Marine Engineering Workshop
Notes and Workbook

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For the 41st Annual Conference on Sail Training and Tall Ships

With Assistance From :

USMMA SAILING FOUNDATION

This work is intended as a learning tool and as a quick reference guide on basic marine engineering principles. All of the images contained within were either copied from US Government Technical Manuals or from sources providing free copy rights to the material.

SCHEDULE

Saturday 2/1

0800-0845	Welcome and Overview
0845-0900	Break
0900-1200	Diesel Engineering
1200-1300	Lunch and Marine Battery Talk
1300-1430	Electrical Theory and Marine Electrical Systems
1430-1445	Break
1445-1600	Electrical Systems, Electrolysis
1600-1615	Break
1615-1715	USCG/ABYC/ABS Requirements

Sunday 2/2

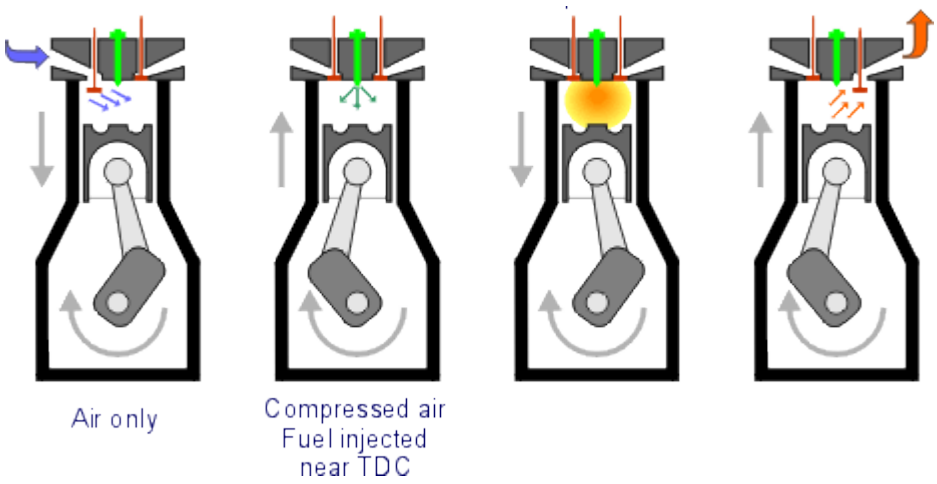
0800-0945	Outboards
0945-1000	Break
1000-1200	Marine Plumbing
1200-1300	Lunch
1300-1400	Hydraulics
1400-1415	Break/Shuttle to San Salvador Build
1415-1600	San Salvador Tour
1600-1615	Break/Shuttle
1615-1700	Wrap Up

Diesel Engineering

Why do we use diesel engines?

They're efficient, robust, and relatively simple machines which makes them great for marine use.

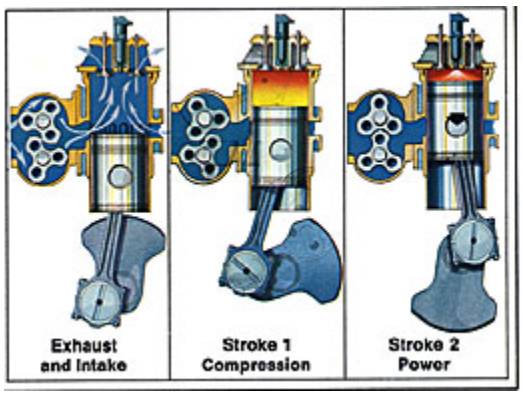
The Diesel Cycle (4 stroke): LABEL THE 4 CYCLES



_____ _____ _____ _____

Diesel engines fire due to compression of air and fuel mixture. Gasoline engines have to be ignited with an electrical spark (spark plugs).

The Diesel Cycle (2 stroke):



$$\text{Compression Ratio} = \frac{\text{displacement volume} + \text{clearance volume}}{\text{clearance volume}}$$

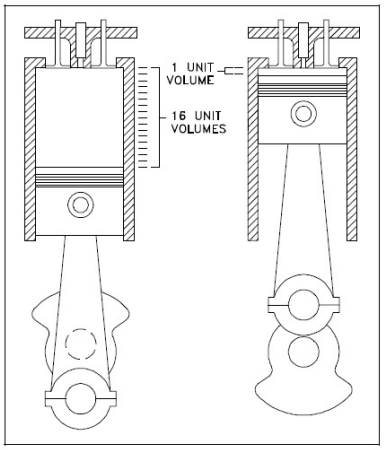


Figure 15 Compression Ratio

THE FOUR IMPORTANT SYSTEMS FOR DIESEL ENGINES

_____ _____ _____ _____

The Fuel System

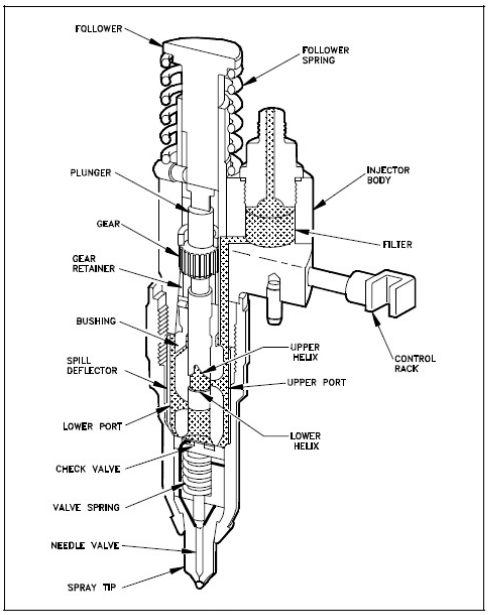


Figure 26 Fuel Injector Cutaway

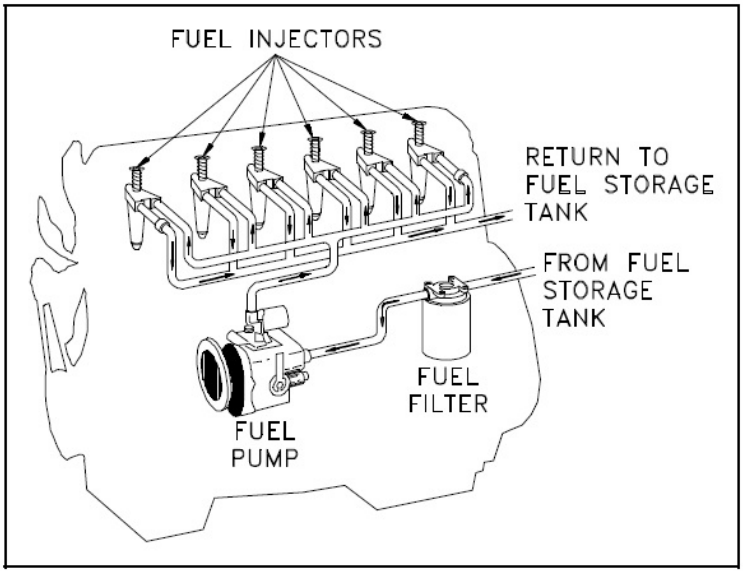
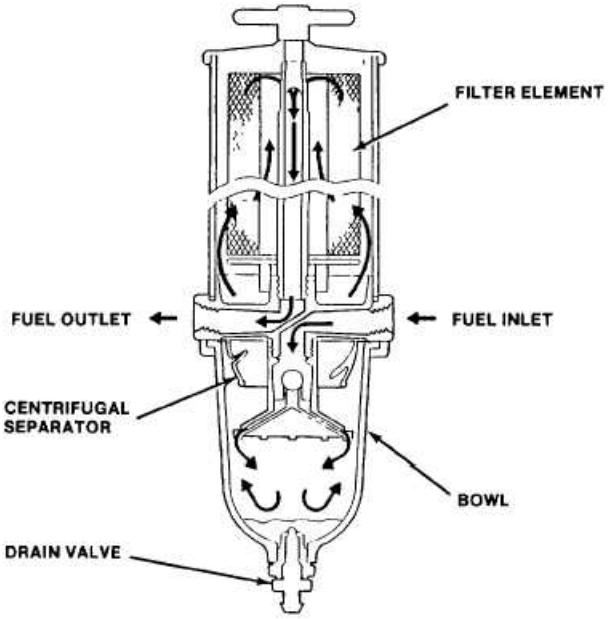


Figure 13 Diesel Engine Fuel Flowpath

NOTES:



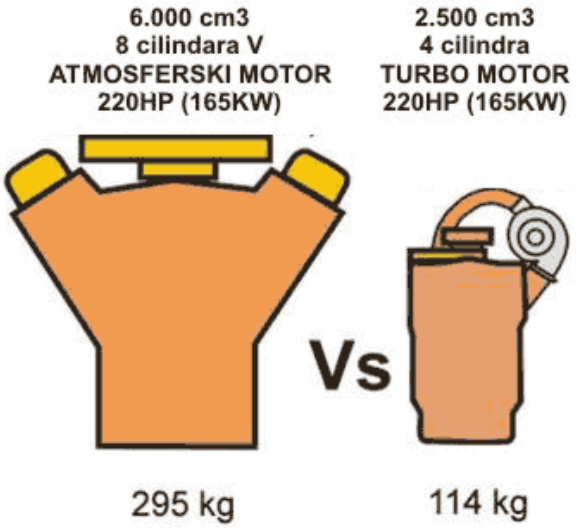
The Air System

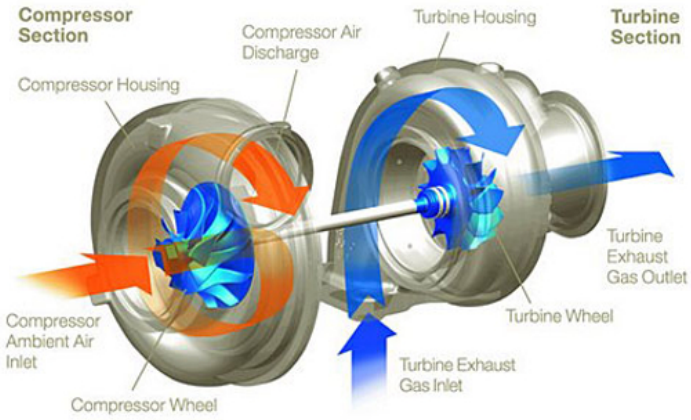
There are two types of air systems on diesel engines:

_____ AND _____

Whats the difference?

MORE power for LESS weight / size





Intake air can be compressed by a turbocharger, or COOLING, or both.

The most efficient applications will have an intercooler and a compound turbocharger but these aren't commonly found on high speed marine diesel engines.

The Lubricating System

Oil serves TWO purposes: _____ AND _____

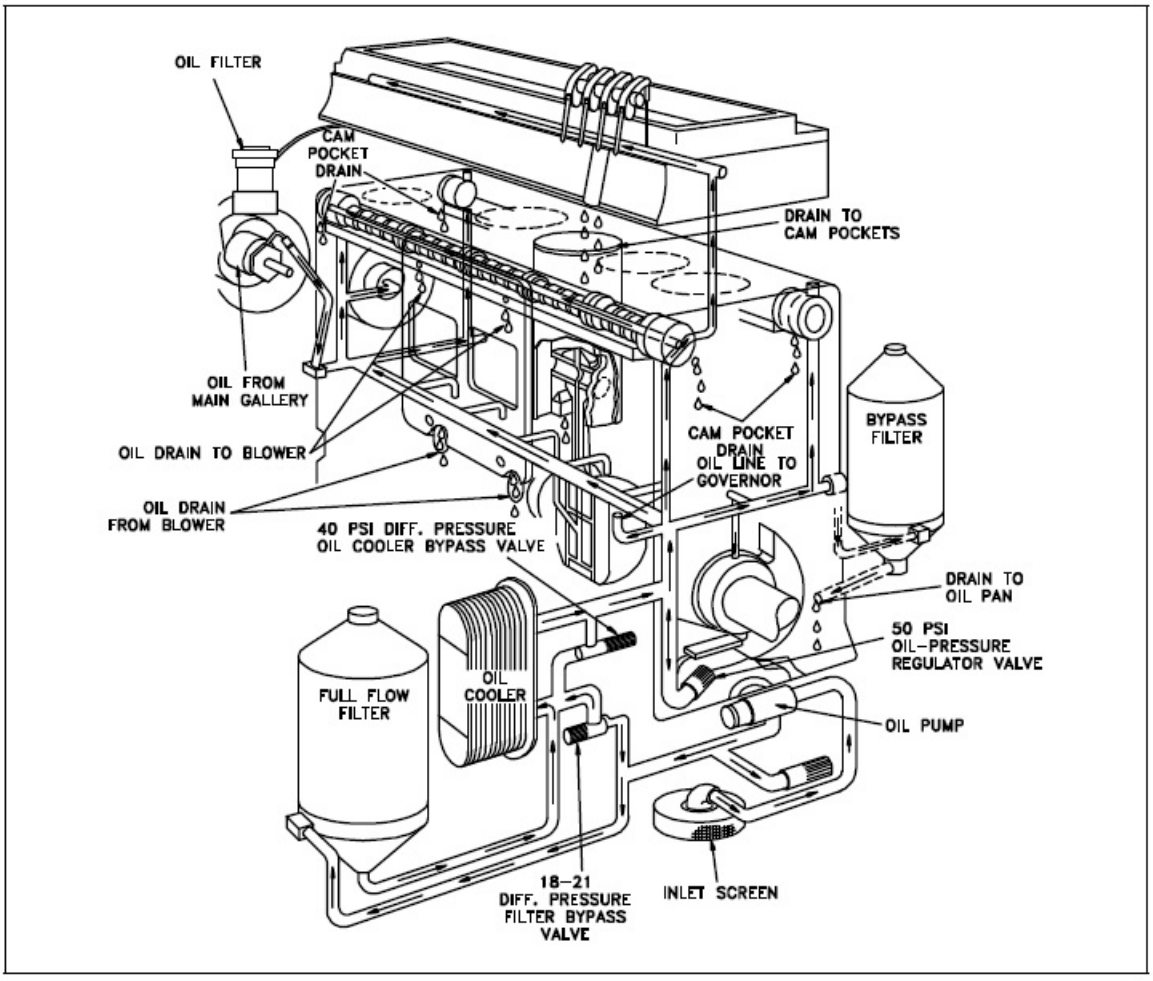
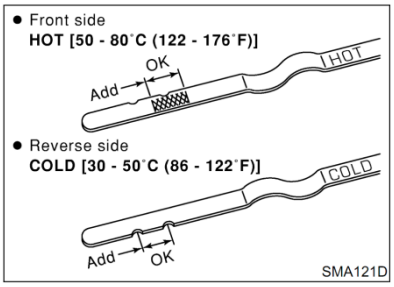


Figure 12 Diesel Engine Internal Lubrication System



Now that we know where it all goes, what are we concerned with?

When I check the level it is:

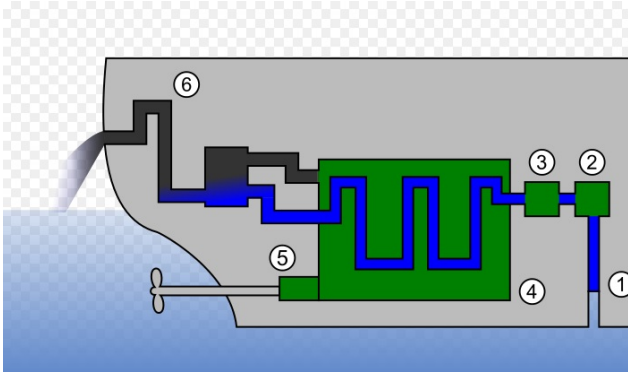
Low (WRITE CAUSES AND NOTES BELOW) **High**

The Cooling System

Two basic types of cooling for marine diesel engines:

_____ AND _____

Generally, the type of cooling used depends on the size of the engine and the heat load it creates.



Liquid Cooled Systems can be:

fully enclosed

semi-enclosed

open

the system shown is OPEN

Important components:

Heat Exchanger

Made of bronze alloy (reduce corrosion)

Should never be dented/damaged

Impeller / Pump

Provides flow for cooling system

If low pressure, impeller may have worn down and need to be replaced

Strainer

Should always be cleaned and observed for flow

Zinc Anodes

Sacrificial: the zincs wear away instead of the engine components

Change before they wear completely away

Electrical Theory

Units

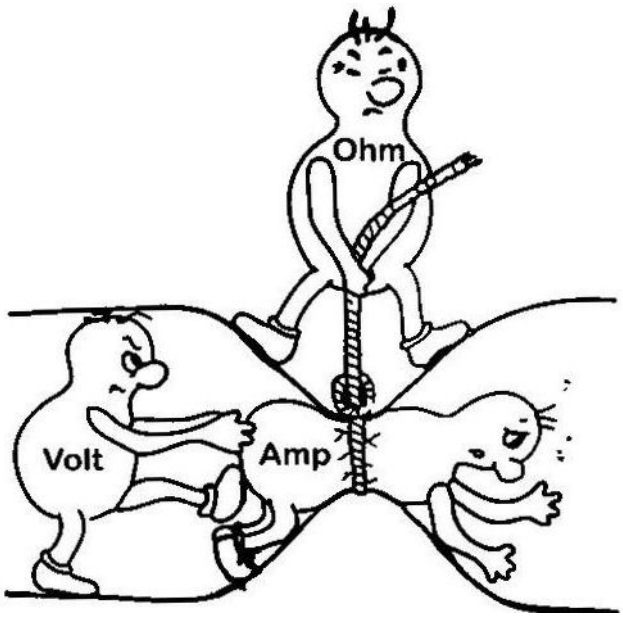
Voltage = _____ Resistance = _____

Potential energy differencec / "the push" *Opposition to flow of electrons*

Current = _____ Power = _____

Amount of flow of electrons *Amount of Energy per unit time*

OHM'S LAW: LABEL V , I , AND R ON THE FIGURE BELOW



Useful Formulas

$$V = I \times R \qquad P = V \times I \qquad P = I^2R = V^2/R$$

SERIES CONNECTIONS

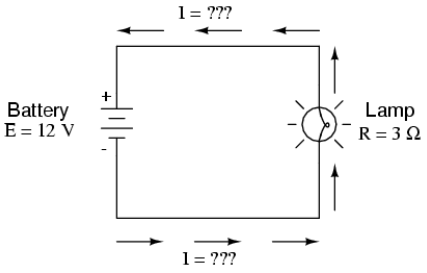
Voltage is additive (V+V+V+V= ___) Current remains equal.

PARALLEL CONNECTIONS

Current is additive (A+A+A+A= ___) Voltage remains equal.

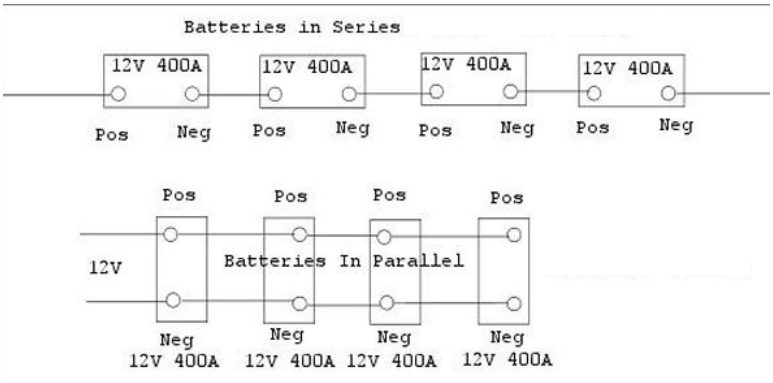
Electrical Theory Practice Problems:

1. **Find the Current given a 12V battery and 3Ω lamp.**



What then is the wattage of the lamp shown? _____

2. **Find the Voltage and Amperage put out by these series and parallel battery banks.**



The Difference between AC and DC power

Direct Current

Alternating Current

<u>Direct Current</u>

Was discovered first

Advantages / Disadvantages

Use on vessels

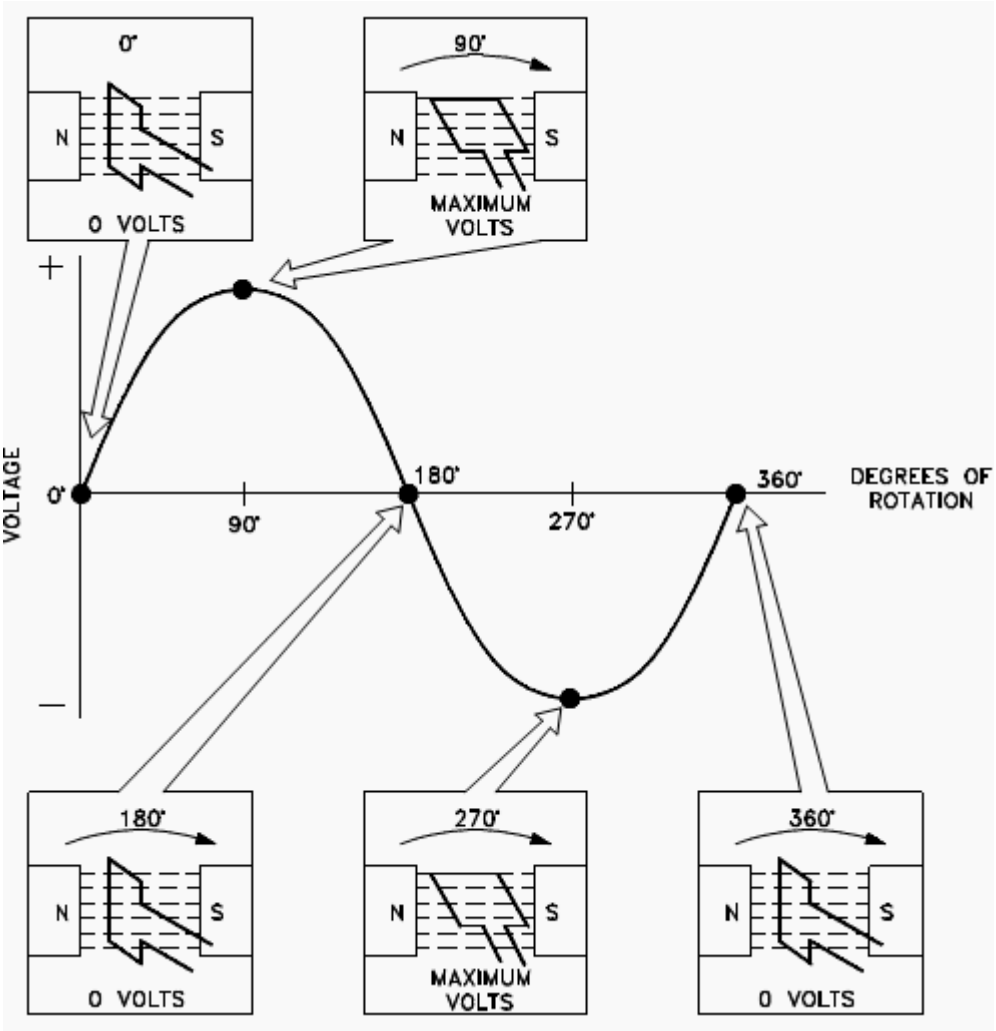
<u>Alternating Current</u>

Was pioneered by _____

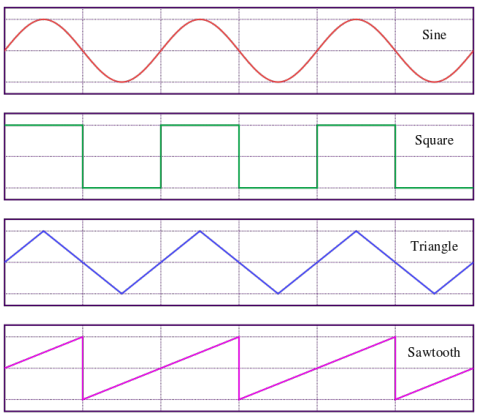
Advantages / Disadvantages

Use on vessels

How A/C generators make a sine wave:



Does your equipment require a clean sine wave?

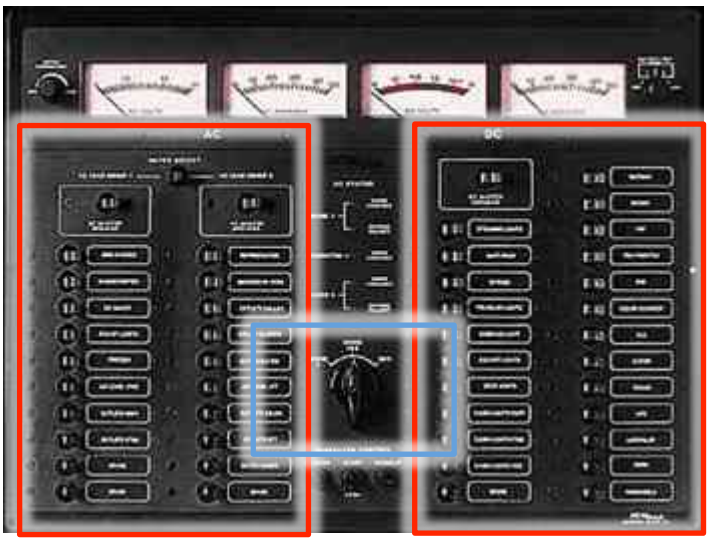


You can see or hear the square waveform on a television as lines on the screen or a steady buzz or hum.

Marine Electrical Systems

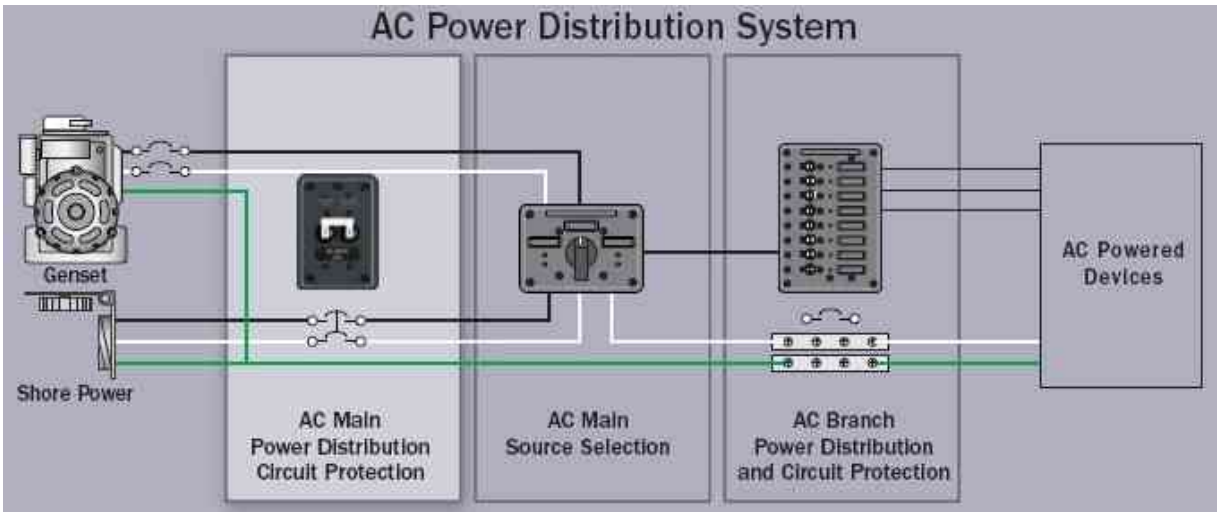
Where to start…. How about the switchboard?

The switchboard is a great place to start because it shows all of the power sources and all of the loads. This is also where we manage the loads so we don't trip things offline. Get to know the switch board:



But How Does it Get There? Here's a simple A/C only power distribution system as an example.

Label the parts of the system and note why they're important.

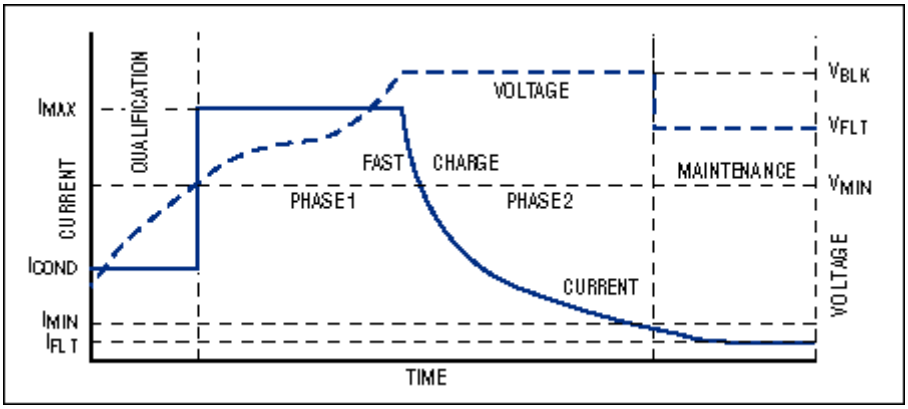


Battery Chargers

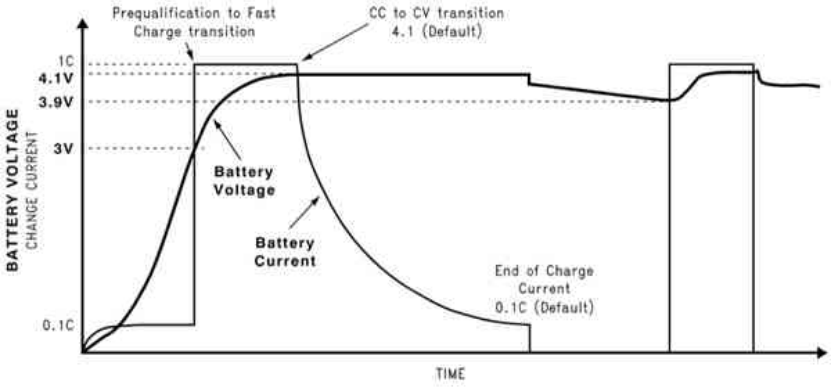
What type of battery charger do I need? That depends on your batteries! List below the characteristics of the two types of batteries and the chargers required.

Starting Batteries: Deep Cycle (House bank) Batteries

Charging Profiles:



LEAD ACID BATTERY



LITHIUM ION BATTERY

Inverters

How do I get 120VAC power to charge my cell phone when we're running on 24V Batteries?!

Originally, inverters used DC currents, electromagnets, and swinging arms with contactors to create an alternating type of current (think a pendulum clock with contactors on the end and a magnet running it. Today inverters run on semiconductors and an oscillating circuit which is much more efficient (and smaller and quieter). Remember back to the sine wave forms we showed before and the equipment that uses clean sine wave forms? How do we get different AC wave forms from an inverter? More expensive inverters use capacitors and filters to provide a more clean wave form.

Inverter / Chargers

Modern inverters can also be set up with battery chargers. In many cases because they have isolator shunt wiring or an isolator plate they can prevent damage from back-feeding battery voltage to shorepower circuits.

AC / DC Motors

Motors come in all shapes and sizes and power all different types of equipment. The easiest way to tell if a motor is AC or DC is to see which part of the switch panel it is on.

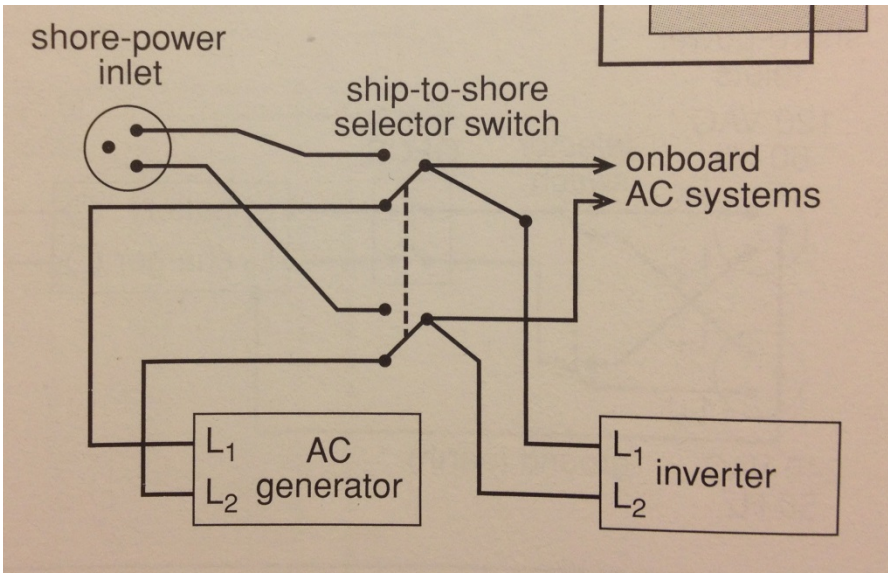
Common equipment with AC motors includes : **BECAUSE**

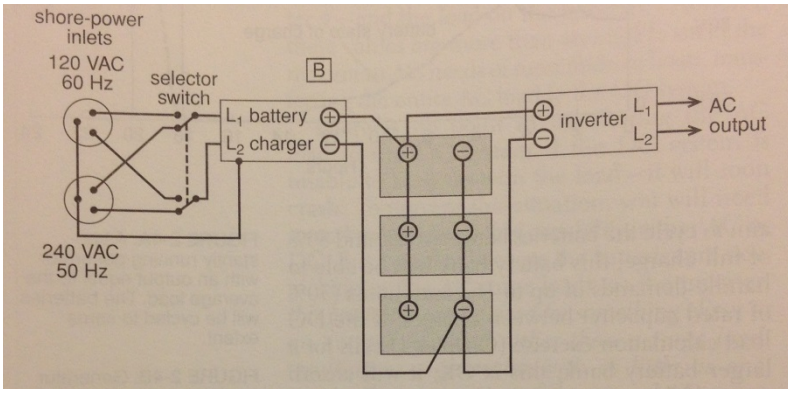
- Air Conditioning and Refrigeration
- Winches
- Scientific Equipment
- Motors for Hydraulics
- Electric Stoves
- Coffee Maker

Generation and Shore Power (50/60 Hz)

First of all, whats a Hz?

50 or 60 cycles is the number of times the current alternates one full cycle per second. European and North American power systems run on different cycles because they generate their energy differently.



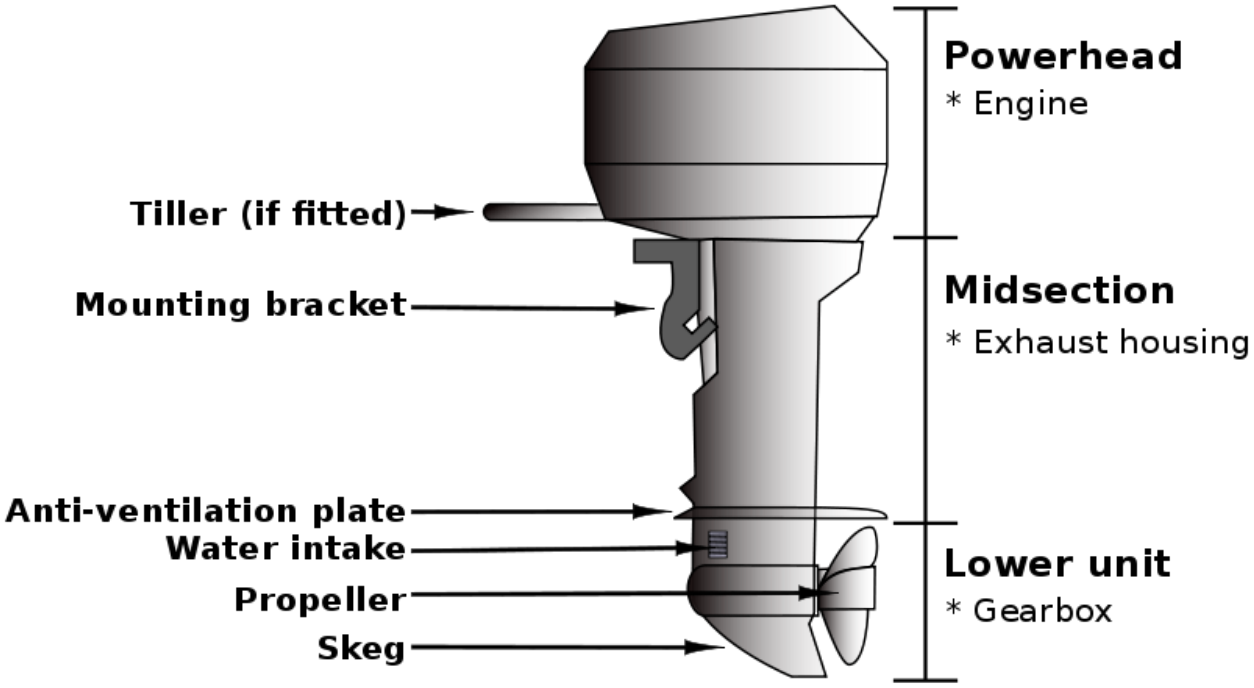


USCG/ABYC/ABS

NOTES:

Outboard Motors

Basic Sections



<u>Visual checks (daily)</u>

Oil Level

Fuel Level

Cracks, sun damage to hoses (fuel)

Ensure cooling water flows easily!

Standard Maintenance Intervals

The table below is a representative example of maintenance to be performed on the generic outboard engine. Engine manufacturer instructions should be followed for specific outboard engine in use.

	1 MONTH	3 MONTHS	6 MONTHS	1 YEAR	2 YEARS
RUN ENGINE IN FRESH WATER	*				
FUEL FILTER: CHECK AND CLEAN	*				
SPARK PLUGS: CHANGE IF NECESSARY	*				
PROPELLER: PULL OFF AND CLEAN PROPELLER SHAFT		*			
ZINC ANODE: SCRUB / REPLACE AS NECESSARY		*			
ENGINE HEAD: FLUSH WITH FRESH WATER, CLEAN, SPRAY WITH CLEANING SOLVENT		*			
ENGINE LUBRICATION: GREASE THE SPECIFIED POINTS		*			
FUEL TANK: CLEAN (DETERGENT AND FRESH WATER)			*		
CRANK CASE: CHANGE OIL			*		
IMPELLER: REPLACE IMPELLER AND GREASE CRANKSHAFT				*	
FULL SERVICE BY DEALER REPRESENTATIVE					*

<u>Common Problems with Outboard Engines:</u>

Marine Plumbing and Hydraulics

Piping

Material choice for piping of systems onboard a boat is important! What are the factors that determine which material to use?

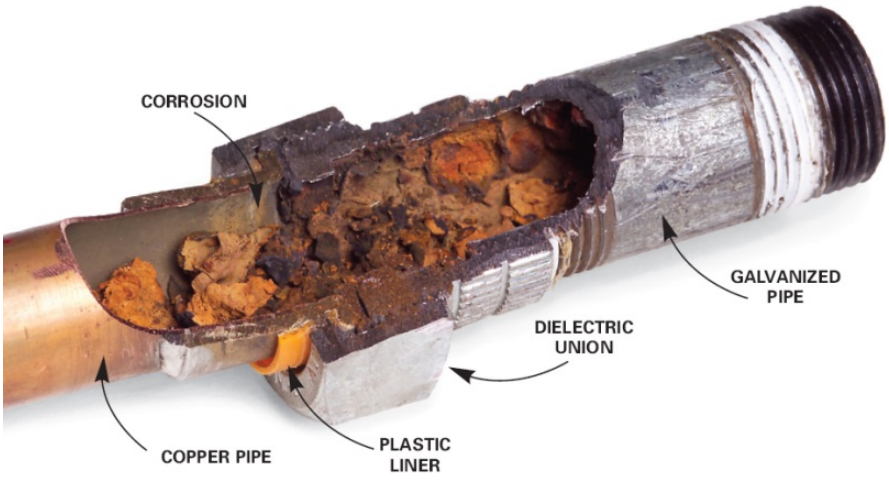
Seawater is commonly piped with _____ because _____

Sewage (Black and Grey water) is usually piped with _____-
because_____

Is Fire Main piping usually thicker walled than other systems?_____
Why?_____

Electrolysis

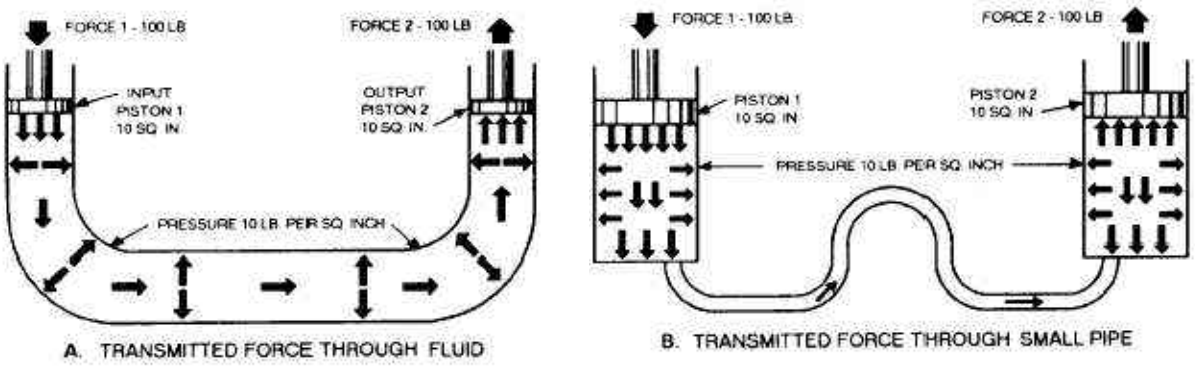
So if the wrong piping material is used you can guess the consequence (burst because it can't handle pressure, corroded because of pH, etc.). But what happens when you mix materials?



Think: Battery

Pressure (Pascal's law)

So how does pressure work? Pascal's Law says that pressure works equally in every direction.



Pressure is shown as force/area. This pressure can be caused by a pump or by the weight of a fluid in a column. Name two common fluids that can cause changes in pressure due to their weight.
_____ and _____

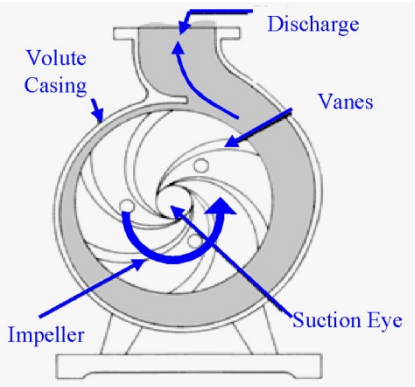
Why Hydraulics are Useful:

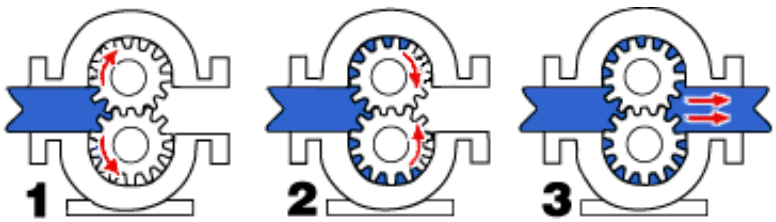
Pressure can be used to our advantage similar to electrical energy. If transformers send high voltage more efficiently across long distances so do pumps with fluids.

Hydraulics use the fact that pressure is force equally distributed in all directions AND a _____ fluid to transmit energy.

ADVANTAGES DISADVANTAGES

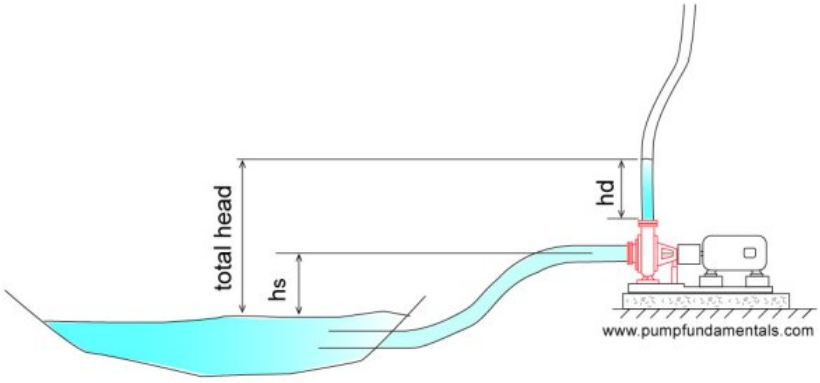
Pumps





What is the difference between pressure and head?

EXPLAIN PUMP HEAD:



Common Systems with Common Problems (CLASS DISCUSSION)

Fire system

Sewage System

Fresh Water System