“What’s All This @#$%# About Diesel Engines, I’m Looking For My Shadow”
Outline

• Basic Marine Diesel Engine Operating Principals
• Daily Checks
• Routine Maintenance
• Trouble Shooting
• Electrical Systems
References

- Troubleshooting Marine Diesels by Peter Compton
- Marine Diesel Engines: Maintenance, Troubleshooting, and Repair by Nigel Calder
- Boatowners Mechanical and Electrical Manual by Nigel Calder

- Link to Presentation will be Posted on Front Page of Fairwind Website:
  www.fairwind.org
Fairwind Diesel Engines in CIH

- Universal 5411 aka M15; 1982
- Universal M25XP; 1995
- Universal M25XP; 1998
- Universal M25XP; 2015
- Westerbeke 20B2; 1995
- Mitsubishi L2E; 2018
- Westerbeke 38; Rebuilt ~ 2012
- Yanmar 3GM30F; 1997
- Yanmar 3JH3E; 2001
Diesel Engine 101

- Diesel Engines Operate by Injecting Fuel into a High Temperature Air Environment
  - Fuel Self Ignites not Requiring Spark
  - Minimum 750F Ignition Temperature
  - Typical Compression Ratio’s Between 17:1 and 21:1

- Most Diesels Use Glow Plugs to Heat Fuel When Engine is Cold
Engine Cylinder Pressure

- Cylinder Seals Are Not Perfect
- Cylinder Pressure will Bleed Off During Slow Cranking
- Faster Cranking Speed Gives Higher Pressure Hence Higher Temperature
  - Easier Starting
- Glow Plugs Help Starting When Pressure is Lower than Optimal
- Compression Release Will Allow Higher Cranking Speed
  - Helpful When Batteries are Weak
Fuel System for Four Cylinder Diesel

Diagram of a fuel system with labels:
- Filter
- Leak-off pipes
- Feed pump
- Injectors
- Tank
- High Pressure Pump

Injector Designs:
- Compression spring
- Body
- Nozzle
- Holes
- Nozzle valve
Cylinder/Injector Designs

- Universal M25XP Uses a Pre Combustion / Swirl Type Chamber
- Injectors Spray onto Glow Plug
- Injectors Should Periodically Be Sent Out for Inspection / Rebuild
Injection Designs

Engines with swirl or pre-combustion chambers use injectors with pintle nozzles.

Direct-injection engines use injectors with multi-hole nozzles.
Pre-Start Engine Checks

- Closed System Coolant Reservoir at Proper Level
- Raw Water Valve Open
- Raw Water Strainer Clean
- Raycor Fuel – Water Separator Clear
- Oil Level within Limits
- Battery Voltage Level ≥ 12.6V
### Fairwind Monthly Maintenance Check List

<table>
<thead>
<tr>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check operation of all thru-hull valves.</td>
</tr>
<tr>
<td>Check battery connections for tightness &amp; corrosion. Add distilled</td>
</tr>
<tr>
<td>water to bottom of filler neck if low.</td>
</tr>
<tr>
<td>Check oil, transmission fluid and coolant levels.</td>
</tr>
<tr>
<td>Check engine zinc and note percent remaining.</td>
</tr>
<tr>
<td>Inspect seawater intake screen and fuel separator; clean, if</td>
</tr>
<tr>
<td>necessary.</td>
</tr>
<tr>
<td>Check fuel level and contact last user if below half.</td>
</tr>
</tbody>
</table>

### Fairwind Quarterly Maintenance Check List

<table>
<thead>
<tr>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check operation of all thru-hull valves.</td>
</tr>
<tr>
<td>Check drive shaft packing gland for proper leakage.</td>
</tr>
<tr>
<td>Inspect engine, head and galley hoses for leakage.</td>
</tr>
<tr>
<td>Inspect coolant level in expansion bottle and add if necessary.</td>
</tr>
<tr>
<td>Check engine zinc and replace if necessary.</td>
</tr>
<tr>
<td>Check fuel filters.</td>
</tr>
<tr>
<td>Inspect battery fluid levels and top off with distilled water if</td>
</tr>
<tr>
<td>needed.</td>
</tr>
<tr>
<td>Check operation of fresh water pump.</td>
</tr>
</tbody>
</table>
Yearly / Bi-Annual Maintenance

- Oil Change and Filters (100 hrs)
- Fuel Filters
- Set Valve Spacing
- Remove Injectors for Inspection/Rebuild (3 – 5 Years)
- Throttle/Transmission Cable Adjustment
- Check Glow Plugs
- Raw Water Impeller
- Engine Alignment & Mount Adjustment
So What Could Go Wrong?

• Electrical Systems
  • Batteries
  • Connections
  • Sensors

• Cooling System
  • Raw Water Flow
  • Coolant Leaks
  • Thermostat

• Fuel System
  • Contamination
  • Filters
  • Lift Pumps

• Mechanical
  • Injectors
  • Mounts
  • Cables
Troubleshooting

Engine does not turn over;
1. PERCO in “off” position
2. Low Batteries
3. Starter solenoid failed

Engine turns but won’t start;
1. Electric fuel pump bad
2. Glow plugs not functioning
3. Fuel filter clogged
4. Air in the fuel system

Note: do not continue cranking over 20 seconds more than 3 times without draining the exhaust aqua lift tank.

Engine runs but no water from exhaust
1. Thru-hull valve not open
2. RW pump impeller bad
3. RW pump key or shaft broken
4. Blockage in system
Engine Trouble Shooting Matrix

Troubleshooting Chart 9-1.
Diesel Engine Problems: An Overview

<table>
<thead>
<tr>
<th>Poor starting</th>
<th>Low compression</th>
<th>Lack of fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throttle closed/fuel shut-off solenoid faulty/tank empty</td>
<td>Lift pump diaphragm holed</td>
<td>Plugged fuel filters</td>
</tr>
<tr>
<td>Air in fuel lines</td>
<td>Dirty fuel</td>
<td>Defective injectors/poor quality fuel</td>
</tr>
<tr>
<td>Injection pump leaking by</td>
<td>Injection timing advanced or delayed</td>
<td>Too much fuel injected</td>
</tr>
<tr>
<td>Piston blow-by</td>
<td>Dry cylinder walls</td>
<td>Valve blow-by</td>
</tr>
<tr>
<td>Worn valve stems</td>
<td>Decompressor levers on/valve clearances wrong/valves sticking</td>
<td>Plugged air filter</td>
</tr>
<tr>
<td>Pre-heat device inoperative</td>
<td>Plugged exhaust/turbocharger/kink in exhaust hose</td>
<td>Oil level low</td>
</tr>
<tr>
<td>Wrong viscosity oil</td>
<td>Diesel dilution of oil</td>
<td>Dirt in oil pressure relief valve/defective pressure gauge</td>
</tr>
<tr>
<td>Governor sticking/loose linkage</td>
<td>Governor idle spring too slack</td>
<td>Defective water pump/defective pump valves/air bound water lines</td>
</tr>
<tr>
<td>Closed sea cock/plugged raw-water filter or screen/plugged cooling system</td>
<td>Uneven load on cylinders</td>
<td>Worn bearings</td>
</tr>
<tr>
<td>Seized piston</td>
<td>Auxiliary equipment engaged</td>
<td>Battery low/loose connections</td>
</tr>
<tr>
<td>Engine overload/rope in propeller</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Troubleshooting Chart 9-5. Smoke in Exhaust**

<table>
<thead>
<tr>
<th>Black</th>
<th>Smoke</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstruction in airflow:</td>
<td></td>
<td>Worn or stuck piston rings</td>
</tr>
<tr>
<td>Dirty air filter</td>
<td></td>
<td>Worn valve guides</td>
</tr>
<tr>
<td>Defective turbo/supercharger</td>
<td></td>
<td>Turbo/supercharger problems:</td>
</tr>
<tr>
<td>High exhaust back pressure</td>
<td></td>
<td>Worn oil seals</td>
</tr>
<tr>
<td>Excessively high ambient air temperature</td>
<td></td>
<td>Plugged oil drain</td>
</tr>
<tr>
<td>Overload:</td>
<td></td>
<td>Overfilled oil bath–type air filter</td>
</tr>
<tr>
<td>Rope around propeller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oversized propeller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavily fouled bottom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive auxiliary equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defective fuel injection</td>
<td></td>
<td>High crankcase oil level/pressure</td>
</tr>
<tr>
<td></td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>White</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water in the fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air in the fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defective injector</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cracked cylinder head/leaking head gasket</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: When an exhaust is water cooled, it is difficult to distinguish white smoke from the normal exhaust.
Trouble Shooting Guides

CHART 1
TROUBLESHOOTING MARINE DIESELS—START HERE

Diesel engine problems, at their most basic, usually fall into one of three categories: engine fails to start, engine not running correctly, or engine fails to stop. More specific symptoms flow from these three options. Always start here when troubleshooting a problem with your diesel.

ENGINE FAILS TO START

<table>
<thead>
<tr>
<th>ENGINE DOES NOT TURN</th>
<th>ENGINE TURNS NORMALY—BUT FAILS TO START</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Confirm the engine turns over freely.</td>
<td>1. Check fuel is reaching the injectors.</td>
</tr>
<tr>
<td>2. Confirm the starting system is working correctly.</td>
<td>2. Check the intake and exhaust systems for restrictions.</td>
</tr>
</tbody>
</table>

ENGINE TURNS SLOWLY

1. Is the oil viscosity correct?
   Too heavy an oil will make the engine difficult to turn over, especially in cold weather.
   1. Check the oil level and viscosity. GO TO Chapter 4
2. Confirm the engine will turn over freely.
   1. Check the ignition system. GO TO Chapter 2
3. Confirm the starting system is working correctly.
   1. Check the starting system. GO TO Chapter 8

From Compton
Old Style Raw Water Cooled Diesel

1982 Universal M15
Closed Cycle Cooling System

- Raw Water Flows Thru Heat Exchanger
  - Uses Rubber Impeller
- Closed System Uses Anti-Freeze Water Mixture
  - Has Thermostat
  - Overflow Reservoir
- Temperature Sensor
- Temperature Over Temp Alarm

Note: IR Temperature Sensor Useful For Trouble Shooting Cooling System
Raw Water Pumps

Sherwood Water Pump

Orderdorfer Water Pump
Diesel Fuel Tank

- Inspection Plate for Access to Clean Tank
- Vent Line Moisture Trap

1995 Catalina 30
Types of Fuel Level Sensors

- Fuel Gauge Typically Variable Resistor Float Type
- Resistance => 33 Ohm to 220 Ohm
Catalina 380 with Yanmar Diesel

- Compartment Under Engine Isolated from Bilge
- Note Oil Stain on Absorber
- Reflector for Optical Tach
- Compartment Under Engine Isolated from Bilge
Bleeding Fuel System

- Drain Water from Separator
- Avoid Letting Air into System

Bleeding Air from Fuel Lines
- Bleed Points at Filters and Injectors
  - Pressurize with Lift Pump
  - Pull Fuel with Hand Pump Until Air Bubbles are Gone

Note: Capture Diesel with Absorber
### Universal M25XP Electrical Diagram

- Electrical Circuit Diagrams are Useful for Trouble Shooting
- Don’t Always Match Current System
- Wire Colors Can Change with Modifications
- Systems are Added, Removed, etc

#### Wire Table

<table>
<thead>
<tr>
<th>WIRE NO.</th>
<th>COLOR</th>
<th>WIRE SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Black</td>
<td>#10</td>
</tr>
<tr>
<td>2</td>
<td>Grey</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Yellow-Red</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Orange</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Orange</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Purple</td>
<td>16</td>
</tr>
<tr>
<td>7</td>
<td>Lt. Blue</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td>Tan</td>
<td>16</td>
</tr>
<tr>
<td>9</td>
<td>Opon</td>
<td>16</td>
</tr>
<tr>
<td>10</td>
<td>Grey</td>
<td>16</td>
</tr>
<tr>
<td>11</td>
<td>Orange-Red</td>
<td>14</td>
</tr>
</tbody>
</table>

![Image of Universal M25XP Electrical Diagram](image-url)
Engine Alarm Systems

Typical Engine Alarms
- Oil Pressure
- Over Temperature

Other Options
- Low Voltage
- Raw Water Flow

Water Flow Sensor
Engine Panel

Catalina 30 Engine Panel
- Ignition Key Switch Controls Glow Plug and Lift Pump for Starting
  - Hold Hard Over to Engage
- Push Button Engages Starter Solenoid
- Fuel Stop
- Light and Audible Alarms
- Wires Get Loose or Corroded Making Poor Contact
- Key Switch can Stick or Fail
- Alarms Can be Intermittent or Fail
Catalina 380 Engine Control Wiring
Trouble Shooting Intermittent Tachometer

Tach Sender
Orange Wire
<table>
<thead>
<tr>
<th>Color</th>
<th>Item</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow w/ red stripe (YR)</td>
<td>Starting circuit</td>
<td>Starting switch to solenoid</td>
</tr>
<tr>
<td>Brown/yellow stripe (BY)</td>
<td>Bilge blowers</td>
<td>Fuse or switch to blowers</td>
</tr>
<tr>
<td>or yellow (Y)—see note</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dark gray (Gy)</td>
<td>Navigation lights</td>
<td>Fuse or switch to lights</td>
</tr>
<tr>
<td></td>
<td>Tachometer</td>
<td>Tachometer sender to gauge</td>
</tr>
<tr>
<td>Brown (Br)</td>
<td>Generator armature</td>
<td>Generator armature to regulator</td>
</tr>
<tr>
<td></td>
<td>Alternator charge light</td>
<td>Generator terminal/alternator</td>
</tr>
<tr>
<td></td>
<td>Pumps</td>
<td>Auxiliary terminal to light and regulator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fuse or switch to pumps</td>
</tr>
<tr>
<td>Orange (O)</td>
<td>Accessory feed</td>
<td>Ammeter to alternator or generator output and</td>
</tr>
<tr>
<td></td>
<td>Accessory feeds</td>
<td>accessory fuses or switches</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distribution panel to accessory switch</td>
</tr>
<tr>
<td>Purple (Pu)</td>
<td>Ignition</td>
<td>Ignition switch to coil and electrical</td>
</tr>
<tr>
<td></td>
<td>Instrument feed</td>
<td>instruments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distribution panel to electrical instruments</td>
</tr>
<tr>
<td>Dark blue</td>
<td>Cabin and instrument lights</td>
<td>Fuse or switch to lights</td>
</tr>
<tr>
<td>Light blue (Lt Bl)</td>
<td>Oil pressure</td>
<td>Oil pressure sender to gauge</td>
</tr>
<tr>
<td>Tan</td>
<td>Water temperature</td>
<td>Water temperature sender to gauge</td>
</tr>
<tr>
<td>Pink (Pk)</td>
<td>Fuel gauge</td>
<td>Fuel gauge sender to gauge</td>
</tr>
<tr>
<td>Green/stripe (G/x) (except G/Y)</td>
<td>Tilt down and/or trim in</td>
<td>Tilt and/or trim circuits</td>
</tr>
<tr>
<td>Blue/stripe (Bl/x)</td>
<td>Tilt up and/or trim out</td>
<td>Tilt and/or trim circuits</td>
</tr>
</tbody>
</table>

Note: If yellow is used for DC negative, blower must be brown with a yellow stripe. (ABYC)
Tachometer RPM Senders

AC Signal from Alternator Sent to Tach
• Gives Alternator RPM which may be Different from Engine RPM
• Tach Calibration Factor Needed

AC Signal from Sender Measuring Flywheel
• Provides Accurate RPM to Tach
Alternator Output Versus RPM

Alternator RPM is Higher than Engine RPM Due to Difference In Pulley Diameter

- Estimated to be 50% Higher
- Engine RPM of 2000 Equals Alternator RPM of 3000
- Note Effects of Heating: A Blower Should Be Added if Using Long Periods of Charging
Back of Universal M25XP

- **Glow Plug Solenoid**
  - High Current Switch

- **Electric Lift Pump**
  - Makes Ticking Sound

- **20A Breaker**
  - Feeds Engine Panel
  - Reset Button on either Front or Back

- **Heat Exchanger**
Yanmar Diesel Engines

Mechanical Fuel Pump

Hand Prime Lever
Westerbeke 20B2

- Coolant Temperature Sender
- Starter Solenoid Wire from Panel
- Main 12V Line from Battery to Starter
  - Feeds Engine Panel

Oil Pressure Sender
Mitsubishi L2E

Westerbeke 20B2 Is Based on Mitsubishi L2E Tractor Engine

After a Failure, A New L2E Was Purchased and Marine Components Moved from Old Engine to New

Significant Cost savings
Catalina 400 Wiring Panel
Proceed With Caution!

Use Caution When Connected to Shore Power or With Inverter On, There is 120V
Throttle, Transmission, and Shutoff Cables

Transmission Linkage

Throttle and Shutoff Linkages
Aqua Lift aka Exhaust Muffler

- Exhaust and Water Flow into Aqua Lift
- Exhaust Gases Forces Water Out
- If Engine is Cracked Without Starting Water Can Back Up Into Cylinders
  - Aqua Lift Must Be Drained After 30 Sec
Compression Release Levers

Universal M25XP

Yanmar 3GM30F
Fairwind Diesel Engines/Transmissions in CIH

**Diesel Manufacturer**
- Universal 5411 aka M15; 1982
- Universal M25XP; 1995
- Universal M25XP; 1998
- Universal M25XP; 2015
- Westerbeke 20B2; 1995
  - Mitsubishi L2E
- Westerbeke 38; Rebuilt ~ 2012
- Yanmar 3GM30F; 1997
- Yanmar 3JH3E; 2001

**Transmission Manufacturer**
- Hurth 50
- Technodrive TMC40P
- Hurth 50
- PRM Newage PRM60D
- JS (Spanish?)
- Hurth 100?
- Kanzaki KM2P
- Kanzaki KM3P
Small Sailboat Transmissions

TMC

PRM

Hurth

JS

Kanzaki
Transmission Issues

• Hurth Transmissions on Universal M25XP Diesels Have Failed
  • Two Were Rebuilt; One of those Failed Again
  • Two Have Now Been Replaced
    • TMC40P
    • PRM60D
  • Hurth Transmission Requirements
    • In Reverse (fixed) or Neutral (Rotating) When Sailing; Never in Forward

• PRM Transmissions
  • Neutral (Rotating) When Sailing; Never in Forward
  • Not Sure About Reverse

• TMC Transmissions
  • Neutral (Rotating) When Sailing; Never in Forward
  • Not Sure About Reverse

• Kanzaki Transmission
  • Must be Left in Neutral when Sailing
  • If Put in Reverse Will Lock Up
Battery Management

- Most Boats have Multiple Batteries
  - Starter
  - House (1 or 2 in parallel)
- Standard Lead Acid Battery has a Voltage of 12.6V When Charged
  - Battery Voltage Drops as Charge is Lost
- Alternator Charges Battery at 14.2 V
- Battery Chargers Will Charge at Between 13.8 and 14.2 V
  - Some with Programmed Voltage Ramps
- A Quick Check of Voltage Gives You Status of Battery, Alternator, and Charger

<table>
<thead>
<tr>
<th>% CHARGED</th>
<th>SPECIFIC GRAVITY</th>
<th>VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>1.265–1.275</td>
<td>12.6</td>
</tr>
<tr>
<td>75%</td>
<td>1.225–1.235</td>
<td>12.4</td>
</tr>
<tr>
<td>50%</td>
<td>1.190–1.200</td>
<td>12.2</td>
</tr>
<tr>
<td>25%</td>
<td>1.155–1.165</td>
<td>12.0</td>
</tr>
<tr>
<td>0%</td>
<td>1.120–1.130</td>
<td>11.7</td>
</tr>
</tbody>
</table>

Load testing is also an effective method of checking a battery’s
Battery Selector Switches

- Some Boats have Separate Engine Switches
- French Boats have Ground Switches
- Never Switch Off when Engine Is Running
  - Alternator Diodes will be Damaged
Multi Battery Wiring Schematic

Key Diagnostic Tool for Electrical Systems
- Digital Volt Meter
  - Volts, Ohms, Amps
- Free at Harbor Freight with Purchase
Catalina 30 Electrical System

- Boat Systems
- Two Deep Cycle House Batteries In Parallel
- One Starting Battery
- Shore Power
- Two Channel Battery Charger

- Diesel Engine
- Starter
- Alternator

- Two Channel Battery Charger
- Shore Power
Jeanneau 36.2 with Yanmar Diesel

As Originally Wired
- Alternator
- Charged Starter Battery
- Battery Charger
- Charged House Batteries
- No Way to Cross Connect

<table>
<thead>
<tr>
<th>Condition</th>
<th>Companionway Switches</th>
<th>Battery Combiners</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Engine</td>
<td>House</td>
</tr>
<tr>
<td>Secure</td>
<td>Open</td>
<td>Closed</td>
</tr>
<tr>
<td>Nominal Operation</td>
<td>Closed</td>
<td>Closed</td>
</tr>
<tr>
<td>Secure w/ACR Fault</td>
<td>Open</td>
<td>Closed</td>
</tr>
<tr>
<td>Engine Battery Fault</td>
<td>Closed</td>
<td>Closed</td>
</tr>
</tbody>
</table>

- Blue Sea Combiner Added
- By-Pass and Separation Switches Added
- Note Heavy Gauge Wire
Blue Sea Systems
SI-ACR Automatic Charging Relay - 12/24V DC 120A

- Automatically combines batteries during charging, isolates batteries when discharging and when starting engines
- Features
  - Protects sensitive electronics by temporary isolation of house loads from engine circuit during engine cranking
  - Designed for 12 or 24 volt systems
  - 12/24 volt auto ranging voltage input
  - Hermetically sealed contacts/vaporproof
  - Ignition protected—safe for installation aboard gasoline powered boats
  - Supports high-output alternators up to 120 Amperes
  - Dual sensing
- Optional Features
  - Start Isolation allows temporary isolation of House loads from Engine circuit during engine cranking to protect sensitive electronics from sags and spikes
  - Remote LED remotely indicates ACR states - requires optional LED
<table>
<thead>
<tr>
<th>Battery Type</th>
<th>Best Use</th>
<th>Engine Cranking Power Marine Cranking Amps: Group 24</th>
<th>Charge/Discharge Cycles</th>
<th>Charging Acceptance Rate</th>
<th>Self-Discharge Rate (per month)</th>
<th>Ruggedness and Maintenance</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting Flooded</td>
<td>Starting engines, Short high-current, shallow discharge applications</td>
<td>Better 550-1000MCA</td>
<td>N/A</td>
<td>N/A Deep discharges ruin these</td>
<td>3%</td>
<td>Vents hydrogen, add water, can spill</td>
<td>Economy</td>
</tr>
<tr>
<td>Dual Purpose Flooded</td>
<td>Double-duty for either starting or deep cycle. Runabouts, boats with one battery bank, two identical banks</td>
<td>Better 650 MCA</td>
<td>200 at 50% depth of discharge</td>
<td>Good 25% of Ah</td>
<td>6%</td>
<td>Vents hydrogen, add water, can spill, equalize periodically</td>
<td>Economy</td>
</tr>
<tr>
<td>Deep Cycle Flooded</td>
<td>House battery bank in multi-bank system</td>
<td>Good 625 MCA</td>
<td>350 6V Golf Cart 700-1000</td>
<td>Good 25% of Ah</td>
<td>6%</td>
<td>Vents hydrogen, add water, can spill, equalize periodically</td>
<td>Economy Lowest initial cost for deep cycle</td>
</tr>
<tr>
<td>Gel</td>
<td>House battery bank in multi-bank system. Greatest longevity. Submersible</td>
<td>OK 575 MCA</td>
<td>1000</td>
<td>Good 25% of Ah</td>
<td>3%</td>
<td>Maintenance free, spillproof, vents almost no hydrogen, submersible</td>
<td>Premium Least costly long term per Ah</td>
</tr>
<tr>
<td>Absorbed Glass Mat (AGM)</td>
<td>High-performance dual purpose batteries with maximum ruggedness. Offshore, cruising, off-road, off-the-grid applications</td>
<td>Better 660 MCA</td>
<td>300</td>
<td>Better 40% of Ah</td>
<td>3%</td>
<td>Maintenance free, spillproof, vents almost no hydrogen, submersible, mount in almost any position, vibration tolerant</td>
<td>Premium</td>
</tr>
<tr>
<td>Thin Plate Pure Lead (AGM)</td>
<td>Cutting-edge starting, cycling and charge acceptance</td>
<td>Best 1010 MCA</td>
<td>400 at 80% depth of discharge</td>
<td>Best 300% of Ah</td>
<td>1%</td>
<td>Maintenance free, spillproof, vents almost no hydrogen, submersible, mount in almost any position, vibration tolerant</td>
<td>Premium plus</td>
</tr>
<tr>
<td>Lithium (Li NMC)</td>
<td>Electric propulsion systems and extreme-performance house batteries</td>
<td>Not a Starting Battery</td>
<td>800 at 100% depth of discharge</td>
<td>Better 100% of Ah</td>
<td>1%</td>
<td>Sealed, spillproof, internally protected cells</td>
<td>Premium prime</td>
</tr>
</tbody>
</table>
Marine Batteries

• Flooded: Lead-Acid
  • Starting: High Current for Short Duration
    • Thin Plates; Shallow Discharge with Quick Recharge
    • Cranking Amps: 75 – 400 A
  • Deep Cycle: Lower Current for Longer Duration
    • Thinker Plates; Deeper Discharge with Longer Recharge
    • Amp-Hours: 200 Ah
• Dual Purpose: One Battery for Both Applications
  • Not a Good Solution

• Issues
  • Sulfation: Sulfate Hardening (Due to Abuse)
    • Equalization: A Controlled Overcharge Can Recover Capacity
    • Disconnect Sensitive Electronics
<table>
<thead>
<tr>
<th>Model</th>
<th>Battery Type</th>
<th>MCA</th>
<th>RC</th>
<th>Ah</th>
</tr>
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<tbody>
<tr>
<td>West Marine Cranking</td>
<td>Battery</td>
<td>1000</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>West Marine Deep Cycle</td>
<td>Battery</td>
<td>615</td>
<td>130</td>
<td>75</td>
</tr>
</tbody>
</table>
Battery Specification Terminology

• **Cranking amps (CCA)**
  - Cranking Amps are the numbers of amperes a lead-acid battery at 32 degrees F (0 degrees C) can deliver for 30 seconds and maintain at least 1.2 volts per cell (7.2 volts for a 12 volt battery). In other words, CA/cranking amps determine how much power you have to start your car/boat in most climates.

• **CCA vs. MCA**
  - The two common power measurements are CCA (Cold Cranking Amps, the number of amps a battery can deliver for 30 seconds at 0°F while maintaining its voltage above 7.2 volts) and MCA (Marine Cranking Amps, similar but measured at 32°F instead of 0°F).
Battery Specification Terminology

• **Reserve Capacity (RC)**
  - RC is a very important rating. This is the number of minutes a fully charged battery at 80°F will discharge 25 amps until the battery drops below 10.5 volts. An amp hour (AH) is a rating usually found on deep cycle batteries.

• **Amp Hrs**
  - This is the number of minutes a fully charged battery at 80°F will discharge **25 amps** until the battery drops below 10.5 volts. An amp hour (AH) is a rating usually found on deep cycle batteries. The standard rating is an amp rating taken for **20 hours**.
Battery Management

Monitoring Amp-Hours on the House Battery (s) is a Good Method for Battery Management
- Recharge when at 50% Capacity
Battery Charger Cycles

- **Bulk Charge**: The initial high current phase.
- **Absorption Charge**: The voltage increases as the battery reaches its terminal voltage.
- **Equalization Charge**: The voltage peaks around 16.0 volts.
- **Float Charge**: Equalization current at 5% of battery’s Ah rating.

![Graph showing battery charger cycles with time, percentage of battery’s Ah capacity, and voltage (volts and amps).](image-url)
Can You Run a Microwave Off of House Batteries?

Samsung MR4381G
1000 W Cooking Power
1580 W Power Consumption
120V @ 13.2A

Thermo King 41-7784
Output 1800W
Input 12V & 150A
Efficiency ~ 90% ?

• The Inverter Will Draw ~ 150A to Power Microwave
• Batteries Can Provide High Current Short Term ~ 30s
• Can Battery Provide 150A for 10 m to Cook Lasagna?
• Will High Load Draw Down Voltage Causing Inverter to Drop Out?
• Will Running Engine / Alternator Reduce the Strain on the Batteries?
• Will Batteries be Damaged?

Two House Batteries in Parallel
Interstate SRM – 4D Deep Cycle
CCA = 1314  RC = 390 @ 25 A
Amp Hrs = 195 ea;  Total Ahr = 390
References

• Troubleshooting Marine Diesels by Peter Compton
• Marine Diesel Engines: Maintenance, Troubleshooting, and Repair by Nigel Calder
• Boatowners Mechanical and Electrical Manual by Nigel Calder

• Link to Presentation will be Posted on Front Page of Fairwind Website:
  www.fairwind.org