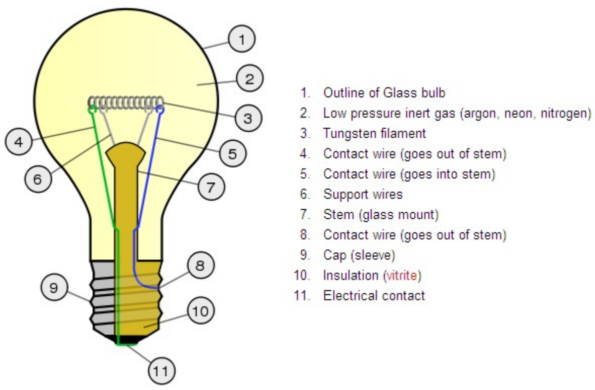

Figure 3.1: Incandescent lamp.

For a long time the incandescent lamp was the most common lamp for general lighting. On board of ships they are still used for certain applications as there are navigation lights, indicator lamps, battery operated emergency

lights a.o. A simple filament type is shown in the next figure, a current passes trough the tungsten filament wire of wich the temperature raises to a 3000 °C at this point the wire becomes incandescent, it glows. The glass bulb is filled with an inert gas such as argon or nitrogen wich helps to prevent filament evaporation. Numerous variations on the ordinary filament lamp are made, to prolong the expected lifetime, ore to give the lamp special properties.
A popular variation of the incandescent lamp is the tungsten-halogen lamp.

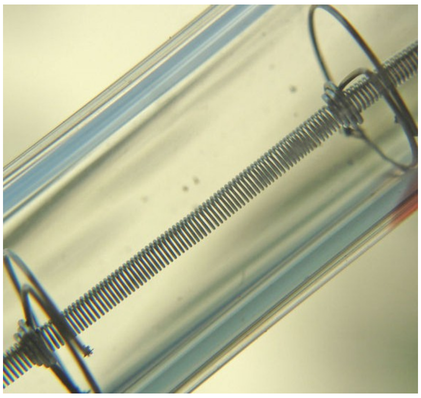

Figure 3.2: Tungsten-halogen lamp.

This lamp has a gas-filled quarts tube or bulb wich also includes a halogen vapour such as iodine or bromine. When the filament is heated, evaporated tungsten particles combine with the halogen vapor to form tungsten-halide. At the high filament temperature the tungsten vapour reforms on the filament. This regenerative process continues repeatedly creating a self cleaning action on the inner surface of the glass tube or bulb.Linear tungsten-halogen lamps must be used in the horizontale position otherwise the halogen vapour will concentrate at its lower end wich results in rapid blackening of the tube and a reduced operating life.

3.2.2 Discharge Lamps

Low pressure fluorescent lamps

A fluorescent lamp or fluorescent tube is a gas-discharge lamp that uses electricity to excite mercury vapor. The excited mercury atoms produce short-wave ultraviolet light that then causes a phosphor to fluoresce, producing visible light.
A fluorescent lamp tube is filled with a gas containing low pressure mercury vapor and argon, xenon, neon, or krypton. The pressure inside the lamp is

Figure 3.3: Low pressure mercury fluorescent lamps.

around 0.3 percent of atmospheric pressure. The inner surface of the bulb is coated with a fluorescent (and often slightly phosphorescent) coating made of varying blends of metallic and rare-earth phosphor salts.

The bulb's cathode (filament) is typically made of coiled tungsten which is

Figure 3.4: A fluorescent lamps filament.

coated with a mixture of barium, strontium and calcium oxides (chosen to have a relatively low thermionic emission temperature).

Fluorescent lamps are negative differential resistance devices, so as more current flows through them, the electrical resistance of the fluorescent lamp drops, allowing even more current to flow. Connected directly to a constant-voltage mains power supply, a fluorescent lamp would rapidly self-destruct due to the uncontrolled current flow. To prevent this, fluorescent lamps must use an auxiliary device, a ballast, to regulate the current flow through the tube.

The simplest ballast for alternating current use is a series coil or choke, consisting of a winding on a laminated magnetic core. The inductance of this winding limits the flow of AC current. Ballasts are rated for the size of lamp and power frequency. Where the mains voltage is insufficient to start

Figure 3.5: Ballast.

long fluorescent lamps, the ballast is often a step-up autotransformer with substantial leakage inductance (so as to limit the current flow). Either form of inductive ballast may also include a capacitor for power factor correction. Fluorescent lamps can run directly from a DC supply of sufficient voltage to strike an arc. The ballast must be resistive, and would consume about as much power as the lamp.
To strike a fluorescent tube, its gas filling must be ionised by a voltage between its cathodes that is slightly higher than that required to maintain the normal discharge. Two common methods are used to strike the tube:
The preheat starter.

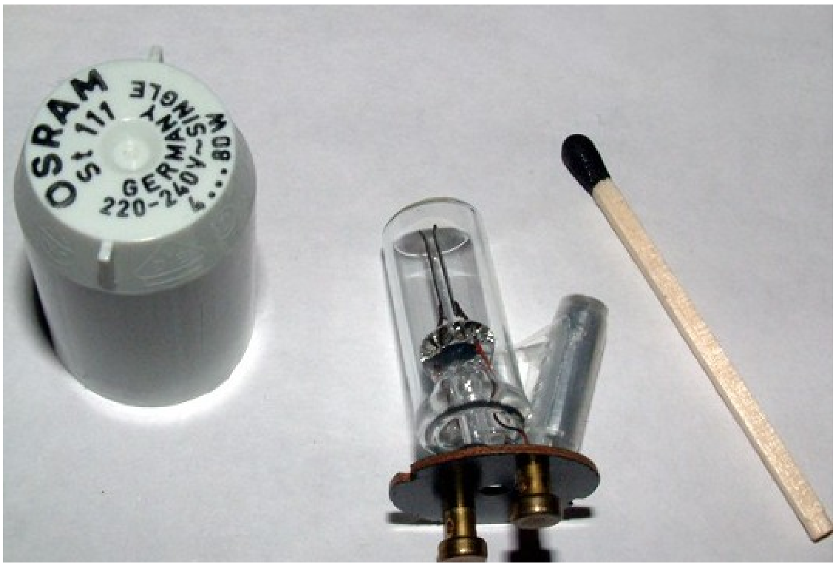

Figure 3.6: The preheat starter.

The automatic glow starter consists of a small gas-discharge tube, containing neon and/or argon and fitted with a bi-metallic electrode. The special bi-metallic electrode is the key to the automatic starting mechanism.

When starting the lamp, a glow discharge will appear over the electrodes

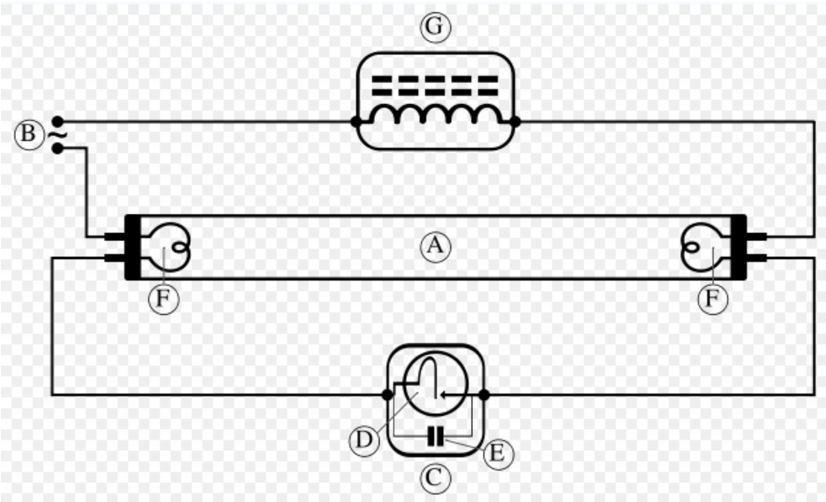

Figure 3.7: The preheat starter circuit.

of the starter. This glow discharge will heat the gas in the starter and cause the bi-metallic electrode to bend towards the other electrode. When the electrodes touch, the two filaments of the fluorescent lamp and the ballast will effectively be switched in series to the supply voltage. This causes the filaments to glow and emit electrons into the gas column by thermionic emission. In the starter's tube, the touching electrodes have stopped the glow discharge, causing the gas to cool down again. The bi-metallic electrode also cools down and starts to move back. When the electrodes separate, the inductive kick from the ballast provides the high voltage to start the lamp. The starter additionally has a capacitor wired in parallel to its gas-discharge tube, in order to prolong the electrode life.
Once the tube is struck, the impinging main discharge then keeps the cathode hot, permitting continued emission without the need for the starter to close. The starter does not close again because the voltage across the starter is reduced by the resistance in the cathodes and ballast. The glow discharge in the starter will not happen at the lower voltage so it will not warm and thus close the starter.
Tube strike is reliable in these systems, but glow starters will often cycle a few times before letting the tube stay lit, which causes undesirable flashing during starting. (The older thermal starters behaved better in this respect.) If the tube fails to strike, or strikes but then extinguishes, the starting sequence is repeated. With automated starters such as glowstarters, a failing tube will cycle endlessly, flashing as the lamp quickly goes out because emis-

sion is insufficient to keep the lamp current high enough to keep the glow-starter open. This causes flickering, and runs the ballast at above design temperature. Some more advanced starters time out in this situation, and do not attempt repeated starts until power is reset.

Rapid start

Newer rapid start ballast designs provide filament power windings within the ballast; these rapidly and continuously warm the filaments/cathodes using low-voltage AC. No inductive voltage spike is produced for starting, so the lamps must be mounted near a grounded (earthed) reflector to allow the glow discharge to propagate through the tube and initiate the arc discharge. In some lamps a "starting aid" strip of grounded metal is attached to the outside of the lamp glass.

High frequency ballasts

Since introduction in the 1990s, high frequency ballasts have been used with either rapid start or pre-heat lamps. These ballasts convert the incoming power to an output frequency in excess of 20 kHz. This increases lamp efficiency. These are used in several applications, including new generation tanning lamp systems, whereby a 100 watt lamp can be lit using 65 to 70 watts of actual power while obtaining the same lumens as magnetic ballasts. These ballasts operate with voltages that can be almost 600 volts, requiring some consideration in housing design, and can cause a minor limitation in the length of the wire leads from the ballast to the lamp ends.

Disinfection lamps

Mercury fluorescent tubes are also used as disinfecting devices for drinking

Figure 3.8: Germicidal lamp.

water and sanitation water. These so called germicidal lamps produces an ultraviolet light which kills germs. The most common form of germicidal lamp looks similar to an ordinary fluorescent lamp but the tube contains no fluorescent phosphor. In addition, rather than being made of ordinary borosilicate glass, the tube is made of fused quartz. These two changes combine to allow the 253.7 nm ultraviolet light produced by the mercury arc to pass out of the lamp unmodified (whereas, in common fluorescent lamps, it causes the phosphor to fluoresce, producing visible light). Germicidal lamps still produce a small amount of visible light due to other mercury radiation bands. *If looking straight into one of these lamps your eyes can be burned in seconds, similar to arc welding. You will only notice the burns a few hours later.*

High pressure mercury-vapor lamps

Figure 3.9: Mercury-vapor lamp.

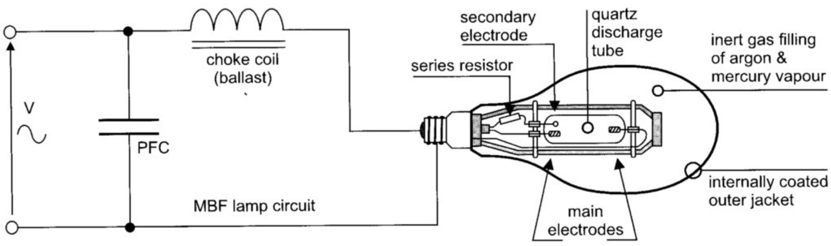

Figure 3.10: HP mercury-vapor lamp and circuit.

On board of ships often used as flood lights for the illumination during cargo operations and as primary ilumination of the engineroom (top). Often used are mercury-vapor lamps wich have a better color spectrum than the sodium based lamps. A mercury-vapor lamp is a gas discharge lamp which uses mercury in an excited state to produce light. The arc discharge is generally confined to a small fused quartz arc tube mounted within a larger borosilicate glass bulb. The outer bulb may be clear or coated with a phosphor; in either case, the outer bulb provides thermal insulation, protection from ultraviolet radiation, and a convenient mounting for the fused quartz arc tube.

The mercury vapor lamp is a negative resistance device and requires auxiliary components (for example, a ballast) to prevent it from taking excessive current. The auxiliary components are substantially similar to the ballasts used with fluorescent lamps.

Also like fluorescent lamps, mercury vapor lamps usually require a starter which is often contained within the mercury vapor lamp itself. A third electrode is mounted near one of the main electrodes and connected through a resistor to the other main electrode. When power is applied, there is sufficient voltage to strike an arc between the starting electrode and the adjacent main electrode. This arc discharge eventually provides enough ionized mercury to strike an arc between the main electrodes. Occasionally, a thermal switch will also be installed to short the starting electrode to the adjacent main electrode, completely suppressing the starting arc once the main arc strikes.

When a mercury vapor lamp is first turned on, it will produce a dark blue glow because only a small amount of the mercury is ionized and the gas pressure in the arc tube is very low, so much of the light is produced in the ultraviolet mercury bands. As the main arc strikes and the gas heats up and increases in pressure, the light shifts into the visible range and the high gas pressure causes the mercury emission bands to broaden somewhat, producing a light that appears more-white to the human eye, although it is still not a continuous spectrum. Even at full intensity, the light from a mercury vapor lamp with no phosphors is distinctly bluish in color. The pressure in the silica glass tube rises to approximately one atmosphere once the bulb has reached its working temperature. If the discharge should be interupted (e.g. by interuption of the electric supply), it is not possible for the lamp to restrike until the bulb cools enough for the pressure to fall considerably.

All mercury vapor lamps (including metal halide lamps) must contain a feature (or be installed in a fixture that contains a feature) that prevents ultraviolet radiation from escaping. Usually, the borosilicate glass outer bulb of the lamp performs this function but special care must be taken if the lamp is installed in a situation where this outer envelope can become damaged. If lamps with the outer envelope damaged are not replaced, people exposed to the light risk sun burns and eye inflammation. Special "safety" lamps are made which will deliberately burn out if the outer glass is broken. This is usually achieved by using a thin carbon strip, which will burn up in the presence of air, to connect one of the electrodes.

Sodium-vapor lamps

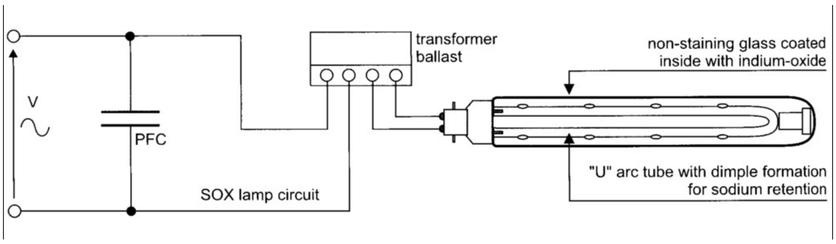

Figure 3.11: SOX lamp and circuit.

High pressure sodium (HPS) lamps contain additional elements such as mercury, and produce a dark pink glow when first struck, and a pinkish orange light when warmed. Some bulbs also briefly produce a pure to bluish white light in between. This is probably from the mercury glowing before the sodium is completely warmed. Colors of objects under these lamps cannot be distinguished.
High pressure sodium lamps are quite efficientabout 100 lm/Wwhen measured for photopic lighting conditions. They have been widely used for outdoor lighting such as streetlights and security lighting.
End of life At the end of life, high-pressure sodium lamps exhibit a phe-

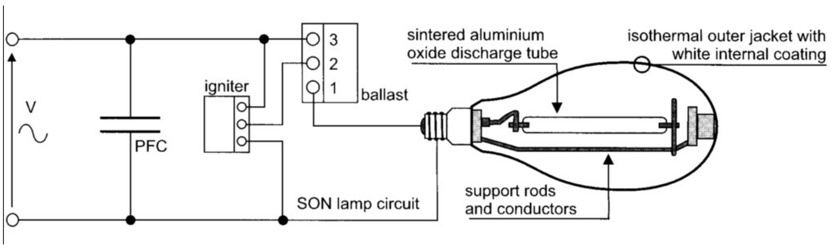

Figure 3.12: SON lamp and circuit.

nomenon known as cycling, which is caused by a loss of sodium in the arc. Sodium is a highly reactive element, and is easily lost by combination with other elements, and migration through the arc tube walls. As a result, these lamps can be started at a relatively low voltage but as they heat up during operation, the internal gas pressure within the arc tube rises and more and more voltage is required to maintain the arc discharge. As a lamp gets older, the maintaining voltage for the arc eventually rises to exceed the maximum voltage output by the electrical ballast. As the lamp heats to this point, the arc fails and the lamp goes out. Eventually, with the arc extinguished, the lamp cools down again, the gas pressure in the arc tube is reduced, and the ballast can once again cause the arc to strike. The effect of this is that the lamp glows for a while and then goes out, repeatedly.

3.2.3 Navigation and Signal Lights

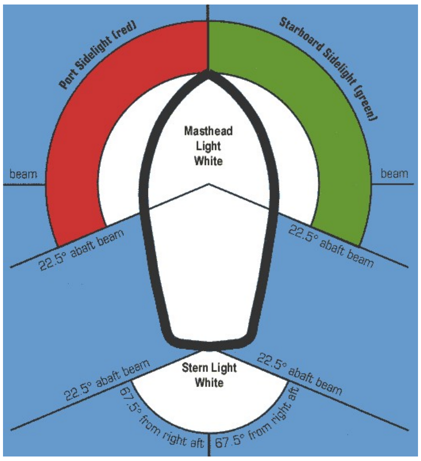

Figure 3.13: Ship's navigation lights requirements.

Navigation lights specifications are described by the the International Maritime Organisation in their *International Regulations for Preventing Collisions at Sea*.
By far the most common arrangement is to have specially designed navigation *running* lights referred to as Foremast, Mainmast,Port, Starboard and Stern. Two anchor lights, fitted forward and aft, may also be switched from the Navigation light panel on the bridge. For ship's longer than 50 metres, the masthead lights must be visible from a range of six nautical miles and other navigational lights from three nautical miles. To achieve such visibility, special incandescent filament lamps are used with a typical power rating of 65 W. Due to the essential safety requirements all navigation lights have two fittings at each position, or two lamps and lampholders with a dual fitting. Each light must be seperately supplied, fused, monitored and switched from the navigation light switchboard on the bridge. The main 220V supply is

Figure 3.14: Navigation Light Panel.

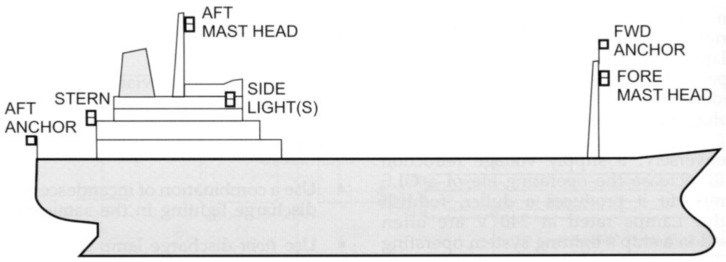

Figure 3.15: Ship's navigation lights arrangement.

provided from the essential services section of the main switchboard. The stand-by power supply is fed from the emergency switchboard.
On the Navigation light panel we can switch over from main to stand-by power, we have indicator lamps for each navigation light and an audible alarm in the case of lamp failure. The signal mast or xmas-tree has a com-

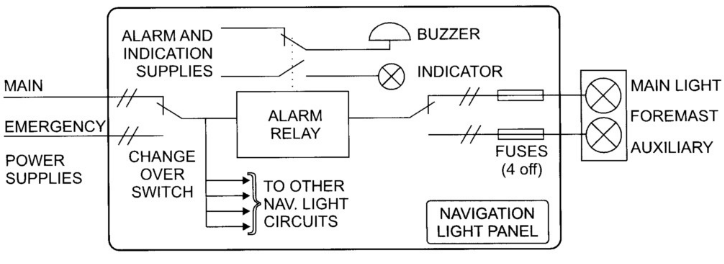

Figure 3.16: Navigation lights circuit.

bination of various signal lights in red, green, blue and white colors. These lights can be switched in certain patterns to signal states relating to international and national regulations. Pilotage requirements, health, dangerous cargo conditions, etc., are signalled with these lights. White Morse-Code lights may also be fitted on the signal mast. The NUC (Not Under Com-

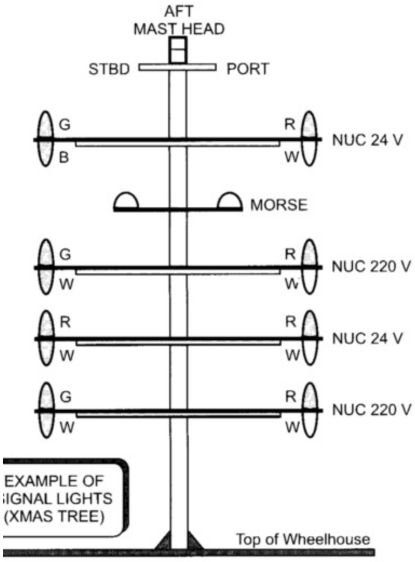

Figure 3.17: Xmas tree.

Figure 3.18: Signal lights switchboard.

mand) state is signalled using two all-round red lights vertically mounted at least 2 meters apart. Such important lights are fed from the 24V battery emergency power, but may be doubled by a pair on the 220V emergency power supply.

3.2.4 Emergency Lighting

Depending upon the ship's classification,e.g.,tanker,roro,passenger,etc.,and tonnage the Safety of Life at Sea (SOLAS) Convention prescribes minimum

requirements for emergency lighting troughout the vessel.
Most emergency light fictures are continually powered by the 220V emergency switchboard, emergency light fittings are specially identified, often with a red disc, ore the complete base is painted red to identicate their function.
A few emergency lights may be supplied by the ship's 24V battery eg. the main machinery spaces the radio telephone in the wheelhouse and the steering gear room.
A new trend is emerging to place battery supported lighting fixtures where the battery takes over immediately after a power failure.
Boat station emergency lights are switched on when required. They usually have there own battery wich will provide power only for a limited time depending on regulations.

3.3 Cathodic Protection For Ships.

3.3.1 History.

Cathodic protection was succesfully applied even before the science of electrochemistry was developed. It is particular to the shipping industrie to note that Humprey Davey first used cathodic protection on British navale ships in 1824.

3.3.2 A litle electrochemistry

The basis of corrosion in general:

- Hydrogen evolution
$$2H^+ + 2e \longrightarrow H_2 \tag{3.1}$$
- Oxygen reduction
$$O_2 + 2H_2O + 4e \longrightarrow 4OH^- \tag{3.2}$$
- Metal ion reduction
$$M^{3+} + e \longrightarrow M^{2+} \tag{3.3}$$
- Metal deposition
$$M^+ + e \longrightarrow M \tag{3.4}$$

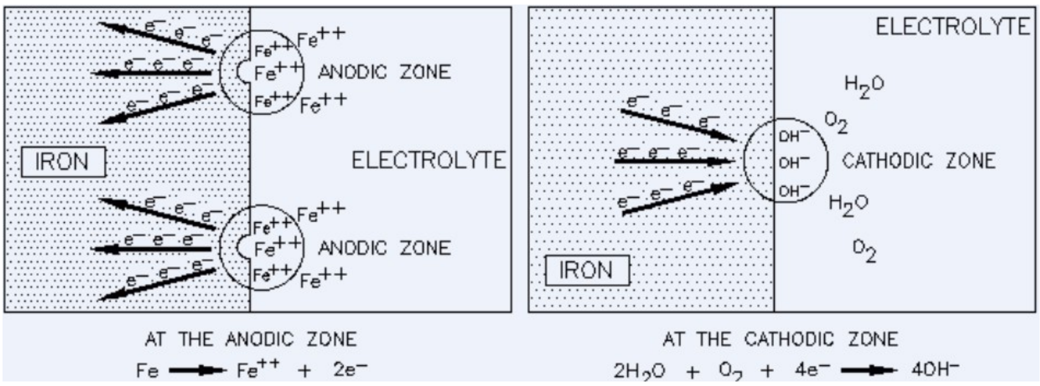

Figure 3.19: anodic reaction and cathodic reaction.

Metal ion reduction and metal deposition are less common reactions. All of the above reactions have one thing in common they use electrons. In

addition, these reactions can largely be used to interpret most corrossion problems.
Consider what happens when iron is immersed in seawater that is exposed to the atmosphere - corrosion occurs. The anodic reaction is:

$$Fe \longrightarrow Fe^{2+} + 2e \tag{3.5}$$

Since the seawater is exposed to the atmosphere it contains dissolved oxygen and is nearly neutral, where the cathodic reaction is:(1.2)

$$O_2 + 2H_2O + 4e \longrightarrow 4OH^-$$

Keeping in mind that sodium and chloride ions do not perticipate in the reaction, the overall reaction is obtained by adding (1.2) and (1.5):

$$2Fe + 2H_2O + O_2 \longrightarrow 2Fe^2 + 4OH \longrightarrow 2Fe(OH)_2 \downarrow \tag{3.6}$$

In an oxygenated environment ferrous hydroxyde that precipitates from solution is unstable and further oxidises to the ferritic salt:

$$2Fe(OH)_2 + 2H_2O + \frac{1}{2}O_2 \longrightarrow 2Fe(OH)_3 \tag{3.7}$$

The final product is known as rust.

3.3.3 What is cathodic protection.

Cathodic protection is achieved by supplying electrons to the metal structure to be protected. The addition of electrons to the structure will tend to suppress metal dissolution and increase the rate of oxygen evolution.
In conventional electrical theory current is considered to flow from (+) to (-) and as a result a stucture is protected if current enters it from the electrolyte (seawater). Conversely accelerated corrosion occurs if current passes from the metal to the electrolyte (seawater). Cathodic protection of a structure can be achieved in two ways, namely:

- by application of an external power supply (impressed current)
- by application of an appropriate galvanic system (sacrificial anode)

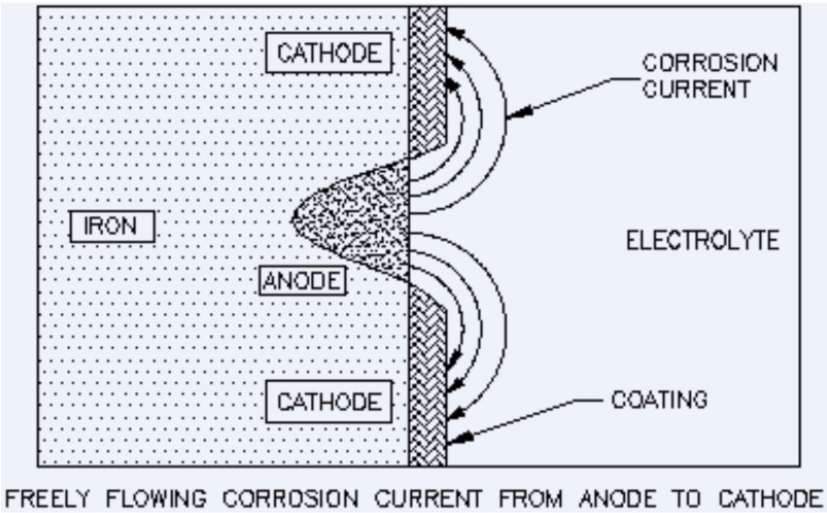

Figure 3.20: No protection at all.

3.3.4 Cathodic protection in human language

When two dissimilar metals are immersed in sea water and connected together a current will flow through the water from the more reactive (anodic) to the less reactive (cathodic). Due to the electrochemical action the anodic metal will tend to go into solution (ie corrode) whilst the cathodic metal will remain stable (ie protected by the anodic metal).
Similar reactions occur at numerous places on a steel structure due to the potential difference between areas (anodic cathodic) for a veriety of reasons eg lack of chemical uniformity of the steel, breaks in paint coating. The reaction also occurs in the presence of a different (coupled) metal (eg welds; brackets). Variations in sea water flow and aeration can also give rise to potential differences on a plate surface causing current flow which will result in corrosion.
The principle of cathodic protection is to swamp these localised corrosion currents by applying an opposing current from an external source. (Either the sacrificial anode system or impressed current system may be used). For the structure to be adequate protected the potential of all areas of metal must be depressed to a value more negative than any natural anodic area. This potential may be measured against a standard reference electrode in sea water.
The current density required to protect a ship's hull will depend on a number of variables such as, speed of ship, condition of outer bottom paint, salinity, temperature of sea water etc. Currrent density requirements are based on the following assumptions:

- About 32 mA/m^2 is needed for adequate protection of painted steel.
- About 110 mA/m^2 is needed for adequate protection of unpainted steel.
- About 150 mA/m^2 is needed for adequate protection of non-ferrous metal.
- About 540 mA/m^2 is needed for adequate protection of propellers.

To determine wether complete protection of the underwater structure has been achieved it is necessary to measure the potential difference against a reference electrode. For adequate protection the painted steel must have a potential of 750 to 850mV negative with respect to a silver/silverchloride reference electrode. Below 750mV the risk of corrosion is increased. Above 850mV there is a danger of damage to paint coating caused by hydrogen evolution from protected surface.
To ensure protection of rudders and stabilizer fins it is necessary to provide each with a low resistance connection to the hull. This bonding is achieved by means of a flexible cable fitted between rudder (or stabiliser) stock and a convenient point on the hull.
The propeller shafting may require bonding to the hull.

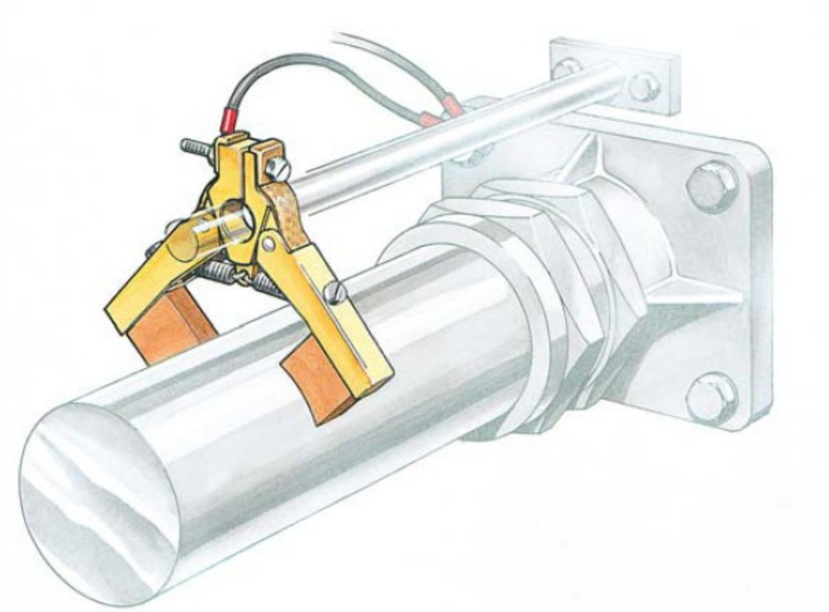

Figure 3.21: Propeller shafting may require bonding to the hull.

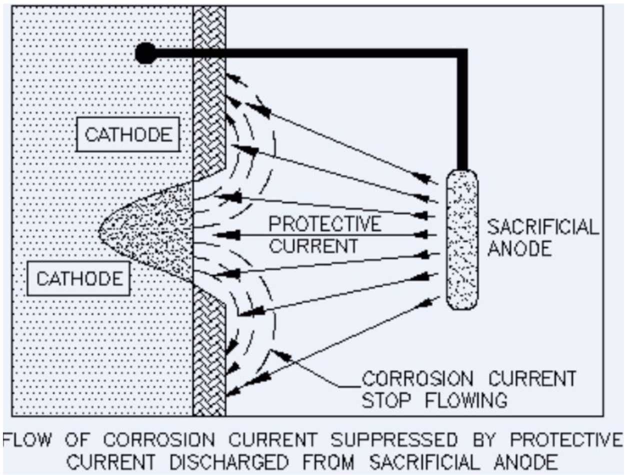

Figure 3.22: Sacrificial cathode system.

Sacrificial anode cathodic protection

?? shows sacrificial cathode protection applied to a ship's hull. Galvanic coupling is shown between the ship's hull and a zinc anode. The zinc is anodic (+) with respect to the steel and corrodes preferentially when coupled with steel.

Corrosion takes place all over submerged steel. But, if the steel has been coated, the corrosion attack is concentrated at points of paint breakdown and takes the form of deep pits weld grooving ore even complete penetration of the plate.

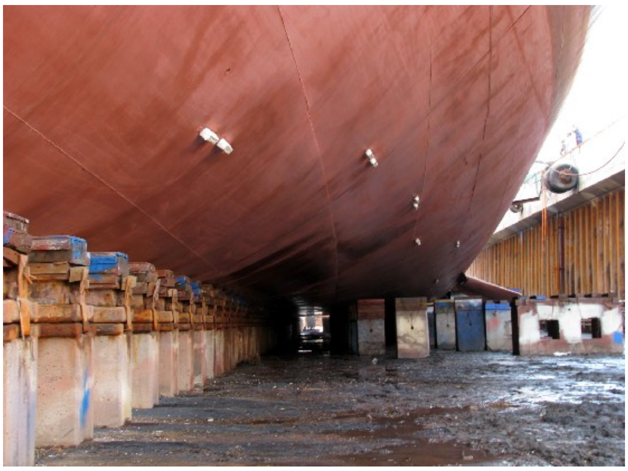

Figure 3.23: sacrificial anodes on a ship's hull.

Impressed current protection system.

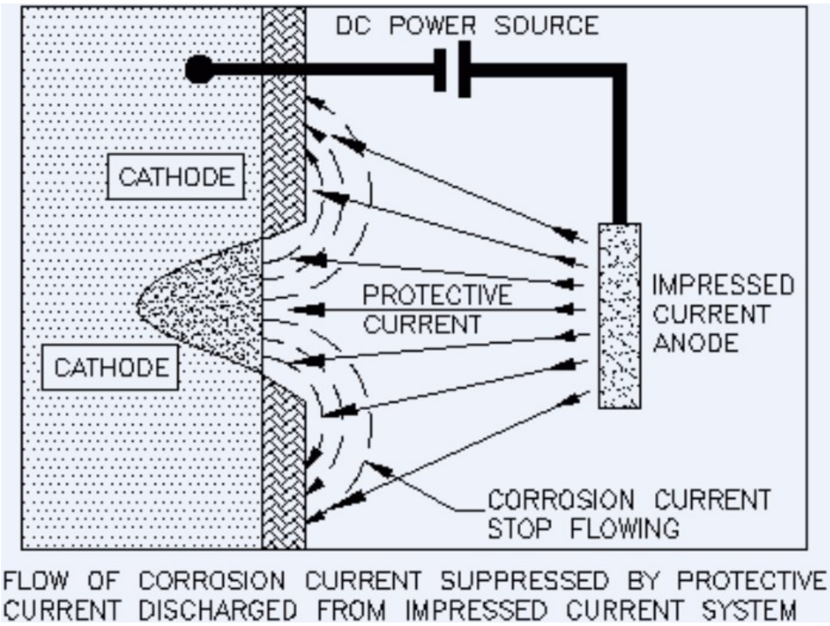

Figure 3.24: Impressed current system.

Impressed current cathode protection systems fitted in ship's consist of a number of anodes (lead or platinised titanium) fitted to the hull at selected places below the waterline, and control equipment wich automatically regulates the anode current to the required value. Direct current is supplied to the anodes, after transformation and rectification, from the ship's 440 V 60 Hz 3-phase a.c. distribution system. The control equipment comprises reference electrodes, an amplifier assembly and one or more transformer rectifier units.

Current control is usually regulated by electronic thyrister controllers and the diagram in the next fig. outlines a typical scheme.

The control equipment automatically monitors the size of anode current required wich will vary with conditions as there are; sea water temperature, ship's speed, condition of the coating and salinity. Typical anode current density range from 10 mA/m^2 to 40 mA/m^2 for the protection of painted surfaces and 100 to 150 mA/m^2 for bare steel surfaces. The total impressed current for a hull in good condition may be as low as 20A. Maximum controller outputs may be up to about 600 A at 8 V.

Measurements should regularly be logged together with the ship's operating conditions as there are; sea water temperature and salinity, draught, speed at sea or berthed.

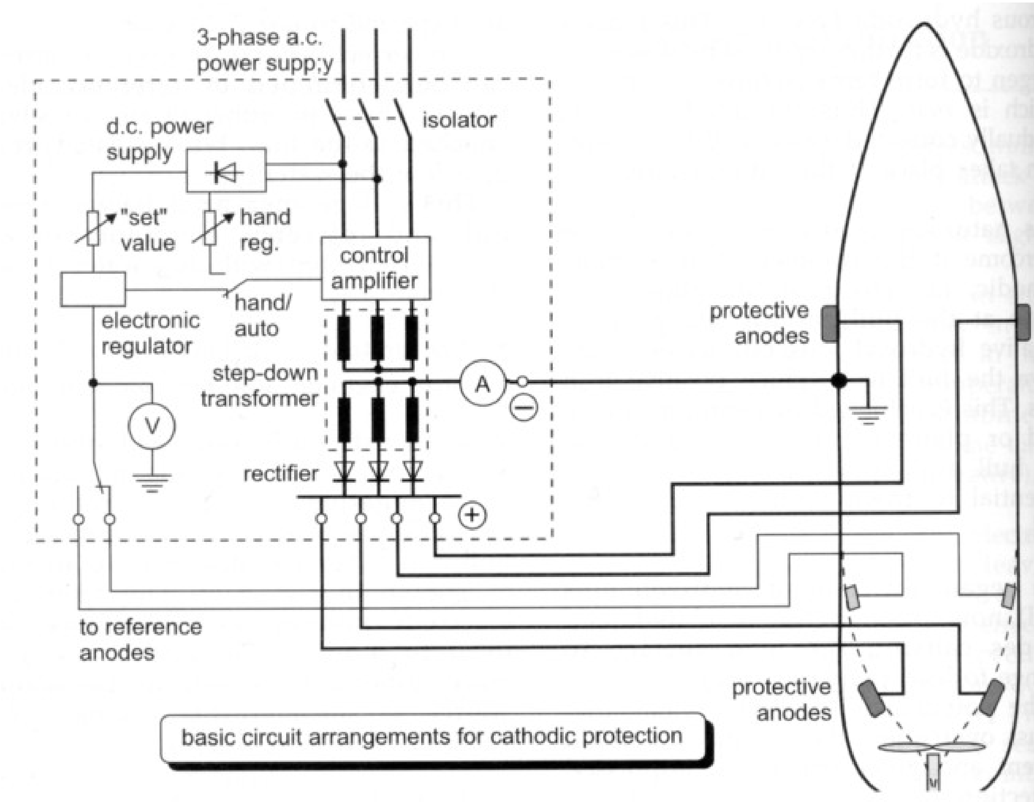

Figure 3.25: Ships anodes and impressed current control system.

When the ship is stopped at sea, voltage reading can be taken between a reference anode and the ship's hull. Check the manufacturer's instructions regarding the manipulation of the reference electrode.

Safety

It is always wise to turn of the impressed current cathodic protection system when divers have to work in the vincinity of the hull.

applications

Cathodic protection on ship's is not only used to protect the outer hull, we can find sacrificial anodes in seawater systems, bun coolers, fresh water heaters, coolers and even in ballast tanks.

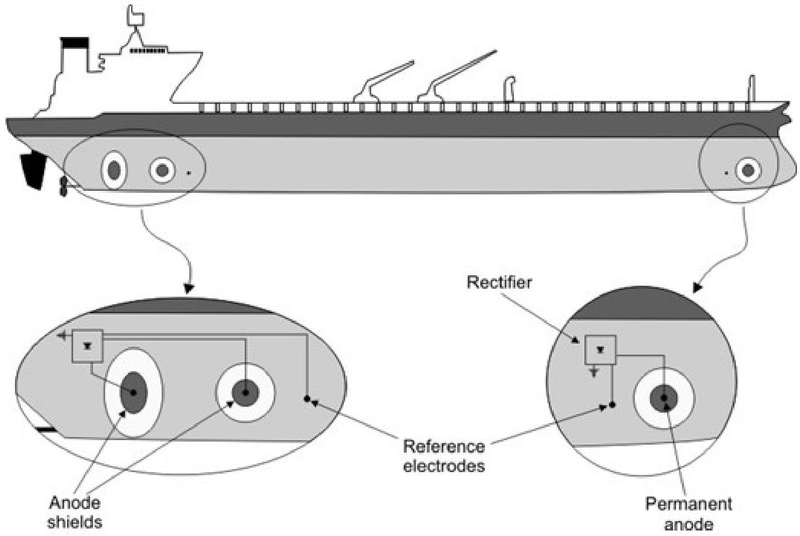

Figure 3.26: Impressed current system on a tanker.

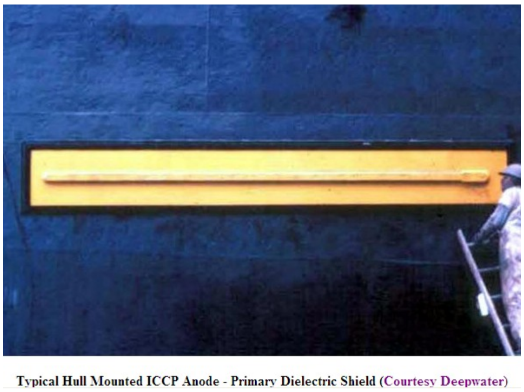

Figure 3.27: Impressed current anode.

Figure 3.28: Sacrificial anodes in a ballast tank.

Chapter 4

High Voltage Safety.

4.1 introduction

As the demand for electrical power increases on vessels the supply current ratings becomes too high at the usual 3phase 440 V.
To reduce the size of both steady state and fault current levels it is necessary to specify a higher power system voltage at the higher power ratings.
In marine practice voltages below 1000 V are considered LV (low voltage). HV (high voltage) is any voltage above 1 KV.
Typical marine HV system voltages are 3.3 KV and 6.6 KV. 10 KV Systems are emerging with the still increasing power demands. By generating electrical power at 6.6 KV instead of 440 V the distribution and switching of power levels above about 6 MW becomes more practicable and manageable.
By generating electrical power at 440V from 3 x1 megawatt, 0.8 power factor diesel generator sets, each generatorr main cable and circuit breaker has to handle a full load current of:

$$Power(watt) = \sqrt{3} \times Voltage(volt) \times Current(amp) \times Powerfactor(cos\phi)$$

$$P = \sqrt{3} \times U \times I \times cos\phi$$

Which returns a current of:

$$\frac{1000000}{\sqrt{3} \times 440 \times 0.8} = 1640amps$$

If a short circuit fault occures on one of the outgoing feeder cables from the

main switchboard the feeder circuit breaker would need to be rated to break a prospective fault current of about 65 KA.
For the same system at 6.6 KV the full-load current of each generator is:

$$\frac{1000000}{\sqrt{3}} \times 6600 \times 0.8 = 109A$$

Also, the fault level at the main board would be as low as 4.5 KA.
In addition to the above, the power loss in an HV installation may be calculated by:

$$P = I^2 \times R$$

Power loss is reduced if the voltage is stepped up and thus it is always efficient to transmit power at a higher voltage. Thes are a few mayor reasons why vessels have shifted towards high voltage systems.

4.2 Training

The 2010 Manilla Amendments to the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) introduced revised competence standards for the engine department, including a new additional requirement for engine personnel to have undergone training and education in HV systems.

The Mannila Amendments entered into force on 1 January 2012. Seafarers who started their training before 1 july 2013 may continue to meet the previous training requirements until january 2017. However, from 1 january 2017, engineering personnel wil have to demonstrate that they meet the new HV requirements. Companies should confirm individual flag state requirements, but it is likely that, when it comes to revalidating their certificate (every 5 year), engineering officers who are unable to provide documentary evidence of previous sea services on ships fitted with HV systems or of having completed an appropriate HV course will have an HV limitation placed on their Certificate of Competency.

Companies will also need to confirm any national requirements for the approval of HV courses, but for engineering personnel at the management level, an approriate course is likely to have to cover as a minimum:

- The functional operational and safety requirements for a marine HV system.

- Assignement of suitably qualified personnel to carry out maintenance and report of HV switchgear of various types.
- Taking remedial action necessary during faults in a HV system.
- Producing a switching strategy for isolating components of a HV system.
- Selecting suitable apparatus for isolation and testing of HV aquipment.
- Carrying out a switching and isolation procedure on a marine HV-system.
- Performing tests of insulation and resistance on high voltage equipment.

4.3 Definitions

4.3.1 Additional earth

An earth connection applied to apparatus after application of a CME, normally applied at the point of work if not already fitted with CME.

4.3.2 Approved

A type of form sanctioned for use by the DPA/superintendent/senior electrical engineer.

4.3.3 Authorised person (AP)

An authorised person is appropriately trained and appointed in writing by the superintendent/electrical engineer to carry out work as permitted by these rules.

4.3.4 Caution notice

A notice conveying a warning against interference with the apparatus to which it is attached.

4.3.5 Chief engineer

Senior engineer onboard the vessel responsible for all vessel technical operations and maintenance.

4.3.6 Circuit main earth (CME)

An earth connection applied for the purpose of making apparatus safe to work on before a permit to work or sanction for test is issued and which is nominated on the document.

4.3.7 Competent person

A competent person is appropriately trained and has sufficient technical knowledge or experience to enable him to avoid danger. It is the duty of the authorised person issuing a permit to work to satisfy himself that the persons are competent to carry out the work involved.

4.3.8 Danger notice

A notice calling attention to the danger of approach or interference with the apparatus to which it is attached.

4.3.9 Dead

At or about zero voltage and disconnected from all sources of electrical energy.

4.3.10 Earthed

Connected to the general mass of earth in such a manner as will ensure at all times an immediate discharge of electrical energy without danger.

4.3.11 High voltage (HV)

All voltage exceeding 1000 V ac.

4.3.12 High voltage apparatus

Any apparatus, equipment or conductors normally ooperated at a voltage higher than 1000 V ac.

4.3.13 Isolated

The disconnection and separation of the electrical equipment from every source of electrical energy in such a way that this separation and disconnection is secure.

4.3.14 Key safe

A device for the safe retention of keys used to lock means of isolation, earthing or other safety devices.

4.3.15 Limitation of acces (LoA)

A form issued by an authorised person to a competent person, defining the limits of the work to be carried out in the vincinity of, but not on, high voltage electrical apparatus.

4.3.16 Live

Electrically charged from a supply of electricity.

4.3.17 Permit to work (PTW)

A form of declaration signed and given by an authorised person to a competent person in charge of the work to be carried out on or in close proximity to high voltage apparatus, making known to him the extend (in time and space) of the work, exactly what apparatus is dead, is isolated from all live conductors, has been discharged and earthed and, insofar as electric hazards are concerned, on wich it is safe to work.

4.3.18 Safety lock

A lock used to secure points of isolation, safety devices and earth circuits, being unique from other locks used on the system.

4.3.19 Sanction for test (SFT)

A form of declaration, signed and given by an authorised person to another authorised person in charge of testing high voltage apparatus making known to the recipient what apparatus is to be tested and the conditions under which the testing is to be carried out.

4.3.20 Designated person ashore (DPA)

A senior electrical/mechanical engineer suitably qualified and appointed in writing by the company to be responsible for compilation and administration of procedures for high voltage installations and operations.

4.4 What is classed high voltage onboard a vessel

In marine practice, voltages below 1000V ac are considered LV (low voltage). HV (high voltage) is any voltage above 1000V. Typical marine HV systems are 3.3KV, 6.6KV and 11KV.

4.5 HV Equipment

The principal items of a high voltage electrical system would be:
The main generating sets.
The main and auxillary HV switchboards with associated switchgear, protective devices and instrumentation.
High voltage cables.
HV to LV transformers.
HV to HV transformers typically step down or isolating transformers supplying propulsion converters and motors.
HV motors for propulsion, thrusters, ballast-pumps, cargo-pumps and compressors.

4.5.1 HV Insulation Requirements

The winding arrangements for marine HV generators and motors are similar to those at LV exept for the need for much better insulating materials such as Micalastic or similar.
The windings of HV transformers are usually insulated with an epoxy resin and quartz powder compound. This is a non-hazardous material wich is maintenance free, humidity resistant and tropicalised. Insulation for the HV conductors requires a more complicated design than is necessary for LV cables. Buth HV cables provide a significant saving in weight and space, leading to easier installation and a more compact result. Where air is being used as the insulating medium between bare copper busbars and terminals, the creepage and clearance distances between live parts and earth are greater on HV systems.

4.6 Major features of a HV system compared to a LV system

- HV systems have more extensive and complex networks and aonnections.
- Acces to HV areas is strictly limited and securely controlled.
- Isolation procedures are more involved and switching strategies have to be formulated and recorded.
- Isolated equipment must be earthed down.
- Appropriate test probes and instruments should be used.
- Diagnostic insulation resistance testing is necessary.
- HV systems may sometimes be earthed neutral and use current limiting resistors.
- Special HV circuit breakers should be installed.
- Current magnitude and time is used for discrimination in protection/monitoring devices.

4.7 Dangers when working on HV equipment

4.7.1 Electric shock

Making personal contact with any electric voltage is potentialy dangerous. At high voltage levels the electric shock potential is lethal. Body resistance decreases with increased voltage level wich enhances the current flow. Remember that an electric current shock of as low as 15mA can be fatal. The risk to people working in HV areas can be greatly minimized by the diligent application of sensible general and company regulations and procedures. Factors likely to increase the risk of receiving an electric shock include the following.

- HV work on board du to limited space may be carried out in close proximity to a person(s) not familiar with HV hazards. Therefore the area must be properly cordoned off from surrounding work that may be going on and danger notices well posted.

- There will be large areas of earthed metal that can be easily touched, increasing the possibility of electrical shock from an HV conductor.
- High voltage isolation testing can be particulary hazardous when several parts of the equipment are energised for a period of time.
- Some equipment could be using water in its operation which can lead to an increased risk of injury. In general, water conducts electricity and reduces the resistance of the skin.
- The use of instruments when taking measurements of high voltages can increase the risk of injury if they are inadvertently used without the earth (protective) conductor connected. This can result in the enclosure of the instrument becoming live at high voltages.
- High voltage equipment will store energy after disconnection. For example, on a 6.6KV switchboard a fatal charge may still be present on the equipment hours or even days later.
- If during maintenance an HV circuit main earth (CME) is removed from the system, it must not be worked on, as the HV cabling can recharge itself to a high voltage from induced voltages from nearby live HV cabling.

4.7.2 Arc

- An arc is a discharge of electrical current across a gap.
- An arc fault is a high power discharge of electricity between two or more conductors.
- The radiation of heat in an arc is very high and it can very easily set a persons clothes on fire.

4.7.3 Arc Blast

- Arc blast pressure derives from two things. First, the expansion of metal in a boiling, vaporising state, and second the heating of ambient air by passage of the arc.
- The mixture of vaporised water and metal in air near the arc generates a rapidly expanding plasma of ionized vapor, which can lead to extensive injuries.

4.8 Electrical Permit Work System

The access procedure to HV switchboards and equipment must be strictly controlled by using a Electrical-Permit-Work-System(PTW), isolation procedure involving a safety key system, and Earthing Down.
The format of a permit will vary for different companies and organisations. Before work is commenced on HV equipment an PTW must be issued. This permit is usually the last stage of a planned maintenance task organised and approved by the authorising officer to be carried out by the responsible person.

4.9 Additional procedures to be implemented for HV systems

For HV systems, additional procedures and precautions should be taken. These are as follows:

4.9.1 Sanction-to-test system

Usually testing on an HV system can only be carried out after the circuit main earth (CME) has been removed. An example of this can be insulation testing as it involves the system being checked for insulation to earth.
A sanction-to-test should be issued in a similar manner to a permit-to-work. A sanction-to-test should never be issued on an apparatus on wich a permit-to-work is still in force, or on wich another sanction-to-test is in force.
Note: Maintenance and repair cannot be carried out under a sanction-to-test.

4.9.2 Limitation of acces form

When carrying out HV maintenance, it may be dangerous to allow unrestricted work be carried out nearby. Workers carrying out maintenance nearby may not have HV training and may not be familiar with the risks involved when working on or near HV equipment. Due to these risks the Limitation of acces form should be used. This form states the type of work that is allowed to be carried out nearby the HV work, the limitations imposed (space and time) and the safety precautions taken. The form is to be issued and signed by the authorised person (AP) and a confirmation of receipt signature by the person carrying out the work. The form should include a sign off and a cancellation section.

4.9.3 Earthing Down

Earthing Down is required to ensure that any stored electrical energy in the inherent capacitance of the epuipment insulation after isolation is safely discharged to earth. The higher values of insulation resistance required on HV cabling leads to a high value of insulation capacitance (C) this coupled with the high voltage means the energy stored (W) in HV equipment is far greater than that in LV systems.

$$\frac{C \times V^2}{2} joules$$

Earthing down also ensures that isolated equipment remains at a safe potential during work procedures.
Earthing down at a HV switchboard is of two types. **Circuit Earthing:** an incoming ore outgoing feeder cable is connected by a heavy earth connection from earth to all three conductors after the circuit breaker has been racked out, this is done at the circuit breaker using a special key. The key is then locked in the key safe. The circuit breaker cannot be racked in until the circuit's earth connection has been removed. **Busbar Earthing:** when it is necessary to work on a section of busbars they must be completely isolated from al possible electrical sources. This will include generator incomers, section or bus-tie breakers and transformers on that bus-bar section. The busbars are connected together and earthed down using portable leads which give visible confirmation of the earthing arrangement.

Chapter 5

Classification and Certification

Repair and maintenance.

- Use of the equipment
- Fault finding
- Planned maintenance
- Who will do it?
  1. competence
  2. confident
  3. familiar with equipment
- Equipment specific instructions
  1. Makers instruction books, manuals
- Regulations and work standards
  1. Shipowner's book
  2. Class rules
  3. Flag regulations

Generally, work onboard ships is subject to local circumstances.
Since the actual electric work is not defined as on land, company practises prevail. All personnel needs to know the risks and operational requirements on electrical equipment.
The amount of electrical work has steadily increased day by day.
The allocation of electrically educated people is usually lagging behind.

In the meantime, trained people have become rare, why??
The everyday organisation and monitoring of the work requires competent and responsible decisions on task allocation.
Misunderstanding between the different proffesional groups involved have to be minimized:

- Electricians
- Mechanics
- Administration office people

5.1 classification and certification for the equipment

- Equipment is generally classed according to IEC standards.
- The national Flag Rules may ask for certification.
- The major Ship Classification Societies group up as the members of IACS (International Association of Classification Societies). The member societies may cover for each other in some cases of equipment approvals.
- Classification societies approve delivered equipment as:
    1. Type/ standard approved, or
    2. Case-by-case approved (routine tests)

5.2 Mechanical Standards

5.2.1 ISO

The International Organisation for Standardisation, is a world- wide federation.

- The scope of ISO covers standardisation in all fields except electrical and electronic engineering standards, wich are included in IEC-standards.

- Almost everything from drawing sheet size to the welding strenght calculation and re lubrication nipple dimensions has an appropriate ISO standard. The sound pressure level test is also included in ISO standards as are transportation package and container construction.

5.2.2 DIN

Deutsches Institut fur Normung.
DIN standards are old and generally used in Europe.
In DIN standards have been defined dimensional standards for bolts, screws, nuts and accesories for bolt nut assemblies. Also different type of shaft end, material requirements and couplings are standardized in DIN standards. Examples of DIN standards are:

- DIN 476: international paper sizes (now ISO 216 or DIN EN ISO 216)
- DIN 946: Determination of coefficient of friction of bolt/nut assemblies under specified conditions.
- DIN 1451: typeface used by German railways and on traffic signs
- DIN 31635: transliteration of the Arabic language
- DIN 4512: A definition of film speed
- DIN 72552: electric terminal numbers in automobiles

5.2.3 ANSI and ASME

Also inch-based mechanical standards have been defined. For example ANSI (American Standard Institution) and ASME(American Society of Mechanical Engineers) Standards define inch screw threads and give inch based bolts, screws, nuts and bolt/nut assemblies.

5.3 Electrical Standards

5.3.1 IEC

- The International Electrotechnical Commision is the organisation responsible for standardisation in the electric al and electronics field.

- IEC is composed of 44 National Committees wich collectively represent some 80 percent of the worlds population that produces and consumes 95 percent of electric energy.

- The main problem with the IEC standards is that their status in the world is not strong enough. In many countries national electric standards are in common use.

IEC 92

- IEC 60092 Electrical installations in ships

- This standard, forms a series of international standards for electrical installations in seagoing ships, incorporating good practise and coordinating, as far as possible, existing rules.

- The standard is said to form a code for practical interpretation and amplification of the requirements of the international convention on Safety Of Life At Sea (SOLAS).

5.3.2 IEEE 45

What is IEEE 45?

It is the recommended standard for electrical on-board installations based on USA practices. The scope of this standard covers oceangoing vessels and vessels for use on rivers, lakes, bays, etc. It is considered an alternative standard to the IEC 60092, wich are part of ABS rules.

Where is it used?

The IEEE 45 electrical practice is often applied to offshore GOM (Gulf Of Mexico) support vessels and drill ships especially those that are US-build. Outside the US and for non US-flag vessels operating outside the GOM, electrical equipment vendors more frequently adhere to IEC standards.

Can IEEE 45 be used in place of IEC standards to meet ABS Rule requirements?

Both IEEE 45 and IEC standards can be used to meet ABS rules. Equipment, components and systems for which ABS has specific requirements may comply with an alternative standard such as IEEE 45, in lieu of the IEC-based requirements in the Rules. It is essential, however, that IEEE 45 *or* *any other alternative standard proposed* for use is determined by ABS to be *no less effective* than the Rules.

Can parts of IEEE 45 be coupled with parts of IEC standards for meeting ABS Rule requirements

When IEEE 45 is proposed as an alternative, all equipment must fully comply with the IEEE 45 standard.**Coupling sections of several standards together can result in less effective electrical requirements**, and thus, cannot be accepted as being in compliance with ABS Rules. Although ABS has been migrating towards IEC-based rules, it continues to recognize American equipment and practices.

5.3.3 Other international electrical standards

- VDE (German Association of Electrical Engineers)
- CENELEC
- ANSI/ASME
- IEEE(Institute of Electrical and Electronics Engineers)
- NEMA (National Electrical Manufacturers Association)
- BS (British Standards)
- JAS (JAPAN)
- CSA (Canadian Standarts Association)
- AS (Australian Standards)
- API (American Petroleum Institute)

Most national standards cover things like terminal markings, direction of rotation and minimum creepage distances, which affects machine construction but not performance.
In many cases API-standard refer to NEMA standard.*The most frequently used national electrical standard replacing IEC is NEMA*

5.3.4 Marine Standards

The International Asociation of Classification Societies (IACS) is an association representing the world's major classification societies.

IACS Members

- ABS American Bureau of Shipping
- BV Bureau Veritas
- China Classification Society
- DNV Det Norske Veritas
- GL Germanisher Lloyd
- Korean Register of Shipping
- LRS Lloyd's Register of Shipping
- Nippon Kaiji Kyokai
- Polski Rejestr Statkow
- Registro Italiano Navale
- RS Register of shipping (Russia)

Bibliography