


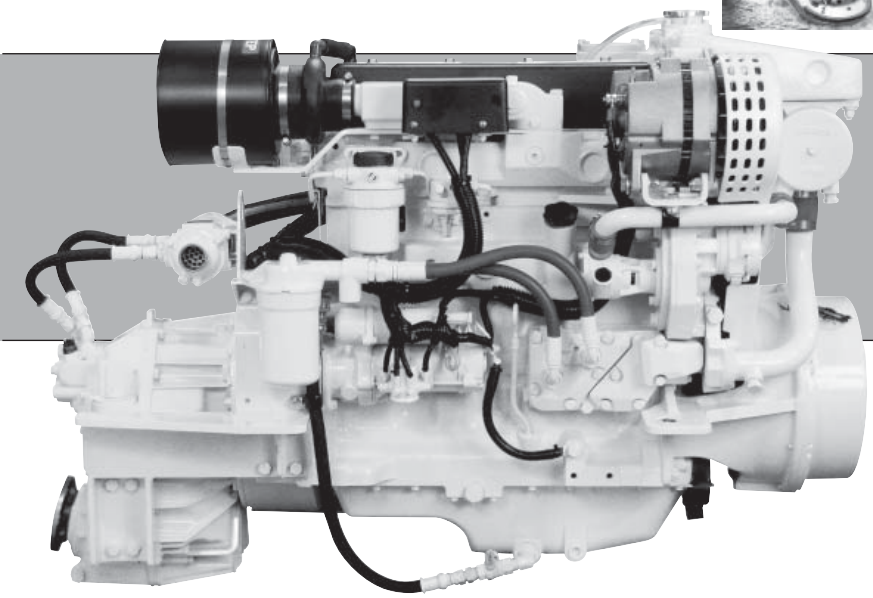

OL2-2

For Models: L1064D, L1064A,
L1066T, and L1066A

OPERATOR'S MANUAL

Marine Generators | Marine Diesel Engines | Land-Based Generators

NORTHERN LIGHTS®

LUGGER




— CALIFORNIA —
Proposition 65 Warning:

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

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OPERATOR'S MANUAL

#OL2-2 for Models

L1064D, L1064A, L1066T, and L1066A

Read this operator's manual thoroughly before starting to operate your equipment.
This manual contains information you will need to run and service your new unit.

Table of Contents

Introduction

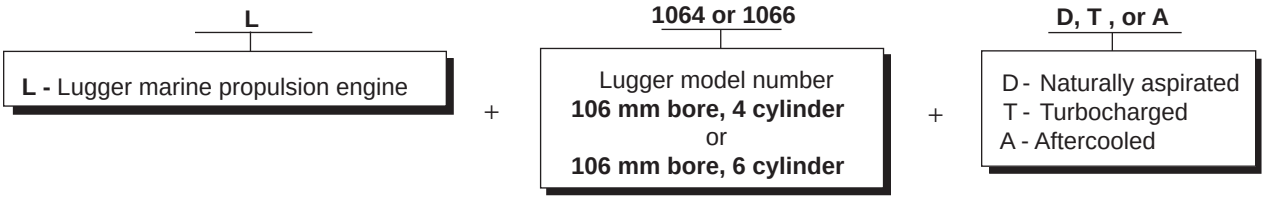
Servicing of marine engines and generator sets presents unique problems. In many cases boats cannot be moved to a repair facility. Marine engines cannot be compared to the servicing of automobiles, trucks or even farm equipment. Failures often occur in remote areas far from competent assistance. Marine engines are taxed far more severely than auto or truck engines; therefore, maintenance schedules must be adhered to more strictly.

Failures begin with minor problems that are overlooked and become amplified when not corrected during routine maintenance.

As operator, it is your obligation to learn about your equipment and its proper maintenance. This is not a comprehensive technical service manual. Nor will it make the reader into an expert mechanic. Its aim is to aid you in maintaining your unit properly.

Model Numbers

Model numbers give the unit's application, block model, aspiration, and RPM:



L1064D = Lugger® naturally aspirated marine propulsion engine with a John Deere Powertech Tier II 4045 engine block, with a mechanically controlled fuel system.

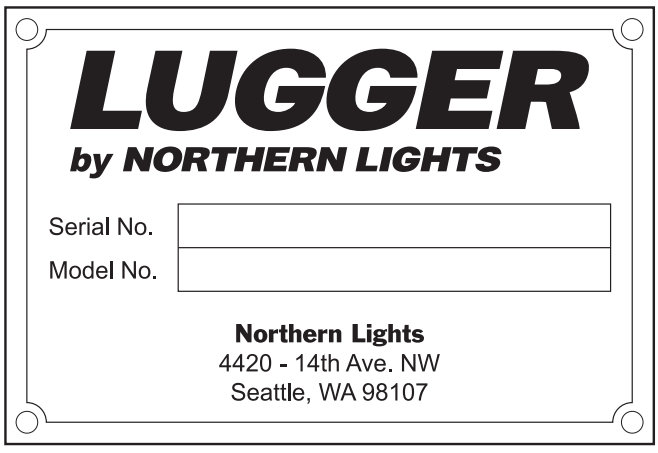
L1064A = Lugger® aftercooled marine propulsion engine with a John Deere Powertech Tier II 4045 engine block, with a electronically controlled fuel system.

L1066T = Lugger® turbocharged marine propulsion engine with a John Deere Powertech Tier II 6068 engine block, electronically controlled fuel system.

L1066A = Lugger® aftercooled marine propulsion engine with a John Deere Powertech Tier II 6068 engine block, electronically controlled fuel system.

Serial Numbers

When referencing Northern Lights, Inc. equipment by serial number, please refer only to the number stamped on the Northern Lights® or Lugger® serial number plate.



Warranty

A warranty registration certificate is supplied with your set. It entitles the original purchaser of our equipment to a warranty covering material or assembly faults. The extent of coverage is described in the Limited Warranty Statement. We recommend that you study the statement carefully.

NOTE: If the warranty is to apply, the servicing instructions outlined in this manual must be followed. If further information is needed, please contact an authorized dealer or the factory.

Safety Rules

CAUTION: ***Accident reports show that careless use of engines causes a high percentage of accidents. You can avoid accidents by observing these safety rules. Study these rules carefully and enforce them on the job.***

- Never leave engine without proper security.
- Turn the coolant tank cap slowly to relieve pressure before removing. Add coolant only when the engine is stopped and cool.
- Mount a fire extinguisher near engine.
- Always disconnect the battery ground strap before making adjustments.
- Operate engines in properly ventilated areas.
- Keep trash and other objects away from engine.
- Escaping fluids under pressure can penetrate your skin. Use a piece of cardboard or wood, not your hands, to search for leaks.
- Avoid wearing loose clothing without a belt when working around engines.
- Do not oil or grease engine while it is running.
- Always disconnect the ECU (Electronic Control Unit) connectors and remove the ground connection for the engine control system-to-machine frame before welding on engine. Make sure no other electronic components are in the ground path also.
- Use caution in handling fuel. Never refuel a hot or running engine. Do not smoke while filling fuel tank or servicing fuel system.
- Keep your hands, feet, hair and clothing away from power-driven parts.
- Check for any loose electrical connections or faulty wiring.
- Engines should be operated only by knowledgeable, qualified personnel.
- Look completely around engine to make sure that everything is clear before starting.
- Do not operate an engine that isn't in proper working order. If an unsafe operating condition is noted, tag the set and control panel so others will also know about the problem.
- Provide first aid kits.

CALIFORNIA
Proposition 65 Warning:

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

CAUTION: This symbol is used throughout this book to alert you to possible danger areas. Please take special notice of these sections.

Lugger Component Locations

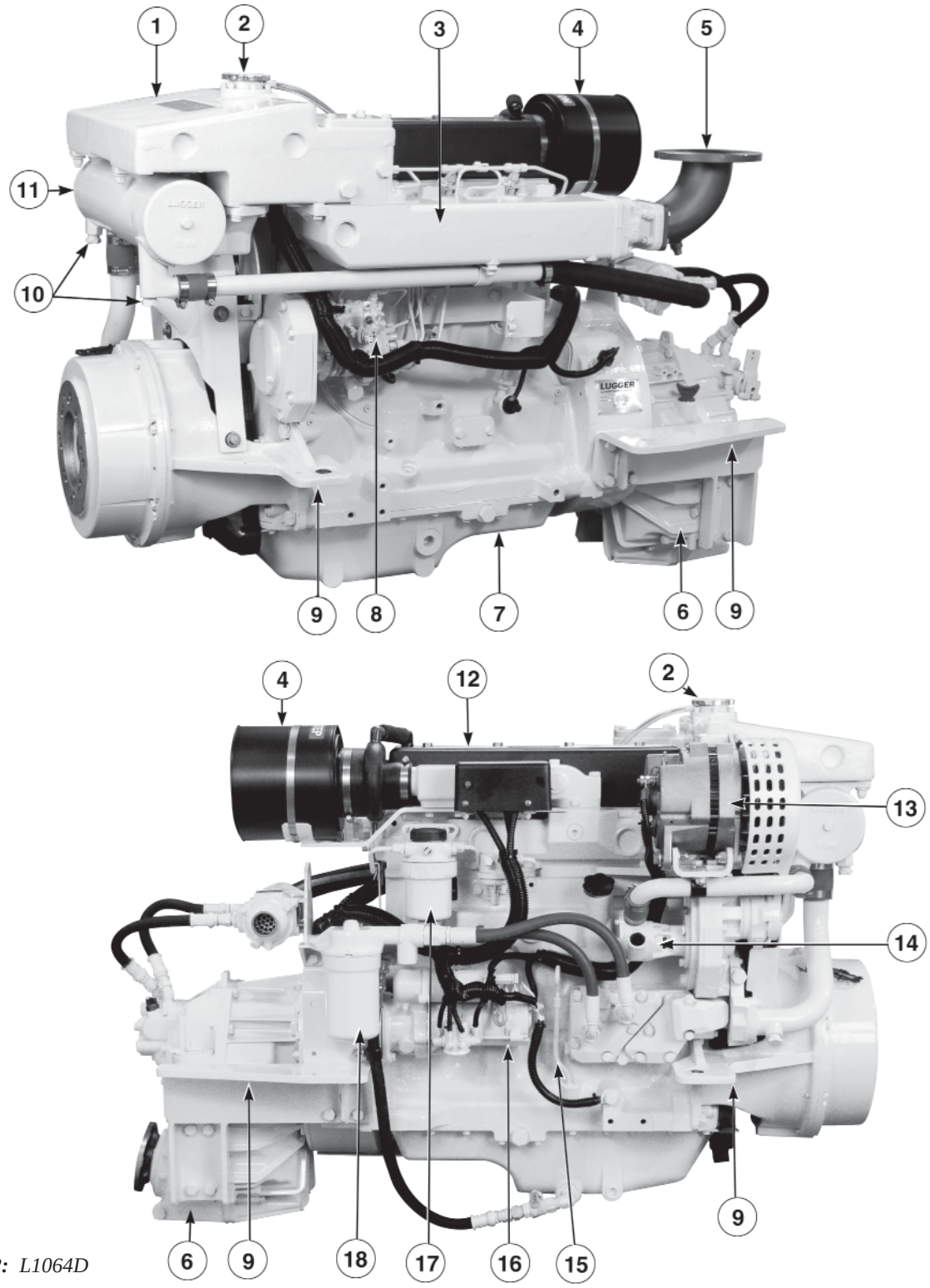


Figure 1 & 2: *L1064D*

1. Expansion Tank
2. Coolant Fill
3. Exhaust Manifold
4. Air Cleaner
5. Dry Exhaust Elbow
6. Marine Gear
7. Oil Pan
8. Injection Pump
9. Mounting Foot
10. Heat Exchanger Zincs
11. Heat Exchanger
12. Rocker Arm Cover
13. Alternator
14. Raw Water Pump
15. Dipstick
16. Starter
17. Fuel Filter
18. Oil Filter

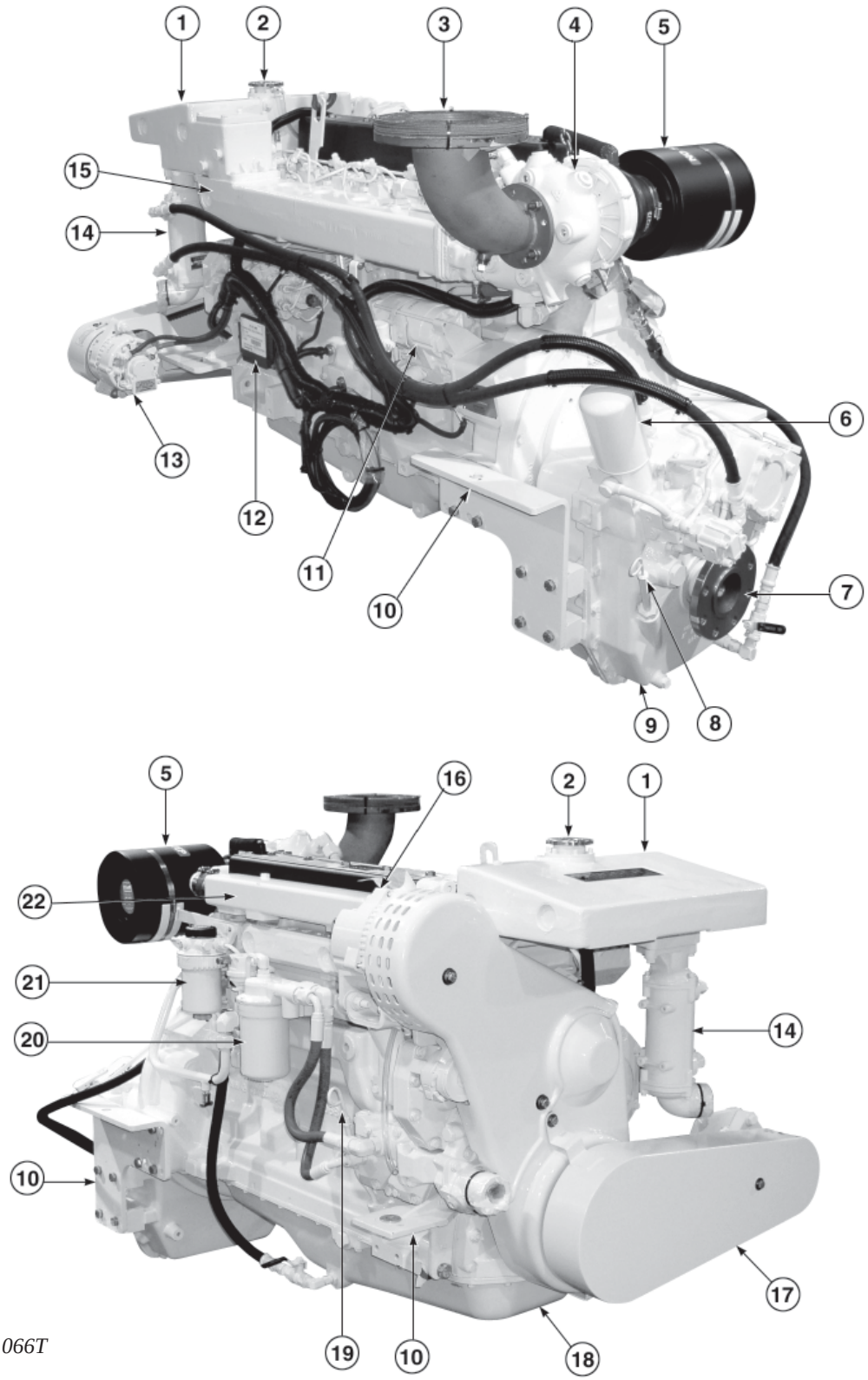


Figure 3 & 4: *L1066T*

1. Expansion Tank
2. Coolant Fill
3. Dry Exhaust Elbow
4. Turbocharger
5. Air Cleaner
6. Gear Filter
7. Gear Output Flange
8. Gear Dipstick
9. Marine Gear
10. Mounting Foot
11. Starter
12. ECU (Electronic Control Unit)
13. Second Alternator (Optional)
14. Gear Oil Cooler
15. Exhaust Manifold
16. Alternator
17. Belt Guard (2nd Alternator optional)
18. Oil Pan
19. Dipstick
20. Oil Filter
21. Fuel Filter
22. Intake Manifold

Lugger Control Panel

Figure 5: *Lugger Powerview Control Panel*

1. TACHOMETER

The tachometer shows the engine speed in revolutions per minute (RPM). Numbers are multiples of 100.

2. HOUR METER

Keeps track of the engine running time.

3. DC VOLTMETER

When the engine is stopped, the voltmeter shows the condition of the battery, When the engine is running, it indicates the voltage output of the alternator.

4. KEY SWITCH

Turning the key clockwise to the first position will switch on the current. continue turning the key clockwise to start the engine. When the engine starts, immediately turn the key back to the first position while the engine is running.

The key must be kept in the on or first position while the engine is running.
Turn the key counterclockwise as far as possible to stop the engine.

Note:
Optional flybridge panels have engine start switches instead of key switches.

5. POTENTIOMETER

Dims the panel lights.

6. ALARM HORN

Shut down engine if possible and investigate immediately.

7. COOLANT TEMPERATURE GAUGE

Water temperature gauge shows the temperature of the cooling water. If the gauge registers over 200° or drops below 140°, stop the engine and investigate.

8. OIL PRESSURE GAUGE

The oil pressure gauge shows the oil pressure in the engine lubricating system. If the pressure drops below 15 PSI at a speed higher than idling, stop the engine immediately.

Lugger Control Panel

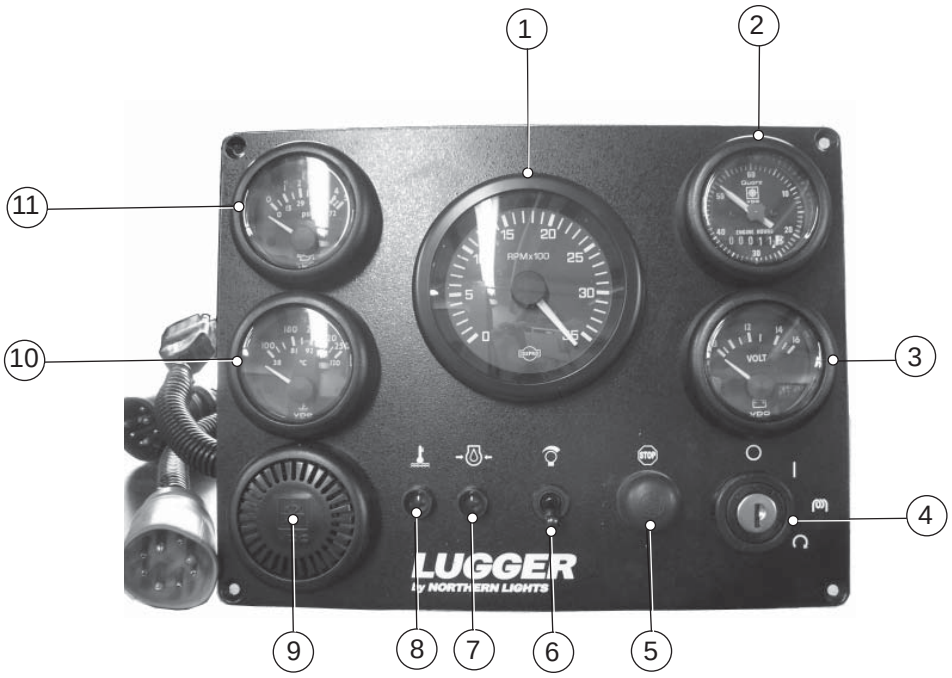


Figure 2: *Lugger Instrument Control Panel*

1. TACHOMETER

The tachometer shows the engine speed in revolutions per minute (RPM). Numbers are multiples of 100.

2. HOUR METER

Keeps track of the engine running time.

3. DC VOLTMETER

When the engine is stopped, the voltmeter shows the condition of the battery, When the engine is running, it indicates the voltage output of the alternator.

4. KEY SWITCH

Turning the key clockwise to the first position will switch on the current. continue turning the key clockwise to start the engine. When the engine starts, immediately turn the key back to the first position while the engine is running. The key must be kept in the on or first position while the engine is running.

Note:
Optional flybridge panels have engine start switches instead of key switches.

5. STOP BUTTON

Stops engine immediately.

6. INSTRUMENT PANEL LIGHTING

The switch turns on the instrument panel lights.

7. OIL PRESSURE FAULT LIGHT

Indicates low oil pressure.

8. ENGINE TEMPERATURE FAULT LIGHT

Indicates engine is over-heating. Activates in conjunction with alarm horn.

9. ALARM HORN

Shut down engine if possible and investigate immediately.

10. COOLANT TEMPERATURE GAUGE

Water temperature gauge shows the temperature of the cooling water. If the gauge registers over 200° or drops below 140°, stop the engine and investigate.

12. OIL PRESSURE GAUGE

The oil pressure gauge shows the oil pressure in the engine lubricating system. If the pressure drops below 15 PSI at a speed higher than idling, stop the engine immediately.

Operating Procedures

BEFORE STARTING

1. Check the water level by removing the pressure cap from the expansion tank. In order to give the cooling water room to expand, the level should be about 1 3/4 in. (4-5 cm) below the filler cap sealing surface when the engine is cold. When filling with coolant, the venting cock on top of the turbocharger should be opened to ensure that no air pockets form in the cooling system **(see Service Point #13).**

CAUTION: *Use protective clothing and open the filler cap carefully when the engine is warm to prevent burns.*

2. Check the oil level in the crankcase with the dipstick. The oil level should be between the "waffled area" and the "oo". Never allow the level to go below the "oo". Always add the same viscosity of oil as is already in the crankcase **(see Service Point #1)**.
3. Check the fuel tank level and open any fuel valves.
4. Disengage clutch, if equipped.
5. Close the seacock, check and clean the strainer and reopen the seacock.
6. Place the battery switch in the ON position.

NOTE: *The battery switch must always be kept ON while the engine is running. If the switch is turned OFF while the engine is running, the battery charging regulator could be ruined.*

Starting

1. Put the gear control in the neutral position.
2. Move the throttle control to the full speed position and return back to idle.
3. Turn the key switch to the first position. Check the voltage meter to see the condition of the batteries. For starting, the voltmeter should not read below 12 volts (24 volts for 24 volt systems).
4. Turn the key to the starting position and as soon as the engine starts, release the key. Move the throttle up until the engine is running at approximately 1000 RPM.
5. Do not crank the starter for more than 15 seconds consecutively. If the engine fails to start with the first attempt, be sure that the starter has stopped completely before re-engaging.

NOTE*: Never race a cold engine. Operate at 1000 RPM for a 3 to 5 minute warm-up period.*

Operating

1. Check oil pressure as soon as the engine has started. Oil pressure should be above 15 PSI. The engine must never be run if the oil pressure is below 15 PSI.
2. Check the voltmeter. It should read 13 to 14 volts (26 to 28 volts for 24 volt systems) at 60°F (16°C).
3. Water temperature should not rise over 200°F (94°C). If it does, shut down the engine and investigate the cause of overheating.
4. Do not exceed 800 RPM when shifting marine gear. Repeated shifts at higher engine speeds can damage the reverse gear.
5. If the proper propeller is used, the engine should reach its approximate RPM's at full throttle. If the maximum rated RPMs for your engine application is exceeded at full throttle, then your propeller is too small. If you cannon reach your maximum rated RPMs at full throttle, either your propeller is too large or bottom growth is slowing the boat.
6. To establish maximum cruising RPM: establish the RPM at full throttle and subtract 200-300 RPM. This will promote engine life and reduce fuel consumption.

Shutdown

1. Run engine three to five minutes in neutral at 1000 RPM, for cool down period.
2. Return engine to low idle.
3. Turn the key switch counterclockwise as far as possible to stop the engine.
4. Close the sea cock and fuel valves and put the battery switch in OFF position.
   NOTE: *Do not turn the battery switch to OFF while the engine is running.*

SHUTDOWNS AND ALARMS

1. Your unit is fitted with a warning system to indicate high water temperature or low oil pressure. Propulsion engines have warning horns to sound and warn you of a problem. Remember - when the engine is not running the horn will sound when key is in the "ON" position because there is no oil pressure.

   NOTE: *Do not rely on your warning or shutdown system to the exclusion of careful gauge monitoring. Watching your gauges can prevent damage to the unit and dangerous power losses.*

2. Do the following when your shutdown system is activated:
   a. Check the temperature gauge. If the temperature is above 205°F (97°C), shut off the engine immediately.
   b. Use the Trouble Shooting Guide on pages 26- 28 to isolate the cause of the overheat.

CAUTION: *Do not remove the water fill cap of an overheated engine. Escaping high temperature steam can cause severe burns. Allow the engine to cool and then remove the cap slowly,* ***using protective clothing.***

   c. Make repairs and restart after the temperature gauge registers below 180°F (83°C).
   d. Watch the temperature gauge regularly and turn off the unit if the temperature rises above 200°F (94°C). Repeat the troubleshooting process.

3. If the shutdown is activated and the temperature gauge shows temperature within normal temperature range:

   a. Check the engine crankcase oil level.
   b. If the oil level is low, fill with recommended lubricating oil and restart. Watch the oil pressure gauge carefully and shut off the engine if it does not show a normal reading after a few seconds of operation.
   c. If the oil level was normal, DO NOT restart the engine. Call your Northern Lights or Lugger dealer for assistance.

BREAK-IN PERIOD

1. Your engine is ready to be put into service. However, the first 100 hours on a new or reconditioned engine are critical to its life and performance. This is especially true of an engine that runs at a constant speed such as a propulsion engine.

2. Operate with an average of 75% load on your engine for the first 100 hours. Maintain no less than a 50% load to ensure proper seating of the piston rings.

3. Oil consumption is greater during break-in as piston rings take time to seat.

4. Your engine comes equipped with break-in oil. Change engine oil and filter at 50 hours using API Service Category CC, CD, or CE break-in oil. Change the oil and filter again at 100 hours. (Consult the lubricants section for oil recommendation.)

5. Frequently check the engine temperature and oil pressure gauges.

Service Schedule Chart, Mechanically Controlled Fuel System

The Servicing Schedule Chart below shows the service schedule required for proper maintenance of your marine engine or generator set. More detailed coverage of each Service Point (SP) is listed on the page noted in the 'page' column.

DAILY:
- SP1 Check oil level in engine
- SP8 Check primary fuel filter
- SP15 Check cooling water level

AFTER FIRST 50 HOURS:
- SP2 Change engine oil
- SP3 Change lube oil filter

EVERY 50 HOURS:
- SP21 Check electrolyte in batteries

FIRST 100 HOURS:
- SP2 Change engine oil
- SP3 Change lube oil filter

EVERY 250 HOURS:
- SP2 Change engine oil
- SP3 Change lube oil filter
- SP4 Check air cleaner
- SP9 Change primary fuel filter element
- SP13 Check turbocharger air, oil & cooling lines for leakage
- SP19 Check zinc electrodes
- SP23 Test thermostats

AFTER FIRST 600 HOURS:
- SP6 Check valve clearance

EVERY 600 HOURS / YEARLY:
- SP4 Replace air cleaner
- SP5 Check belt condition
- SP7 Check crankshaft vibration damper
- SP10 Change secondary fuel filter
- SP11 Check injectors
- SP14 Check turbocharger boost pressure
- SP16 Check and flush cooling system
- SP20 Change impeller in raw water pump
- SP22 Check the state of the charge of the batteries

EVERY 2000 HOURS:
- SP6 Check valve clearance, adjust if necessary
- SP12 Check fuel injection pump
- SP17 Check and clean heat exchanger
- SP18 Check and clean gear oil cooler

SERVICE POINT	PAGE	OPERATION		DAILY	50 Hours	100 Hours	250 Hours	600 Hours	2000 Hours
		ENGINE:							
SP1	15	Check oil level		●					
SP2	15	Change engine oil	2)		1)	1)	●		
SP3	15	Change lube oil filters	2)		1)	1)	●		
SP4	15	Check (replace) air cleaner	2) 4)				●	●	
SP5		Check belt condition	2)					●	
SP6	16	Check valve clearances	2)					●	●
SP7	17	Check crankshaft vibration damper						●	
		FUEL SYSTEM:							
SP8	17	Check primary filter (Racor)	3)	●					
SP9	17	Change primary filter element (Racor)	3) 4)				●		
SP10	17	Change secondary fuel filter	2) 4)					●	
SP11	18-19	Check injectors	2)					●	
SP12	20-22	Check fuel injection pump							●
		TURBOCHARGER:							
SP13	23	Check air, oil & cooling water lines for leakage	2)				●		
SP14	23	Check boost pressure						●	
		COOLING SYSTEM:							
SP15	25	Check cooling water level		●					
SP16	25	Check and flush cooling system	2)					●	5)
SP17	25	Check and clean heat exchanger	2)						●
SP18		Check and clean gear oil cooler	2)						●
SP19	25-26	Check zinc electrodes	2) 4)				●		
SP20	26	Change impeller in raw water pump	2) 4)					●	
		ELECTRICAL SYSTEM:							
SP21	27	Check electrolyte level in batteries	2) 4)		●				
SP22	27	Check condition of batteries with hydrometer	2)				●		
SP23		Test thermostats					●		
		OUT OF SERVICE:							
SP24	27	Winterizing or out-of-service	4)						

1) Change the oil and filter at 50 hours, using break-in oil again, until changing at 100 hours, then at every 250 hours.
2) Perform all maintenance once a year even if hour level has not been reached.
3) Consult manufacturer's maintenance schedule, note on chart.
4) Whenever necessary.
5) Check cooling system at 600 hours, flush at 2000 hours or when needed.

Service Schedule Chart, Electronically Controlled Fuel System

The Servicing Schedule Chart below shows the service schedule required for proper maintenance of your marine engine or generator set. More detailed coverage of each Service Point (SP) is listed on the page noted in the 'page' column.

DAILY:
- SP1 Check oil level in engine
- SP8 Check primary fuel filter
- SP15 Check cooling water level

AFTER FIRST 50 HOURS:
- SP2 Change engine oil
- SP3 Change lube oil filter

EVERY 50 HOURS:
- SP21 Check electrolyte in batteries

AFTER FIRST 100 HOURS/ EVERY TWO WEEKS [5]:
- SP2 Change engine oil after first 100 hrs., then check every 2 wks.
- SP3 Change oil filter after first 100 hrs., then check every 2 wks.
- SP4 Check air cleaner valve & restriction indicator gauge [6]
- SP7 Check crankshaft vibration damper[7]
- SP15 Check coolant level

EVERY 250 HOURS:
- SP2 Change engine oil & filters (fuel filter/water bowl)
- SP4 Replace air cleaner
- SP5 Check V-belt condition
- SP9 Change primary filter element (Racor)
- SP25 Check engine mounts
- SP26 Clean crankcase vent tube
- SP27 Check air intake hoses
- SP29 Check electrical ground connection
- SP30 Check engine speeds

EVERY 500 HOURS/ YEARLY:
- SP10 Change secondary fuel filter
- SP11 Check injectors
- SP14 Check turbocharger boost pressure
- SP20 Change impeller in raw water pump
- SP22 Check the state of the charge of the batteries

EVERY 2000 HOURS:
- SP6 Check & adjust valve clearance
- SP7 Check crankshaft vibration damper
- SP12 Check fuel injection pump
- SP16 Check and flush cooling system
- SP17 Check and clean heat exchanger
- SP18 Check and clean gear oil cooler
- SP23 Test thermostats
- SP30 Adjust variable speed (droop)

SERVICE POINT	PAGE	OPERATION		DAILY	50 Hours	100 Hours	250 Hours	500 Hours	2000 Hours
		ENGINE:							
SP1	15	Check oil level		●					
SP2	15	Change engine oil	1) 2)			●	●		
SP3	15	Change lube oil filters	1) 2)			●	●		
SP4	15	Check air cleaner valve	2) 4) 6)			●	●		
SP5		Check belt condition	2)				●		
SP6	16	Check valve clearances	2)					●	●
SP7	17	Check crankshaft vibration damper	7)						●
SP25		Check engine mounts					●		
SP27		Check air intake hoses					●		
SP30		Check engine speeds					●		
		FUEL SYSTEM:							
SP8	17	Check primary filter (Racor)	3)	●					
SP9	17	Change primary filter element (Racor)	3) 4)				●		
SP10	17	Change secondary fuel filter	2) 4)					●	
SP11	15-17	Check injectors	2)					●	
SP12		Check fuel injection pump							●
		TURBOCHARGER:							
SP13	23	Check air, oil & cooling water lines for leakage	2)			●			
SP14	23	Check boost pressure						●	
		COOLING SYSTEM:							
SP15	25	Check cooling water level		●					
SP16	25	Check and flush cooling system	2)					●	
SP17	25	Check and clean heat exchanger	2)						●
SP18		Check and clean gear oil cooler	2)						●
SP19	25-26	Check zinc electrodes	2) 4)			●			
SP20	26	Change impeller in raw water pump	2) 4)					●	
		ELECTRICAL SYSTEM:							
SP21	27	Check electrolyte level in batteries	2) 4)		●				
SP22	27	Check condition of batteries with hydrometer	2)					●	
SP23		Test thermostats							●
SP29		Check electrical ground connection						●	

1) Change the oil and filter before the first 100 hours of operation during engine break-in.
2) Perform all maintenance once a year even if hour level has not been reached.
3) Consult manufacturer's maintenance schedule, note on chart.
4) Whenever necessary.
5) Operate engine at rated speed with 50-70% load for 30 minutes at least.
6) Replace air cleaner element when restriction indicator shows vacuum of 625 mm (25 in.) H_20.
7) Replace damper every 4500 hours or after 60 months.

Service Record

Service Point	OPERATION	HOURS/DATE									
50 HOURS											
SP21	Check electrolyte in batteries										
250 HOURS											
SP2	Change engine oil										
SP3	Change lubricating oil filters										
SP4	Check air cleaner										
SP9	Change primary fuel filter element										
SP13	Check turbocharger air, oil & cooling lines for leakage										
SP19	Check zinc electrodes										
600 HOURS/ 500 HOURS *											
SP4	Replace air cleaner										
SP5	Check belt condition										
SP10	Change secondary fuel filter										
SP14	Check turbocharger boost pressure										
SP16	Check and flush cooling system										
SP20	Change impeller in raw water pump										
SP22	Check state of charge of batteries										
EVERY 1200 HOURS/ 2000 HOURS *											
SP6	Check valve clearances										
2400 HOURS/ 2000 HOURS *											
SP12	Check fuel injection pump										
SP17	Check and clean heat exchanger										
SP18	Check and clean reverse gear oil cooler										

* First number for mechanically controlled fuel system engines, second for electronically controlled fuel system engines.

LUBRICATION

Break-in oil

1. Use one of the following during the first 100 hours of operation:
   a. John Deere Engine Break-In Oil
   b. API Service CE oil
   c. ACEA Specification E1
2. *Do not use* John Deere PLUS-50 oil or engine oils meeting API CG4, API CF4, ACEA E3, or ACEA E2 performance levels during the first 100 hours of operation of a new or rebuilt engine. These oils will not allow the engine to break-in properly.

Lubrication - General

1. Use only clean, high quality lubricants stored in clean containers in a protected area.
2. These oils are acceptable after the first 100 hours:
   a. API Service CC/CD single viscosity oils.
   b. API Service CD/CG-4/CF-4 multi-viscosity oils.
   c. ACEA Specification E3/E2 multi-viscosity oils.
   d. CCMC Specification D5 and Mercedes Benz MB228.3.
   e. CCMC Specification D4 and Mercedes Benz MB228.1.
3. Use the proper weight oil for your average operation temperature.

Air Temperature	Single Viscosity	Multi Viscosity
Above 32°F (0°C)	SAE-30W	SAE15-40W
-10°F to 32°F (-23°C to 0°C)	SAE-10W	SAE10-30W
Below -10°F (-23°C)	SAE-5W	SAE5-20W

4. Some increase in oil consumption may be expected when SAE 5W and SAE 5-20W oils are used. Check oil level frequently.
5. Never put additives or flushing oil in crankcase.

SP1. CHECK ENGINE OIL LEVEL

1. Check the oil level in the crankcase, with the oil dipstick, daily.
2. The oil level must be between the “Waffled area” and the “oo”. Never allow the level to go below the “oo”.
3. Always add the same viscosity of oil as is already in the crankcase.

SP2. OIL CHANGES

1. Using the oil recommended above, change the engine oil and filter after the first 50 hours of operation, the first 100 hours and every 250 hours thereafter.
2. During intermittent cold weather operation, change oil every 100 hours or six weeks, whichever comes first.
3. Change oil at any seasonal change in temperature when a new viscosity of oil is required.
   Refill engine with recommended oil.
4. Engine Lube Oil Capacity:

L1064D - T1	15.5 qts.	14.7 liters
L1064A	21.6 qts.	20.5 liters
L1066T	20 qts.	19.0 liters
L1066A	34.3 qts.	32.5 liters

*depending on oil pan size

SP3. CHANGING OIL FILTER

1. Change the lube oil filter every 250 hours.
2. Use a filter wrench to remove old filter. Dispose of filter in approved manner.
3. Make sure the gasket from the old filter is removed and discarded.
4. Lubricate the rubber gasket on the new filter and screw it on nipple until gasket meet the sealing surface.
5. Using hands only, no wrench, tighten filter one-half turn farther. Overtightening can do damage to filter housing.
6. Fill engine with recommended oil. Start engine and check for leakage. Stop engine and check oil level. Add additional oil if necessary.

SP4. AIR CLEANER

1. Inspect air cleaner every 100 hours. Replace filter every 600 hours, or yearly, whichever comes first for mechanically controlled fuel system engines. For electronically controlled units - replace air cleaner element every 500 hours.
2. Clean the rubber tube at the cleaner. Loosen the hose clamp and the attaching strip for the cleaner.
3. Make sure the rubber tube is in good condition and that new filter is absolutely clean and installed properly.
4. Start the engine and check for leaks.

NOTE: *Make absolutely sure no impurities enter the engine while changing the element. Do not run the engine with the air cleaner removed.*

SP6. VALVE CLEARANCES

The following special tools will be needed:
JDE 820 or JDE 83 Flywheel Turning Tool.
JDE 81-4 Timing Pin.

1. Remove rocker arm cover with ventilator tube.
2. Remove plastic plugs in engine timing holes on front side of flywheel.
3. Rotate flywheel in clockwise direction (viewed from water pump) with the Flywheel Turning Tool until the Timing Pin engages timing hole in the flywheel. Both rocker arms for No. 1 cylinder will be loose at Top Dead Center. If they are not, remove the timing pin and rotate the flywheel one complete turn and reinstall the timing pin in the flywheel.
4. Valve clearances must be checked with the engine cold.
   Intake Valve: 0.012-0.015 in. (0.31-0.38 mm)
   Exhaust Valve: 0.016-0.019 in. (0.41-0.48 mm)
5. If the valves need adjusting, loosen the jam nut (*A* on *Figure 9)* on the rocker arm adjusting screw. Turn the adjusting screw until you feel a slight drag when the feeler gauge slips. With a screwdriver, hold the adjusting screw from turning while tightening the jam nut to specifications. Check the clearance again after tightening the jam nut. Re-adjust as needed.

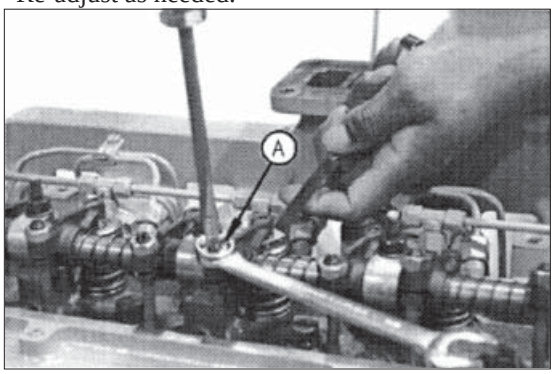


 Figure 9

4-CYLINDER ENGINES:

Lock No. 1 piston at TDC compression stroke (B).
Adjust valve clearance on No. 1 and No. 3 exhaust valves and No. 1 and No. 2 intake valves.
Rotate flywheel 360°. Lock No. 4 piston at TDC compression stroke (C).

NOTE: Firing order is 1 - 3 - 4 - 2

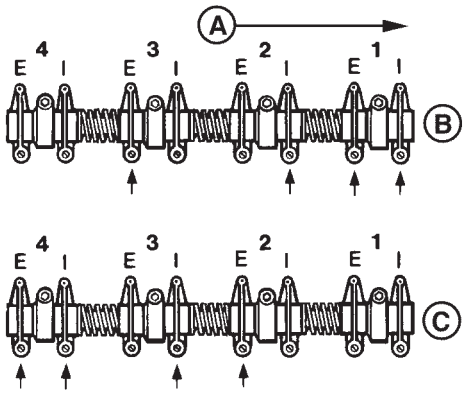


 Figure 10

A - Front of Engine
B - No. 1 Piston at TDC Compression Stroke
C - No. 4 Piston at TDC Compression Stroke
E - Exhaust Valve
I - Intake Valve

Adjust valve clearance on No. 2 and No. 4 exhaust valves and No. 3 and No. 4 intake valves.

6-CYLINDER ENGINES:

NOTE: Firing order is 1 - 5 - 3 - 6 - 2 - 4

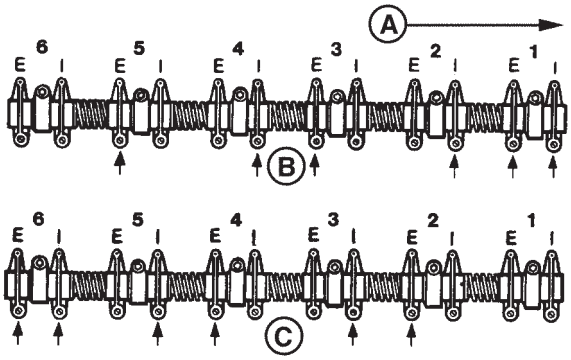


 Figure 11

A - Front of Engine
B - No. 1 Piston at TDC Compression Stroke
C - No. 6 Piston at TDC Compression Stroke
E - Exhaust Valve
I - Intake Valve

Lock No. 1 piston at TDC compression stroke (B).

Adjust valve clearance on No. 1, No. 3, and No. 5 exhaust valves and No. 1, No. 2, and No. 4 intake valves.

Rotate flywheel 360°. Lock No. 6 piston at TDC compression stroke (C).

Adjust valve clearance on No. 2, No. 4, and No. 6 exhaust valves and No. 3, No. 5, and No. 6 intake valves.

FUELS - GENERAL

1. Use only clean, high quality fuels of the following specifications, as defined by ASTM designation D975 for diesel fuels:
   a. Use Grade No. 2 diesel at ambient temperatures above freezing 30°F (0°C).
   b. Use Grade No.1 at ambient temperatures below freezing and for all temperatures at an altitude of above 5,500 ft. (1500 meters).
2. Sulphur content should not exceed 0.5% (preferably less than 0.5%).
3. The cetane number should be a minimum of 45.
4. DO NOT use these unsuitable grades of fuel:
   a. Domestic heating oils, all types.
   b. Class B engine.
   c. Class D domestic fuels.
   d. Class E, F, G or H industrial or marine fuels.
   e. ASTM-D975-60T No. 4-D and higher number fuels.
   f. JP4
5. Storing fuel:
   a. Keep dirt, scale, water and other foreign matter out of fuel.
   b. Avoid storing fuel for long periods of time.
   c. Fill the fuel tank at the end of each day's operation. This will reduce condensation.

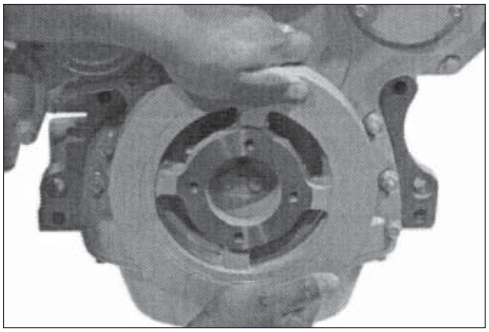
SP8-10. FUEL FILTERS

1. Your engine or generator set should have a primary fuel filter installed. We recommend the Racor brand of fuel filter - water separators.
   a. Check the primary fuel filter daily as recommended by the filter manufacturer. Empty the collection bowl as necessary.
   b. Change the element every 250 hours (500 for electronically controlled fuel system units) or whenever necessary.
   c. If the bowl fills with water, change the primary and secondary elements immediately.
2. Change secondary fuel filter every 600 (500 for electronically controlled units) hours.

NOTE: *The fuel filter on the engine is considered the "secondary fuel filter". The engine will be fitted with a quick change disposable secondary fuel filter. Do not "prefill" the new fuel filter as the fuel used may be contaminated and damage the fuel system components.*

SP7. CRANKSHAFT VIBRATION DAMPER

1. Remove belts.
2. Try to turn the vibration damper in both directions while grasping it with both hands. If rotation can be felt, the damper is defective and should be replaced.

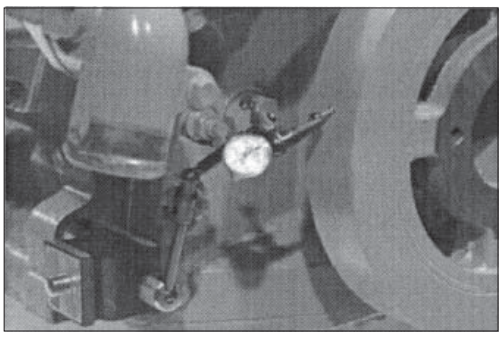


 RG8018 *Figure 12*

NOTE: *The vibration damper assembly should be replaced every 4500 hours or 60 months, whichever occurs first, as the vibration damper assembly is <u>not</u> repairable.*

3. Place a dial indicator *(Figure 13)* so that the probe contacts the damper's outer diameter in order to check the damper radial runout.
4. Make sure the engine is at operating temperature, then rotate the crankshaft using the JD281A, JDE81-4, or the JDE83 Flywheel Turning Tool.
5. If the runout reading exceeds the below specification, replace the vibration damper.

Vibration Damper Maximum
Radial Runout .....1.50 mm (0.060 in.)



 RG7508 *Figure 13*

Servicing

SP8-10. FUEL FILTERS *(Continued)*

a. Turn off the fuel.
b. Open the filter drain plug (Figure 14-A) and drain the filter.

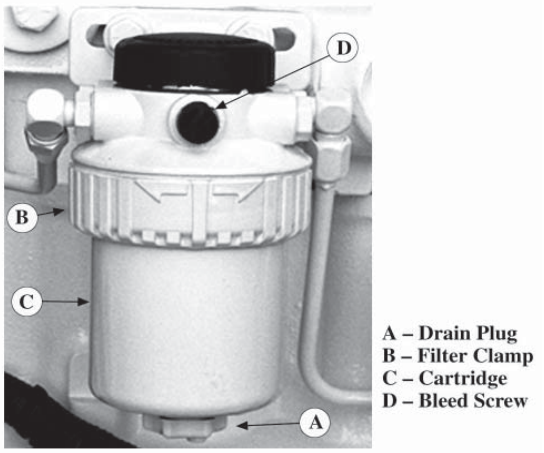


Figure 14: *Secondary Fuel filter*

c. Remove the secondary fuel filter by turning the filter clamp (Figure 14-B) counter clockwise until the filter cartridge (Figure 14-C) slides out.

NOTE: *Before installing a new filter cartridge make sure the surfaces where the cartridge comes in contact with the mounting plate are absolutely clean. Dirt can be washed into the fuel injection system. This may result in severe damage to the fuel injection pump or nozzles. Your generator set may have two secondary filters, depending on the fuel supply system.*

d. Install new filter cartridge.
e. Turn on the fuel.

BLEEDING THE FUEL SYSTEM

CAUTION: *Escaping diesel fuel under pressure can penetrate the skin, causing serious personal injury. Before disconnecting lines be sure to relieve all pressure. Before applying pressure to the system be sure all connections are tight and the lines, pipes and hoses are not damaged. Fuel escaping from a very small hole can be almost invisible. Use a piece of cardboard or wood rather than the hands to search for suspected leaks. If injured by escaping fuel, see a doctor at once. Serious infection or reaction can develop if proper medical treatment is not administered immediately.*

1. Whenever the fuel system has been opened for service, (lines disconnected, filter changed, etc.) it will be necessary to bleed air from the system.

   a. To bleed the fuel system, loosen the bleed plug on the fuel filter.
   Operate the primer pump lever on fuel transfer pump (see component locations) until most of the air bubbles are expelled and clear fuel escapes the bleed plug. Tighten the bleed plug.
   b. If the engine will not start, it may be necessary to loosen the fuel supply pipe at the pump. Operate primer lever of fuel supply pump until fuel flow is free from air bubbles. Retighten fuel supply line to 22 ft. lb. (30 N•m).
   c. If engine still doesn't start, loosen fuel line connection at injection nozzle. Always use a back up wrench when loosening or tightening fuel lines at nozzles and injection pump to avoid damage. With throttle on full, crank the engine over with the starter until fuel without air flows from the loose fuel pipe connection. Repeat procedure for remaining nozzles, if necessary, until engine starts or until air has been removed from system. Tighten the connections to 20 ft. lb. (27 N•m).

SP11. INJECTORS

1. Fuel injectors should be checked by a Lugger-Northern Lights dealer or qualified fuel injection shop every 600 hours.

2. Injector Removal:
   You will need the following special tools:
   JDE38A-Injection Nozzle Puller
   JDE39-Nozzle Bore Cleaning Tool, JD258-Pilot Tool

   a. Before removal, carefully remove all dirt from the cylinder head around fuel injection nozzles. Clean with compressed air to prevent dirt from entering the cylinders or valve seats. Plug the bore in the cylinder head after each fuel injection nozzle has been removed. Cap fuel line openings as soon as they are disconnected.

   b. Immediately fit protective caps over the nozzle tips and the line connections to avoid handling damage.

c. Do not bend the fuel delivery lines. When loosening the fuel pressure lines, hold male union of nozzle line stationary with a backup wrench.
d. Loosen nuts to remove leak-off lines and T-fittings and disconnect fuel injection line from nozzle.

NOTE: *When all fuel injection nozzles have to be removed, disconnect leak-off line assembly at fuel tank, at injection pump, and at each nozzle T-fitting. Lift off complete leak-off line as an assembly.*

e. Remove cap screw, clamp and spacer.
f. Pull injection nozzle out of cylinder head with JDE38A Injection Nozzle Puller.

NOTE: *Do not use screwdrivers, pry bars, or similar tools for this as they might damage the injection nozzle.*

3. Clean Injector Bore:
Always turn the tool clockwise through the bore even when removing from bore, otherwise tool may become dull.
   a. Clean nozzle bore with JDE39 Nozzle Bore Cleaning Tool. Blow debris from bore with compressed air and plug the bore to prevent entry of foreign material.
4. Clean injection nozzles:
   a. Remove carbon stop seal (Figure 15-A) and upper sealing washer (Figure 15-B), using a needle-nose pliers. Discard seals.
   b. Clean exterior of nozzle by soaking in clean solvent or diesel fuel. Clean tip with brass wire brush.

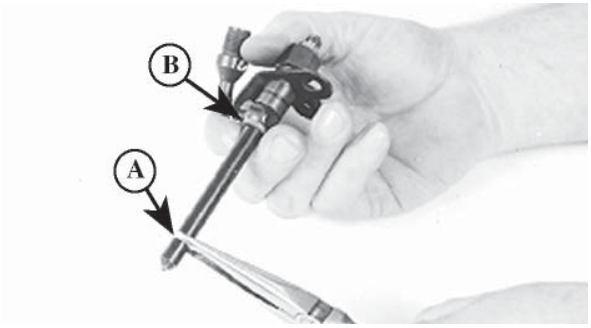


Figure 15

NOTE: *Do not scrape or disturb the teflon coating on the nozzle body above the carbon stop seal groove. This coating will become discolored during normal operation, but this is not harmful. Do not use a motor driven brush to clean up nozzle body.*

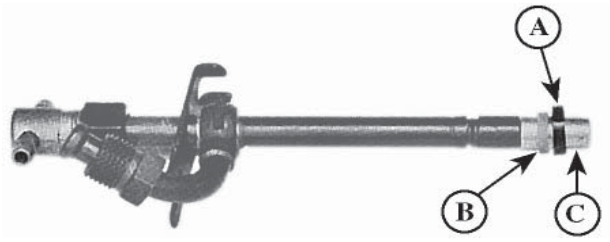


Figure 16

5. Install seals on injection nozzle.

NOTE: *Each time an injection nozzle is removed from the cylinder head, replace carbon stop seal (B) with a new one.*

   a. Position JD258 (ROS16477) Pilot Tool (Figure 16-C) over nozzle tip. If Pilot Tool (included in cleaning kit) is not available, use a No. 16189 Nozzle Protector Cap found on every new or replacement nozzle.
   b. Position a new carbon stop seal (Figure 16-B) on pilot tool. Use a new seal washer (Figure 16-A) to help slide the carbon seal into place until it seats in its groove on nozzle body.
   c. Continue to slide upper sealing washer onto nozzle body until it seats against inlet fitting.

6. Install injection nozzles:

NOTE: *Before installing injection nozzles, make sure nozzles are clean and free from oil or grease. Do not grease or oil the nozzles.*

   a. Remove plug (if installed previously) from nozzle bore in cylinder head and blow out bore with compressed air.
   b. Make sure that the sealing surface of the cylinder head (on which the seal washer will be resting) is smooth and free of damage or dirt. This could prevent proper sealing. Dirt and roughness could also cause distortion to nozzle when the attaching screw is tightened, making the valve stick.
   c. Install nozzle in cylinder head using a slight twisting motion as nozzle is seated in bore.
   d. Install spacer and cap screw. Do not tighten capscrew at this stage.

Install injection nozzles *(continued)*:

Figure 17: *Shows relationship of parts required for installation.*

e. Connect fuel pressure line to nozzle. Leave connection slightly loose until air is bled from system.
f. Tighten nozzle hold-down cap screws to 27 foot lb. (37 N• m).
g. Install leak-off assembly.
h. Bleed air from loose injection line connection. Tighten connection using two wrenches.

SP12. INJECTION PUMP

1. Since operating conditions may vary considerably, it is difficult to give a definite service interval. But, as a rule, the pump settings, maximum speed, idle speed and exhaust smoke should be checked by your dealer after every 2400 hours of operation. Service of the fuel injection pump should only be done if checks indicate pump malfunction.
2. Black smoke can be an indication of pump malfunctions. Before servicing pump, check the other possible causes.
   a. Check cleanliness of air filter.
   b. Check valve clearances.
   c. Clean and check injectors.
3. Any repair which involves disassembly of the injection pump must be carried out by specially-trained mechanics with the proper tools and test devices.

NOTE: *All warranties on the engine become null and void if the injection pump seals are broken by unauthorized persons.*

INJECTION PUMPS – REMOVAL

1. Clean the fuel injection pump, lines and area around the pump with cleaning solvent or a steam cleaner.

   IMPORTANT: *Never steam clean or pour cold water on a fuel injection pump while the pump is running or while it is warm. Doing so may cause seizure of internal rotating pump parts.*

2. Rotate the engine to TDC (Top Dead Center) of number 1 cylinder compression stroke and install the (JDG1511) timing pin into the flywheel.
3. Install the injection pump timing pin (JDG1559) into the pin bore of the injection pump (Fig. 19A) before removing the pump from the engine.

   IMPORTANT: *Always use a backup wrench when loosening or tightening fuel lines at injection pump so that discharge fittings are not altered which will prevent internal pump damage.*

4. Remove the injection pump drive gear cover. Then remove the gear retaining nut and washer from the end of the pump shaft. Do not let the washer fall inside the timing gear cover.

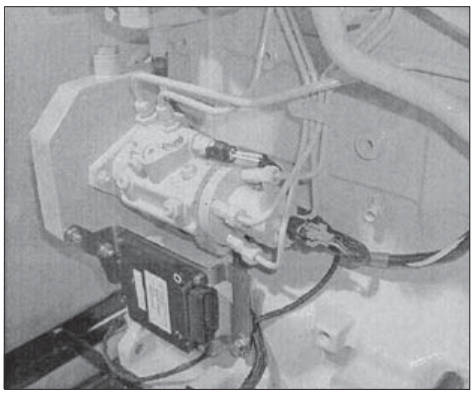


Figure 18
RG12002

INJECTION PUMPS – REMOVAL *CONTINUED*

5. Attach the drive gear puller (JDG1560) to the injection pump drive gear (Fig. 20 B) using two screws (C). Tighten the screws evenly and tighten the center forcing screw (D) against the end of the pump shaft.
6. Tighten the center forcing screw (Fig. 20 D) until the pump drive gear is free from the tapered shaft. Then remove the puller (JDG1560) from the drive gear.

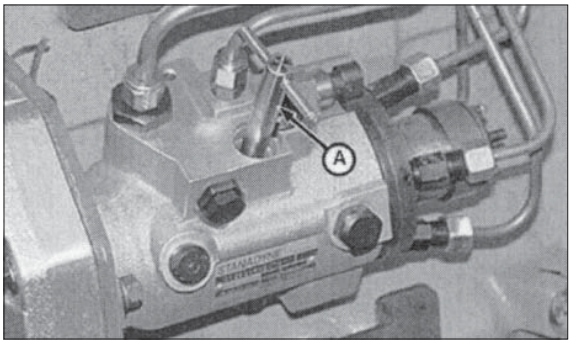


Figure 19
RG12036

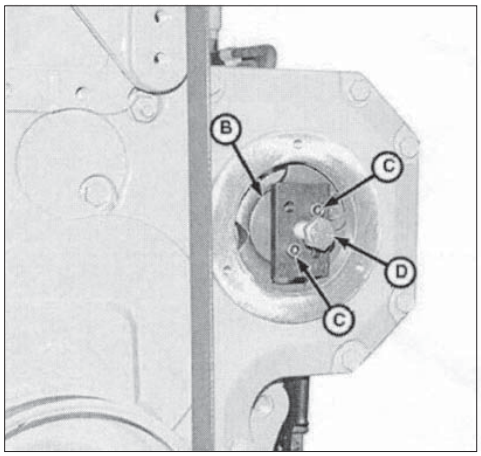


Figure 20
RG12000

7. Remove the temperature sensor connector (Fig. 21 A) and the fuel control solenoid connector (B).

   IMPORTANT: *Always use a backup wrench when loosening or tightening fuel delivery lines at fuel injection pump, so that the pump discharge fittings are not altered. This prevents possible internal pump damage.*

8. Disconnect the fuel supply line (Fig. 21 D) and return line (C). Remove the clamp (E) holding the fuel delivery (pressure) lines (F).

9. Disconnect all the fuel delivery lines (Fig. 21 F) from the injection pump and install protective caps.

10. Remove the three injection pump mounting stud nuts (Fig. 21 G). Remove the pump and place it on a clean level surface and with good lighting inspect the shaft outside diameter for metal transfer caused by gear slippage. Inspect the inside diameter of the injection pump drive gear for the same. If there is evidence of metal transfer on the pump shaft OD or the drive gear ID, the injection pump and drive gear must be replaced.
    Note: The tapered surfaces of the pump drive shaft OD and drive gear ID must be clean of oil or protective coatings when replacing the injection pump drive gear or installing a new pump. Use a cleaner that does not leave a residue. Mating surfaces must be assembled dry and lubricants must not be used.

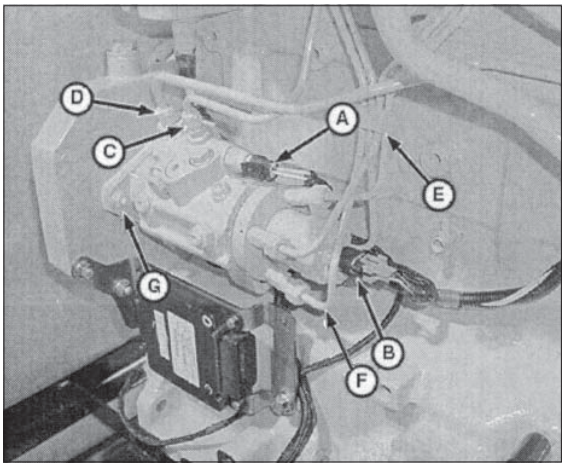


Figure 21
RG12001

INJECTION PUMPS – INSTALLATION

1. Place an injection pump timing pin, JDG1559 (Fig. 22 A) into the pump timing pin bore before installing the injection pump. Insert a small punch or screw driver into the hole on the pump drive shaft (B) until the timing pin drops into the recess in the injection pump drive shaft.

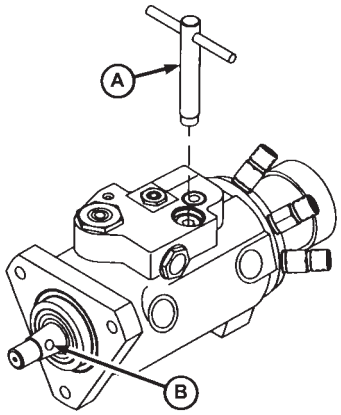


Figure 22
RG12019

Note: *When rotating engine to Top Dead Center of compression stroke on number 1 cylinder, turn engine only in direction of rotation to prevent gear backlash. Poor engine performance could result if gear backlash occurs and throws the injection pump timing off by several degrees.*

2. Make sure that the number 1 cylinder is locked at the TDC of the compression stroke and install a timing pin (JDG1571) in the flywheel. Also leave the injection pump timing pin (JDG1559) in during pump installation (Fig. 19 A).
3. Install the pump onto the mounting studs and tighten the three pump mounting stud nuts (Fig. 23 A) to below specification. Position the drive gear while installing the pump.

Injection Pump Stud Nuts Torque ..... 25 N•m (19 ft-lb)

4. Install injection pump gear (Fig. 24 D) on the drive shaft. Install the injection pump gear mounting nut (C) but do not tighten it yet.

Note: Prevent the injection pump gear from rotating by holding it while applying torque.

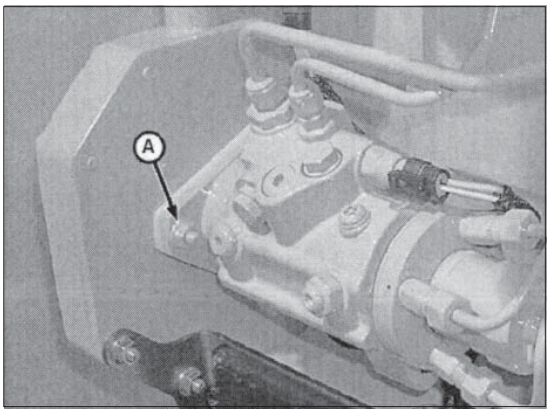


Figure 23
RG12004

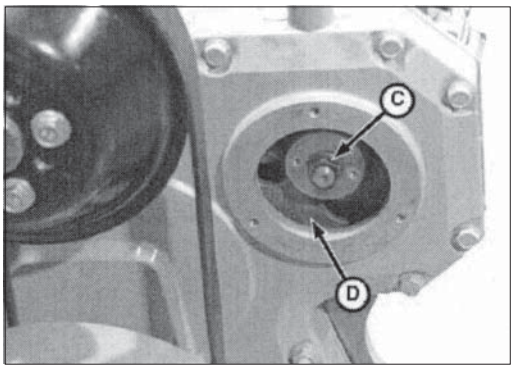


Figure 24
RG12008

5. Rotate the gear counterclockwise (as viewed from front of the engine) to remove any backlash, and tighten the gear mounting nut to below specification.

Injection Pump Gear Mounting Nut Torque:
195 N•m (145 ft-lb)

6. Install the injection pump gear access plate and remove timing pin (Fig. 19 A) from the pump. Install a plug in the injection pump timing pin hole and tighten to below specification.

Pump Timing Pin Plug Torque.....9.5 N•m (7.5 ft-lb)

7. Remove the timing pin from the flywheel.

INJECTION PUMPS – INSTALLATION *Continued*

8. Connect the injection pump fuel delivery (pressure) lines (Fig. 21 F). Begin with the outlet connection to No. 1 cylinder (Fig. 25 I) and continue around the pump head in a counterclockwise direction. Attach lines in the same order as the engine firing (1-5-3-6-2-4 on 6 cylinder engines).

Important: Always use a back-up wrench when loosening or tightening fuel delivery lines at fuel injection pump so that the pump discharge fittings are not altered. This prevents possible internal pump damage.

9. Tighten fuel delivery lines at the pump to below specification.

Fuel Delivery Lines Torque.....27 N•m (20 ft-lb)

10. Put the clamp back (Fig. 21 E).

11. Connect the fuel supply line (Fig. 21 D) and fuel return line (C).

12. Install the temperature sensor connector (Fig. 21A) and fuel control solenoid connector (B).

13. Bleed the air from the fuel system. Start the engine and run it for several minutes and then check the entire fuel system for leaks.

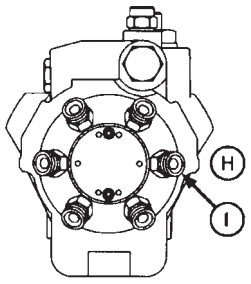


Figure 25

RG12035 H = Engine Block Side
I = Outlet Connection fo No. 1 Cylinder

SP13. TURBOCHARGER

1. Check for air leaks every 200 (100 for electronically controlled fuel system engines) hours. Air leakage will lower engine output and may cause black exhaust smoke and soot.
2. Listen along air line while engine is running. A whistling or hissing sound indicates leakage.
3. Leakage on the pressure side, between turbo and engine, can be found by applying soapy water to the air line.
4. Tighten the hose clamps, replace hose or gaskets as required.
5. Check to see that the lubrication and cooling lines are tight and without leaks.

SP14. TURBO BOOST

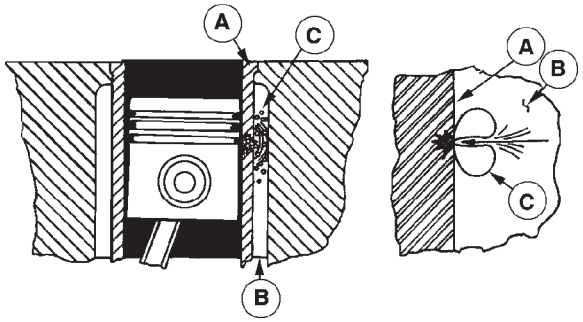
1. This check measures the amount of air the turbo is pushing into the engine. It should be done by an authorized dealer every 600 hours (500 hours for electronically controlled fuel system engines).
2. On the inlet manifold there is a 1/8" NPT threaded port. Remove the plug and install the boost gauge hose. Refer to your engine specifications for correct pressure.

COOLING REQUIREMENTS

1. To meet cooling system protection requirements, the coolant solution must consist of:
   a. Quality water
   b. Ethylene glycol concentrate (EGC) commonly known as antifreeze.
   c. Supplemental coolant additives (SCA's).
2. A coolant solution of ethylene glycol concentrate (EGC-antifreeze), quality water and supplemental coolant additives (SCA's) ***MUST*** be used ***YEAR ROUND*** to protect against freezing, boil-over, liner erosion or pitting and to provide a stable, non-corrosive environment for cooling system components.
3. **Ethylene glycol coolant concentrate (antifreeze) normally DOES NOT contain the SCA chemical inhibitors needed to control liner pitting or erosion, rust, scale, and acidity.**

LINER EROSION (PITTING)

1. Cylinder liner walls (Figure 26-A) which are in contact with engine coolant (Figure 26-B) can be eroded or pitted unless the proper concentration and type of SCA's are present in the coolant. Water pump impellers are also susceptible to pitting.
2. Vapor bubbles (Figure 26-C) are formed when the piston's impact causes the liner walls to vibrate, sending pressure waves into the coolant.
3. These tiny vapor bubbles collect on the surface of metal parts. As the bubbles collapse (pop) a microscopic piece of metal is eroded from the metal part. Over a period of time, this pitting may progress completely through the cylinder liner of a wet-sleeve, heavy-duty diesel engine. This allows coolant to enter the combustion chamber. Engine failure or other serious damage will result.



A - Cylinder Liner Walls **B** - Engine Coolant **C** - Vapor Bubbles

Figure 26

4. Unprotected engines with low quality water as coolant can have liner failure in as few as 500 hours.

WATER QUALITY

1. Distilled, de-ionized, soft water is preferred for use in cooling systems. Bottled distilled water from a food store or water supplier is recommended. Tap water often has a high mineral content. Tap water should NEVER be put in a cooling system unless first tested by a water quality laboratory. Do not use water made by the reverse osmosis method unless it has been PH neutralized.

2. Here are acceptable water quality specifications:

Contaminates	Parts per Million	Grains per Gallon
Maximum Chlorides	40	2.5
Maximum Sulfates	100	5.9
Maximum Dissolved Solids	340	20.0
Maximum Total Hardness	170	10.0
		PH Level 5.5 to 9.0

3. If chlorides, sulfates or total dissolved solids are higher than the above given specification, the water must be distilled, demineralized, or deionized before it is used in a cooling system.
4. If total hardness is higher than 170 ppm and all other parameters are within the given specifications, the water must be softened before it is used to make coolant solution.

EGC: ETHYLENE GLYCOL CONCENTRATE (ANTIFREEZE)

CAUTION: *EGC (Antifreeze) is flammable. Keep it away from any open flame. Avoid contact with eyes. Avoid contact with skin. Do not take internally. In case of contact, immediately wash skin with soap and water. For eyes, flush with large amounts of water for at least 15 minutes. Call a physician. KEEP OUT OF REACH OF CHILDREN. Follow all warnings on the container.*

1. Ethylene glycol coolant concentrate is commonly mixed with water to produce an engine coolant with a low freeze point and high boiling point.
2. A ***low silicate*** form of ethylene glycol coolant is recommended for all diesel engines.
3. Use an ethylene glycol coolant concentrate meeting ASTM D 4985P, SAEJ1941, General Motors Performance Specification GM1899M, or formulated to GM6038M.
4. This product is concentrated and should be mixed to the following specification.
5. If additional coolant solution needs to be added to the engine due to leaks or loss, the glycol concentration should be checked with a hydrometer to assure that the desired freeze point is maintained.

	Distilled Water %	EGC % Antifreeze	Freeze Point	Boiling Point
Optimum	50%	50%	-37°C -34°F	+109°C +226°F
Minimum	60%	40%	-24°C -12°F	+106°C +222°F
Maximum	40%	60%	-52°C -62°F	+111°C +232°F

IMPORTANT

1. **DO NOT** use methyl alcohol or methoxy propanol base EGC. These concentrates are not compatible with chemicals used in supplemental coolant additives. Damage can occur to rubber seals on cylinder liners which are in contact with coolant.
2. **DO NOT** use an EGC containing sealer or stop-leak additives.
3. **DO NOT** use EGC containing more than 0.1% anhydrous metasilicate. This type of concentrate, which is intended for use in aluminum engines, may cause a gel-like deposit to form that reduces heat transfer and coolant flow. Check container label or consult with supplier.

SUPPLEMENTAL COOLANT ADDITIVE (SCA)

CAUTION: *Supplemental coolant additive contains alkali. Avoid contact with eyes. Avoid contact with skin. Do not take internally. In case of contact immediately wash skin with soap and water. For eyes, flush with large amounts of water for at least 15 minutes. Call a physician. KEEP OUT OF REACH OF CHILDREN. Follow all warnings on the container.*

1. ***Important heat exchanger cooled engines***
   Additional SCA's should NOT be added to the mixture of EGC/H_20 on initial fill up of engines with a coolant conditioner-filter. A high SCA concentration will result and can cause silicate-dropout. When this happens, a gel-type deposit is created in the cooling system which retards heat transfer and coolant flow.
2. If additional SCA's are needed, prepare a mixture of 50% quality water and 50%EGC (antifreeze). Add liquid SCA at a rate of 3%, by volume.
   Example: 30 mL of SCA per liter of H_2O/EGC mixture (1.0 fl oz of SCA per qt of H_2O/EGC).
   Add the resulting mixture to the cooling system in quart increments. Run the engine for 2 hours and retest the coolant. Continue process until SCA concentration meets recommended levels.
3. SCA is available from your Northern Lights dealer in the following sizes.
   Pint - Part Number.....20-00002
   1/2 gallon - Part Number.....20-00003
4. ***DO NOT*** *use any coolant system additives containing soluble oil.*

COOLANT TESTING

1. Coolant test kits are available to allow on-site evaluation of the coolant condition.
2. The kits use small strips of paper which are dipped into the coolant. The paper changes color and indicates the SCA concentration. It also indicates the amount of EGC (antifreeze).
3. Test kits are available through your Northern Lights or Lugger Dealer.
   4 Pack - Part Number.....20-00005
   50 Pack - Part Number.....20-00010

SP15. CHECKING COOLANT LEVEL

CAUTION: *The cooling water in the engine reaches extremely high temperatures. You must use extreme caution when working on hot engines to avoid burns. Allow the engine to cool before working on the cooling system. Open the filler cap carefully, using protective clothing when the engine is warm.*

1. Check the coolant level each day before starting the engine.
2. Remove the pressure cap from the expansion tank and check water level. In order to give the coolant an opportunity to expand, the level should be about 1 3/4 in. (4-5 cm) below the filler cap sealing surface when the engine is cold. When filling with coolant, the venting cock on top of the turbocharger (for engines fitted with turbocharger) should be opened to ensure that no air pockets form in the cooling system.
2. The pressure valve in the filler cap releases when the pressure is approximately 7 PSI (0.5 bar). Use a cap pressure tester to check cap if you suspect it is faulty.
4. The makeup coolant, added to compensate for loss or leaks, must meet engine coolant requirements outlined in previous section.

SP16. FLUSHING THE COOLING SYSTEM

CAUTION: *The cooling water in the engine reaches extremely high temperatures. You must use extreme caution when working on hot engines to avoid burns. Allow the engine to cool before working on the cooling system. Open the filler cap carefully, using protective clothing when the engine is warm.*

1. Flush the cooling system and check for leaks and blockage every 600 hours, or yearly. **The engine must be stopped and cold.**
2. Close the seacock.
3. Remove the pressure cap from the expansion tank with caution. If applicable, open the cooling system air vent on top of turbocharger.
4. Open the drains on the exhaust manifold and engine block. Drain the fresh water system (see Component Locations, page 4).
5. For vessels with keel cooling, the vessel must be out of the water to allow draining of the keel cooler.
6. With drains open, pour clean water into the expansion tank. When the water from drain is clear and free from discoloration and sediment, close that drain. When all drains are closed, flushing is complete.
7. Fill the fresh water system by pouring the recommended coolant mixture as described in previous sections.
8. Close cooling system air vent on turbocharger.
9. Open the seacock.
10. Start the engine. Check hoses and connections and repair any leakage.

SP17. HEAT EXCHANGER CLEANING (If applicable)

1. Drain the cooling system.
2. Remove the cooling water pipes between the heat exchanger and the water pump inlet.
3. Disconnect hose to seawater pump.
4. Unscrew the attaching bolts holding the heat exchanger to the expansion tank.
5. Remove bolts holding heat exchanger cover.
6. Wash the core inside and out. If necessary, chemical agents can be used. Also clean the accessible parts of the heat exchanger housing.
7. Reassemble, using new gaskets and sealing rings.

SP19. ZINC ANODES

1. Zincs are installed in the cooling system to protect your engine from electrolysis. Check them faithfully every 250 hours. If you are in warm salt water or where electrolysis is a known problem, check them more often.

Heat exchanger cooled engine:

a. Drain the raw water from heat exchanger (see Component Locations).
b. Remove zinc holders from back of the tank and from front and port side of the heat exchanger (see Component Locations).

Keel Cooled engines.

a. Drain expansion tank and remove zinc holder from tank (see Component Locations).

2. Scrape or steel brush the zinc electrode clean. If more than 50% of the electrode has eroded away, replace it with a new one. The electrode screws out of the holder.
3. Reinstall the zinc holders. Be sure the threads are clean and have good metal to metal contact.

SP20. RAW WATER PUMP

Heat exchanged cooled engines only.

1. Change the sea water pump impeller as needed.
2. Remove the pump end cover. Remove impeller with water pump pliers. Be sure you remove all pieces of a failed impeller.
3. Clean the inside of the housing.
4. Press in the new impeller and place the sealing washer in the outer end of the impeller center if this has not already been done.
5. Replace the cover using a new gasket.

Note: *Make sure there is always an extra impeller and cover gasket in reserve and on-board.*

DRIVEN EQUIPMENT

Gears and PTO's

1. Manufacturer's service recommendations vary. See your Owner's Manual for service information. If you do not have a manual, see your local dealer for the equipment in question.

NOTE: *Some PTO and marine gears have rigid lubrication requirements. Follow service recommendations closely.*

ELECTRICAL SYSTEM - GENERAL

1. Never switch battery switch off or break the circuit between the alternator and batteries while the engine is running. Regulator damage can result.
2. DO NOT reverse the polarity of battery cables when installing the battery.
3. When welding on the unit, disconnect the regulator and battery. Isolate the leads.
4. Disconnect battery cables when servicing the DC alternator.
5. Never test with a screwdriver, etc., against any terminal to see if it emits sparks.
6. A DC circuit breaker protects your control panel and wiring harness.

BOOSTER BATTERIES

CAUTION: *Battery Gas Can Explode. Keep all flames and sparks away from batteries.*

1. Before changing or using booster batteries, check battery electrolyte level. Add distilled water.
2. Booster and main batteries must have the same voltage rating.
3. First, connect positive (+) terminal of booster battery to positive (+) terminal of main battery.

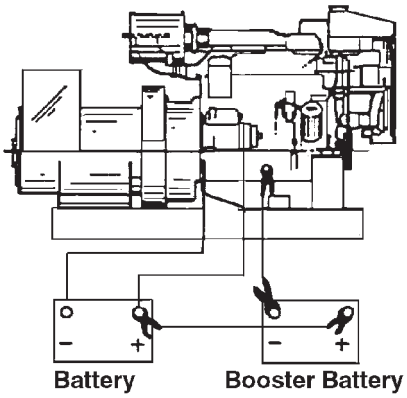


Figure 27: *Booster Battery Connections*

4. Then, connect negative (-) terminal of booster battery to ground on the engine block (see Figure 27).
5. Remove booster battery after starting engine.
6. Sealed batteries: see manufacturer charging and booster instructions.

SP21-22. BATTERY CARE - LEAD/ACID TYPE BATTERIES

1. Check electrolyte level every 50 hours or once per month. Add distilled water to manufacturer's recommended level.
2. Batteries, cables and cable terminals should be checked and cleaned every 100 hours. Clean corrosion with a water and baking soda solution. Flush with clean water. Tighten terminals and grease them to inhibit corrosion.
3. Check the battery condition with a hydrometer every 750 hours.

SP24. WINTERIZING, OUT-OF-SERVICE

If the generator set will not be used for more than 6 months the following preparations should be taken for long term storage.

1. Change the engine oil and replace the filter. Service the air cleaner.
2. Drain, flush, and refill the cooling system.
3. Crank the engine a few times with a starter, without starting the engine.
4. Remove and clean batteries.
5. All engine openings should be sealed with plastic bags and tape.
6. Store in a dry protected place.

To Remove Generator Set from Long-Term Storage:

1. Take off all protective coverings and unseal all the openings that were covered up.
2. Install batteries that are fully charged and connect the terminals.
3. Install the fan and alternator belts if they had been removed.
4. Fill the fuel tank.
5. Perform all pre-start checks.
6. Crank the engine for 20 seconds with the starter, without letting the engine start. Wait 2 minutes and crank the engine an additional 20 seconds to make sure all bearing surfaces are well coated.
7. Start the engine and run at no load in a low idle for several minutes. Make sure the engine is warmed up and check gauges before going under load.
8. Check all gauges and check for leaks.

If you cannot correct problems with these procedures, see your **Lugger or Northern Lights** dealer.

DC ELECTRICAL SYSTEM

✔ Battery Will Not Charge

Loose or corroded connections:
- Clean and tighten battery connections.

Sulfated or worn out batteries:
- Check specific gravity of each battery cell.
- Check electrolyte level of each battery cell.

Loose or defective alternator belt:
- Adjust belt tension.
- Replace belt.

✔ Undercharged Electrical System

Excessive electrical load from added accessories:
- Take off accessories or install higher output alternator.

Engine idling excessively.
- Increase the engine RPM when there is a heavy electrical load.

Poor electrical connections on battery, ground strap, starter, or alternator.
- Inspect connections and clean if necessary.

Defective battery.
- Test battery.

Battery charging rate too high.
- Test charging system.

✔ Starter Inoperative

PTO engaged.
- Disengage PTO.

Check DC circuit breaker:
- If the breaker is tripped, reset it.

Faulty start circuit relay.
- See dealer.

Blown main system fuse.
- Replace fuse.

Loose or corroded connections:
- Clean and tighten loose battery and harness plug connection.

Low battery output:
- Check specific gravity of each battery cell.
- Check electrolyte level of each battery cell.

Defective electrical system ground wire:
- Repair or replace.

✔ Starter Cranks Slowly

Low battery output:
- Battery is too small.
- Battery cables are too small.

Check specific gravity of each battery cell:
- Replace battery if necessary.

Check electrolyte level of each battery cell:
- If low, fill cells with distilled water.

Crankcase oil too heavy:
- Fill with oil of appropriate viscosity.

Loose or corroded connections:
- Clean and tighten loose connections.

✔ Starter and Hour Meter Function but rest of Electrical System Does Not Function

Blown fuse on magnetic switch.
- Replace fuse.

✔ Entire Electrical System Does Not Function

Check DC circuit breaker:
- If breaker is tripped, reset it.

Faulty connection:
- Clean and tighten battery and harness plug connections.

Sulfated or worn out batteries:
- Check specific gravity and electrolyte level of each battery cell.

ENGINE

✔ Engine Hard to Start or Will Not Start

Engine starting under load.
- Disengage PTO if applicable.

Improper starting procedure:
- See starting section of this manual. Take special note of Bypass Switch operation.

No fuel:
- Check level of fuel in fuel tank.

Low battery output:
- Check electrolyte level and condition.

Excessive resistance in starting circuit:
- Clean and tighten all battery connections.

Crankcase oil too heavy:
- Use oil of proper viscosity.

Improper type of fuel:
- Consult fuel supplier and use proper type of fuel for operating condition.

Water, dirt or air in fuel system:
- Drain, flush, fill and bleed system.

Clogged primary fuel filter element:
- Clean or replace filter element.

Clogged secondary fuel filter element:
- Replace filter element.

Dirty or faulty injection nozzles:
- Have your dealer check injection nozzles.

Electronic Fuel System problem (if equipped):
- See your dealer.

Injection pump not getting fuel or air in fuel system.
- Check fuel flow at supply pump or bleed fuel system.

Troubleshooting

If you cannot correct problems with these procedures, see your **Lugger or Northern Lights** dealer.

✔ Engine Runs Irregularly or Stalls Frequently

Below normal engine temperature:
- Remove and check thermostat.

Clogged primary fuel filter element:
- Clean or replace filter element.

Clogged secondary fuel filter element:
- Replace secondary filter element.

Water or dirt in the fuel system:
- Drain, flush, fill and bleed system.

Dirty or faulty injection nozzles:
- Have your dealer check injection nozzles.

Air in fuel system:
- Inspect clamps and hoses on suction side of fuel pump for air leak, bleed fuel system.

Improper type of fuel:
- Consult fuel supplier and use proper type of fuel for operating condition.

✔ Lack of Engine Power

Intake air restriction:
- Service air cleaner.
- Service aftercooler.

Clogged primary fuel filter element:
- Clean or replace filter element.

Clogged secondary fuel filter element:
- Replace filter element.

Improper type of fuel:
- Consult fuel supplier and use proper type of fuel for operating conditions.

Overheated engine:
- See “Engine Overheats” in next category.

Below normal engine temperature:
- Remove and check thermostat.

Injection pump out of time.
- See your dealer.

Electronic fuel system problem.
- See your dealer.

Turbocharger not functioning (if equipped).
- See your dealer.

Leaking exhaust manifold gasket.
- See your dealer.

Defective aneroid control line.
- See your dealer.

Restricted fuel hose.
- Clean or replace fuel hose.

Low fast idle speed.
- See your dealer.

Improper valve clearance:
- Reset valves. Best done by dealer.

Dirty or faulty injection nozzles:
- Replace injectors. Best done by dealer.
- See your local dealer.

✔ Engine Overheats

Engine overloaded.
- Reduce the load.

Low coolant level:
- Fill tank or radiator to proper level.
- Check hoses for loose connections and leaks.

Keel cooling tubes have been painted (marine):
- Remove paint from tubes.

Faulty radiator cap.
- Have technician check.

Stretched belt or defective belt tensioner.
- Check automatic belt tensioner and check belts for stretching. Replace as required.

Low engine oil level.
- Check oil level, add oil as needed.

Incorrect grade of fuel.
- Use correct grade of fuel.

Cooling system needs flushing:
- Flush cooling system.

Defective thermostat:
- Remove and check thermostat.

Defective temperature gauge:
- Check water temperature with thermometer and replace gauge if necessary.

Water pump impeller worn/broken:
- Check impeller and replace if necessary.

✔ Engine Knocks

Low oil level:
- Add oil to engine crankcase.

Injection pump out of time:
- Call your dealer.

Below normal engine temperature:
- Check your thermostats.
- Check water temperature to see if temperature gauge is working properly.

Engine overheating:
- See “Engine Overheating” section.

If you cannot correct problems with these procedures, see your **Lugger or Northern Lights** dealer.

✔ High Fuel Consumption

Engine overloaded.
- Reduce load.

Air in fuel system:
- Bleed fuel system.

Improper type of fuel:
- Use correct fuel for temperature.

Clogged or dirty air cleaner:
- Service air cleaner.

Improper valve clearance:
- See your dealer.

Injection nozzles dirty:
- See your dealer.

Injection pump out of time:
- See your dealer.

Electronic fuel system problem.
- See your dealer.

Engine not at proper temperature:
- Check your thermostats.
- Check water temperature with thermometer and replace gauge if necessary.

✔ Below Normal Engine Temperature

Thermostats not working properly:
- Check thermostats.

Temperature gauge not working properly:
- Check water temperature with thermometer.

✔ Low Oil Pressure

Low oil level:
- Fill crankcase to proper level.

Improper type of oil:
- Drain and fill crankcase with correct oil.

Partially plugged oil filter:
- Replace filter.

✔ High Oil Consumption

Break-in period:
- Oil consumption decreases after break in.

Crankcase oil too light:
- Use proper viscosity oil.

Oil leaks:
- Check for leaks in lines around gaskets and drain plug.

✔ Engine Emits Black or Gray Exhaust Smoke

Clogged or dirty air cleaner:
- Service air cleaner.

Clogged aftercooler:
- Service aftercooler.

Defective muffler (back pressure too high):
- Have dealer check back pressure.

Improper fuel:
- Use correct fuel for temperature.

Engine overloaded.
- Reduce load.

Electronic fuel system problem.
- See your dealer.

Turbocharger not functioning.
- See your dealer.

Injection nozzles dirty:
- See your dealer.

Engine out of time:
- See your dealer.

✔ Engine Emits White Smoke

Improper fuel:
- Use correct fuel for temperature.

Cold engine:
- Warm up engine to normal operating temperature.

Defective thermostat:
- Remove and check thermostat.

Engine out of time:
- See your dealer.

Defective injection nozzles.
- See your dealer.

Specifications L1064

Model Number	L1064D	L1064T1	L1064A
Crankshaft Hp[1] @ High Output/			140 @ 2400 RPM/
Medium Duty/ Continuous Duty	67 @ 2500 RPM	100 @ 2500 RPM	125 @ 2200 RPM/ 115 @ 2000 RPM
Crankshaft kW[2] @ High Output/			104 @ 2400 RPM/
Medium Duty/ Continuous Duty	50 @ 2500 RPM	75 @ 2500 RPM	93 @ 2200 RPM/ 85 @ 2000 RPM

1. Based on SAE J816b. 2. Based on EN ISO 8665: 2006.

Cooling (General)			
Freshwater circulating pump flow	54 US gal @ 2500 rpm (204 ltr @ 2500 rpm)	53 US gal @ 2500 (200 ltr @ 2500 rpm)	51 US gal @ 2400 rpm (192 ltr @ 2400 rpm)
Heat rejection to jacket water	3415 BTU-min	3465 BTU-min	6147 BTU-min
Cooling (Heat Exchanger)			
Raw water intake & discharge dia.	1.25 inch	1.25 inch	2.0 inch NPT
Raw water pump flow @ RPM	31 gpm @ 2500 rpm (117 ℓ pm @ 2500 rpm)	31 gpm @ 2500 rpm (117 ℓ pm @ 2500 rpm)	53 gpm @ 2400 rpm (200 ℓ pm @ 2400 rpm)
Raw water pump max. suction head	39 in (1 m)	39 in (1 m)	39 in (1 m)
Max. raw water temp. at inlet	86° F (30° C)	86° F (30° C)	86° F (30° C)
Freshwater system capacity	5.5 US gal (21 ltr)	5.5 US gal (21 ltr)	5.5 US gal (21 ltr)
Cooling (Keel Cooled)			
Water hose inside diameter	2-3/8 in (60 mm)	2-3/8 in (60 mm)	
Head diameter	1-1/2 in (38 mm)	1-1/2 in (38 mm)	
Turbo tube length*	12 ft (4 m)	18 ft (6 m)	
One inch plain round tube length*	28 ft (8.5 m)	42 ft (12.75 m)	
Skin cooler			
Aluminum*	12 sq ft (1.3 m^2)	18 sq ft (1.65 m^2)	
Steel*	42.5 sq ft (4.0 m^2)	60 sq ft (5.55 m^2)	

**Based on 70° F seawater and minimum boat speed of 8 knots at full speed. Return water on keel cooling 70° to 130° F.*

Electrical			
Minimum battery capacity - 12V	640 CCA	640 CCA	640 CCA
Battery cable size up to 10 ft run	"00"	"00"	"00"
Standard harness length	20 ft (6 m)	20 ft (6 m)	20 ft (6 m)
Air			
Engine air consumption	166 cfm @ 2500 rpm (4.7 m^3/min @ 2500 rpm)	254 cfm @ 2500 rpm (7.2 m^3/min @ 2500 rpm)	360 cfm @ 2400 rpm (10.2 m^3/min @ 2400 rpm)
Minimum engine room vent area	48 sq in (.031 m^2)	73 sq in (.047 m^2)	105 sq in (.068 m^2)
Exhaust gas flow	487 cfm @ 2500 rpm (13.8 m^3/min @ 2500 rpm)	544 cfm @ 2500 rpm (15.3 m^3/min @ 2500 rpm)	858 cfm @ 2400 rpm (24.3 m^3/min @ 2400 rpm)
Exhaust gas temperature at rpm	920° F @ 2500 rpm (493° C @ 2500 rpm)	1184° F @ 2500 rpm (640° C @ 2500 rpm)	887° F @ 2400 rpm (475° C @ 2400 rpm)
Maximum exhaust back pressure	48 in (1219 mm) H_20	30 in (762 mm) H_20	30 in (750 mm) H_20
Suggested dry exhaust I.D.			
Dry	3 in (75 mm)	3 in (75 mm)	3 in (75 mm)
Wet	4 in (100 mm)	5 in (127 mm)	5 in (127 mm)
Fuel and Oil			
Min. fuel suction and return line	3/8 in (9 mm)	3/8 in (9 mm)	3/8 in (9 mm)
Maximum fuel pump head	39 in (1 m)	39 in (1 m)	39 in (1 m)
Crankcase oil capacity	14 US qts (13.2 ltr)	21.7 US qts (20.5 ltr)	21.7 US qts (20.5 ltr)
Gear, PTO, Engine Angle			
Engine rotation (facing flywheel)	Counter-Clockwise	Counter-Clockwise	Counter-Clockwise
Flywheel housing size	SAE #4	SAE #4	SAE #4
Front PTO size (optional)	SAE #5	SAE #5	SAE #5
Max. intermittent operating angle			
Front down	0°	0°	0°
Rear down	12°	12°	12°

Specifications L1066

Model Number	L1066T	L1066A
Crankshaft Hp[1] @ High Output/	170 @ 2500 RPM/	250 @ 2400 RPM/
Medium Duty/ Continuous Duty	165 @ 2400 RPM/ 135 @ 2200 RPM	200 @ 2200 RPM/ 185 @ 2400 RPM
Crankshaft kW[2] @ High Output/	126 @ 2500 RPM/	185 @ 2400 RPM/
Medium Duty/ Continuous Duty	122 @ 2400 RPM/ 100 @ 2200 RPM	148 @ 2200 RPM/ 137 @ 2400 RPM

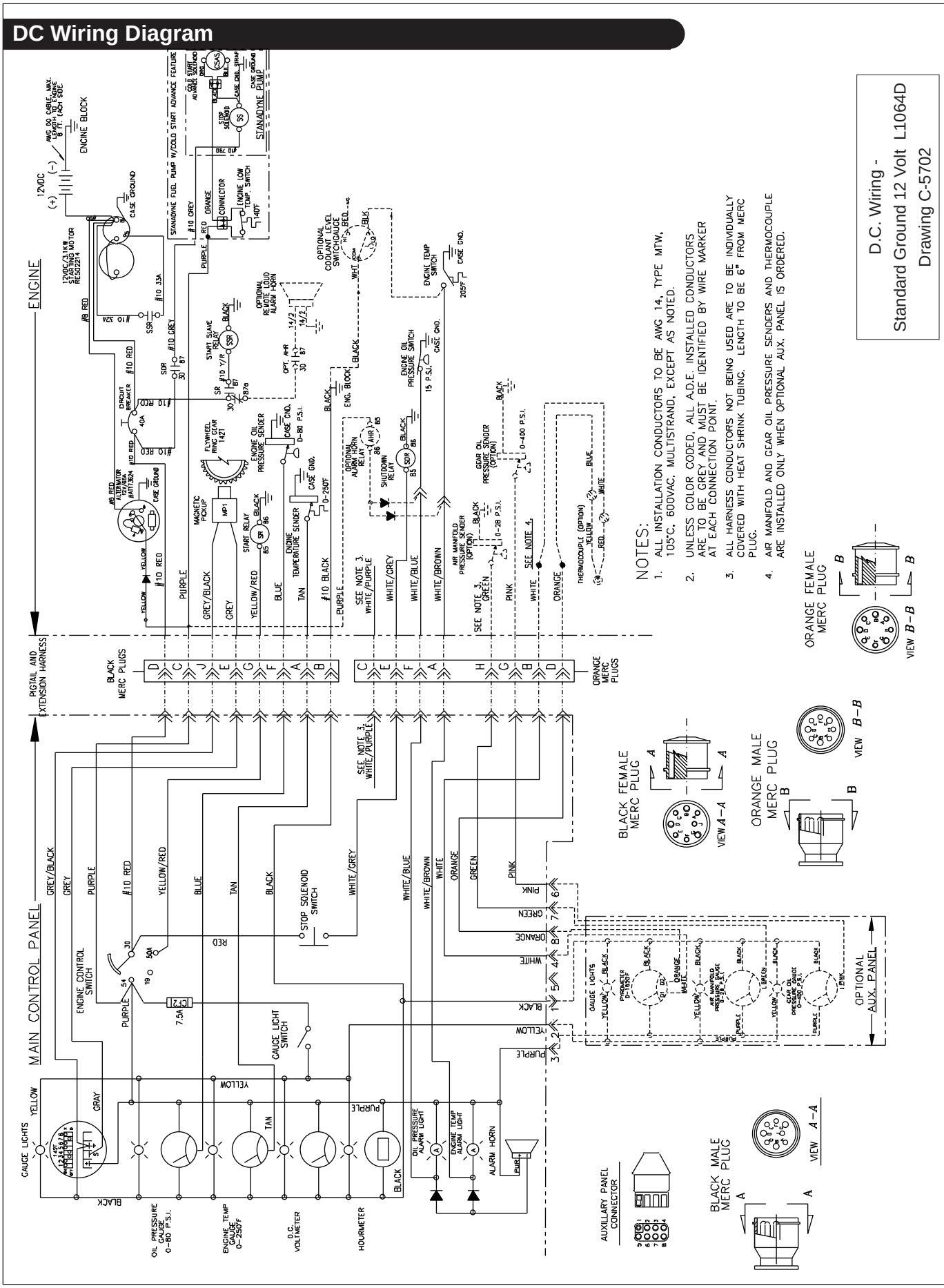
1. Based on SAE J816b. 2. Based on EN ISO 8665: 2006.

Cooling (General)		
Freshwater circulating pump flow	63 US gal @ 2500 rpm (240 ltr @ 2500 rpm)	61 US gal @ 2400 rpm (229 ltr @ 2400 rpm)
Heat rejection to jacket water	5570 BTU-min	5382 BTU-min
Cooling (Heat Exchanger)		
Raw water intake & discharge dia.	1.25 inch NPT	2 inch NPT
Raw water pump flow @ RPM	31 gpm @ 2500 rpm (117 ℓpm @ 2500 rpm)	53 gpm @ 2400 rpm (200 ℓpm @ 2400 rpm)
Raw water pump max. suction head	39 in (1 m)	39 in (1 m)
Max. raw water temp. at inlet	85° F (30° C)	85° F (30° C)
Freshwater system capacity	6.5 US gal (24.6 ltr)	6.5 US gal (24.6 ltr)
Cooling (Keel Cooled)		
Water hose inside diameter	2-3/8 in (60 mm)	
Head diameter	1-1/2 in (38 mm)	
Turbo tube length*	24 ft (7.3 m)	
One inch plain round tube length*	56 ft (17 m)	
Skin cooler		
Aluminum*	26 sq ft (2.4 m^2)	
Steel*	85 sq ft (8.9 m^2)	

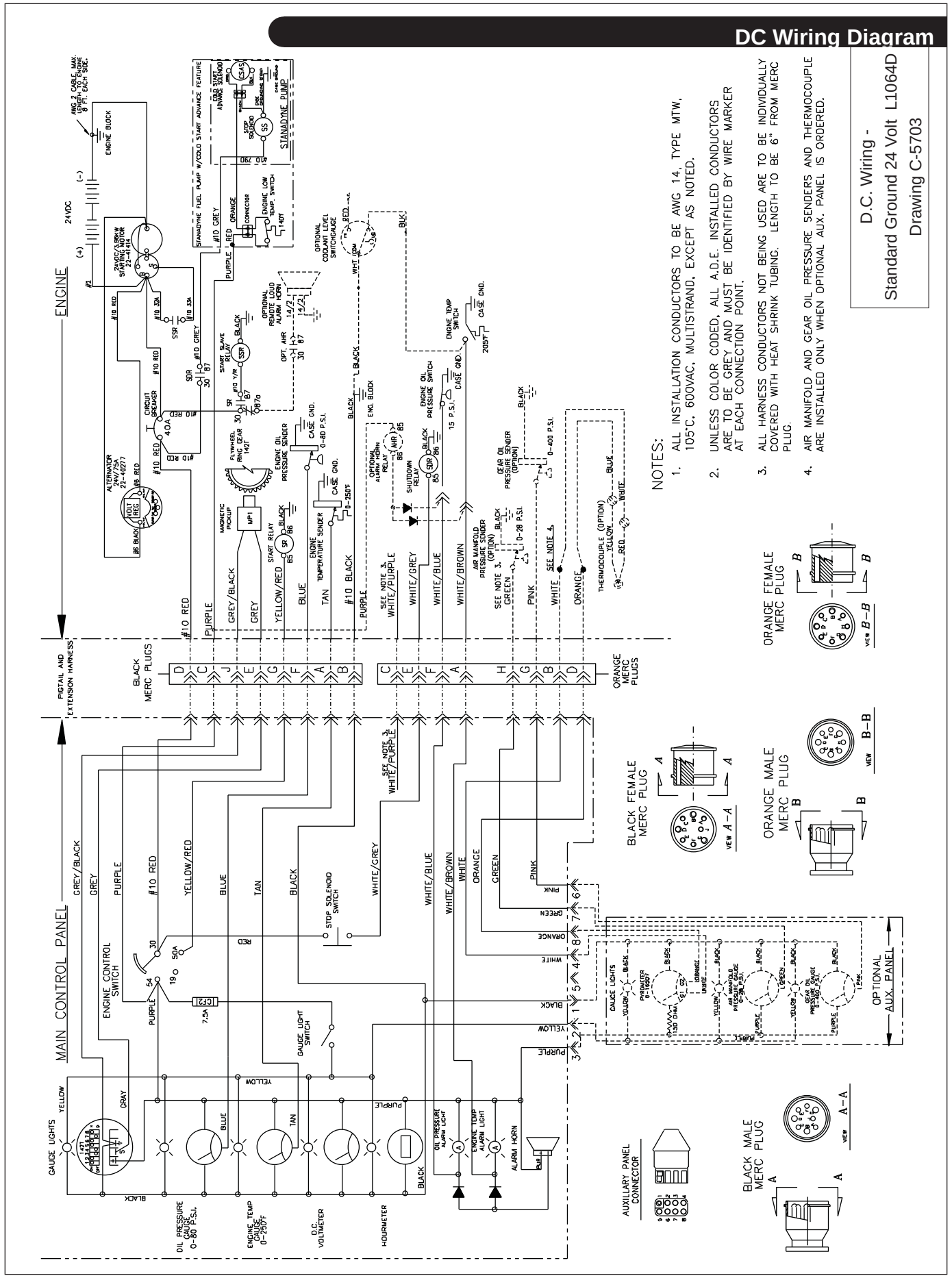
**Based on 70° F seawater and minimum boat speed of 8 knots at full speed. Return water on keel cooling 70° to 130° F.*

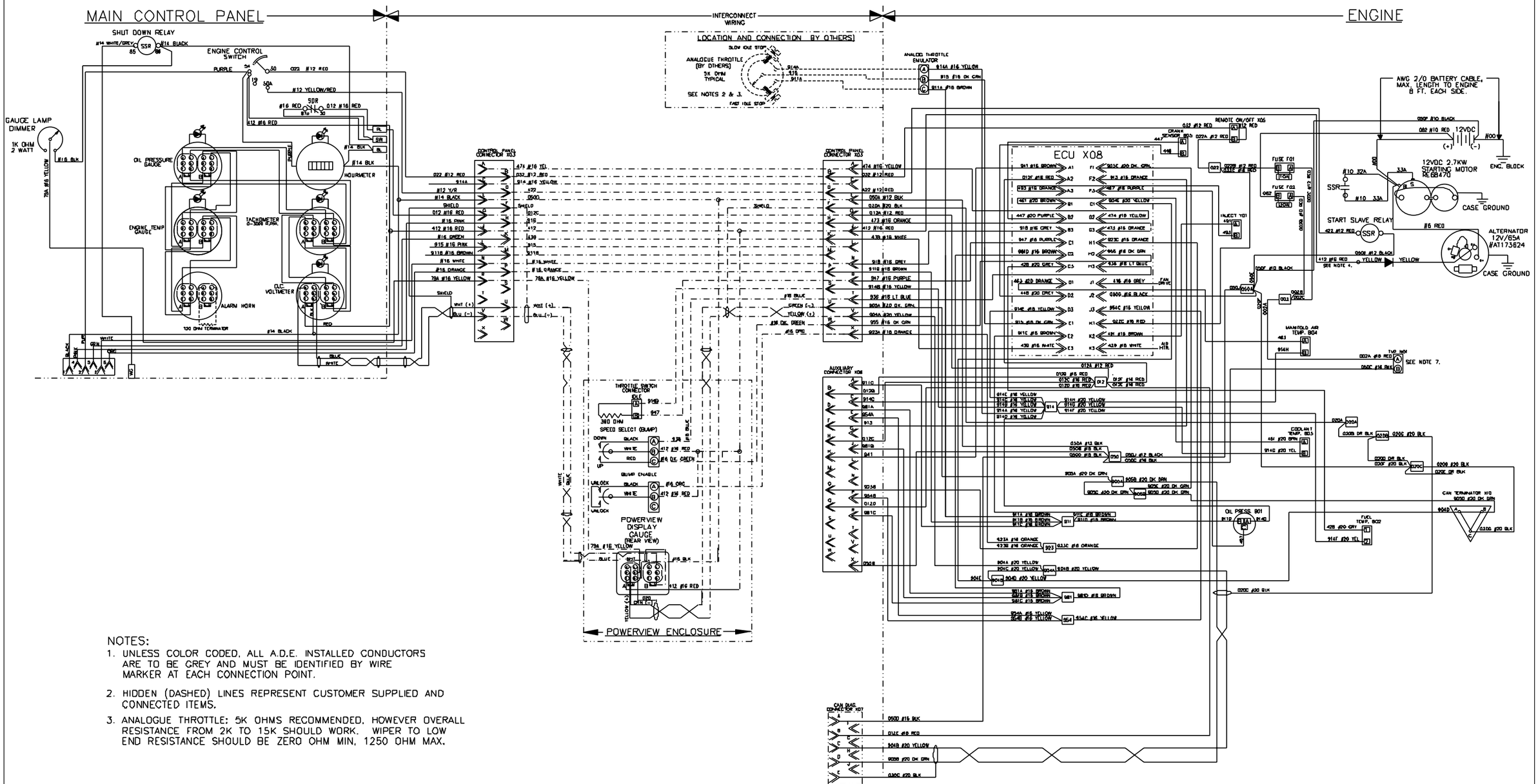
Electrical		
Minimum battery capacity - 12V	800 CCA	800 CCA
Battery cable size up to 10 ft run	“000”	“000”
Standard harness length	20 ft (6 m)	20 ft (6 m)
Air		
Engine air consumption	417 cfm @ 2500 rpm (118 m^3/min @ 2500 rpm)	629 cfm@ 2400 rpm (17.8 m^3/min @ 2400 rpm)
Minimum engine room vent area	113 sq in (.073 m^2)	184 sq in (.012 m^2)
Exhaust gas flow	1038 cfm @ 2500 rpm (29.4 m^3/min @ 2500 rpm)	1465 cfm @ 2400 rpm (41.5 m^3/min @ 2400 rpm)
Exhaust gas temperature at rpm	876° F @ 2500 rpm (469° C @ 2500 rpm)	860° F @ 2400 rpm (460° C @ 2400 rpm)
Maximum exhaust back pressure	30 in (750 mm) H_20	30 in (750 mm) H_20
Suggested dry exhaust I.D.		
Dry	3 in (75 mm)	4 in (100 mm)
Wet	4 in (100 mm)	5 in (127 mm)
Fuel and Oil		
Min. fuel suction and return line	3/8 in (9.5 mm)	3/8 in (9.5 mm)
Maximum fuel pump head	39 in (1 m)	39 in (1 m)
Crankcase oil capacity	19 US qts (18 ltr)	19 US qts (18 ltr)
Gear, PTO, Engine Angle		
Engine rotation (facing flywheel)	Counter-Clockwise	Counter-Clockwise
Flywheel housing size	SAE #2	SAE #2
Front PTO size (optional)	SAE #5	SAE #5
Max. intermittent operating angle		
Front down	0°	0°
Rear down	15°	15°

DC Wiring Diagram



DC Wiring Diagram

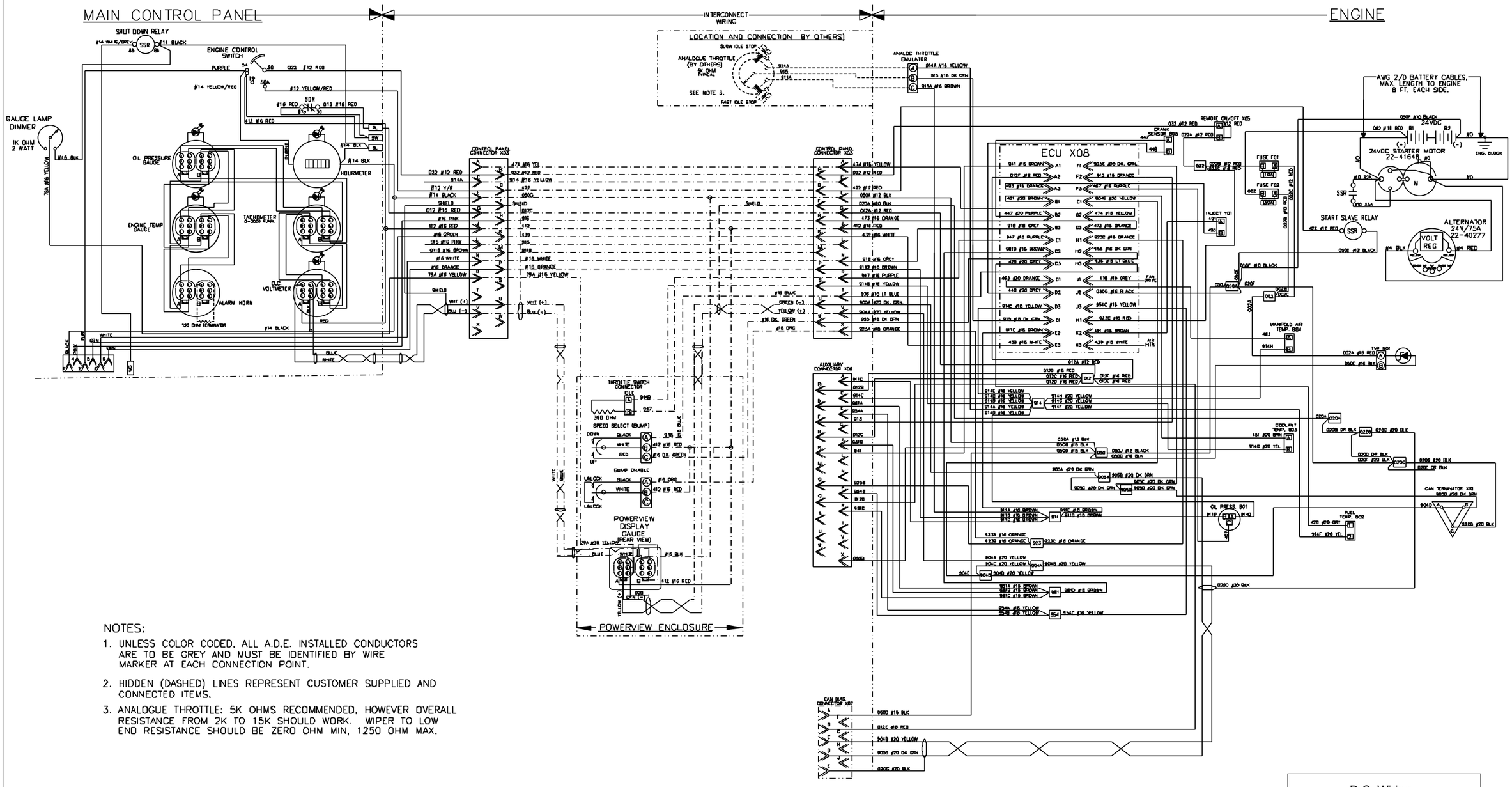




NOTES:

1. UNLESS COLOR CODED, ALL A.D.E. INSTALLED CONDUCTORS ARE TO BE GREY AND MUST BE IDENTIFIED BY WIRE MARKER AT EACH CONNECTION POINT.
2. HIDDEN (DASHED) LINES REPRESENT CUSTOMER SUPPLIED AND CONNECTED ITEMS.
3. ANALOGUE THROTTLE: 5K OHMS RECOMMENDED, HOWEVER OVERALL RESISTANCE FROM 2K TO 15K SHOULD WORK. WIPER TO LOW END RESISTANCE SHOULD BE ZERO OHM MIN, 1250 OHM MAX.

D.C. Wiring -
Standard Ground 12 Volt L1064A
Drawing D-3867



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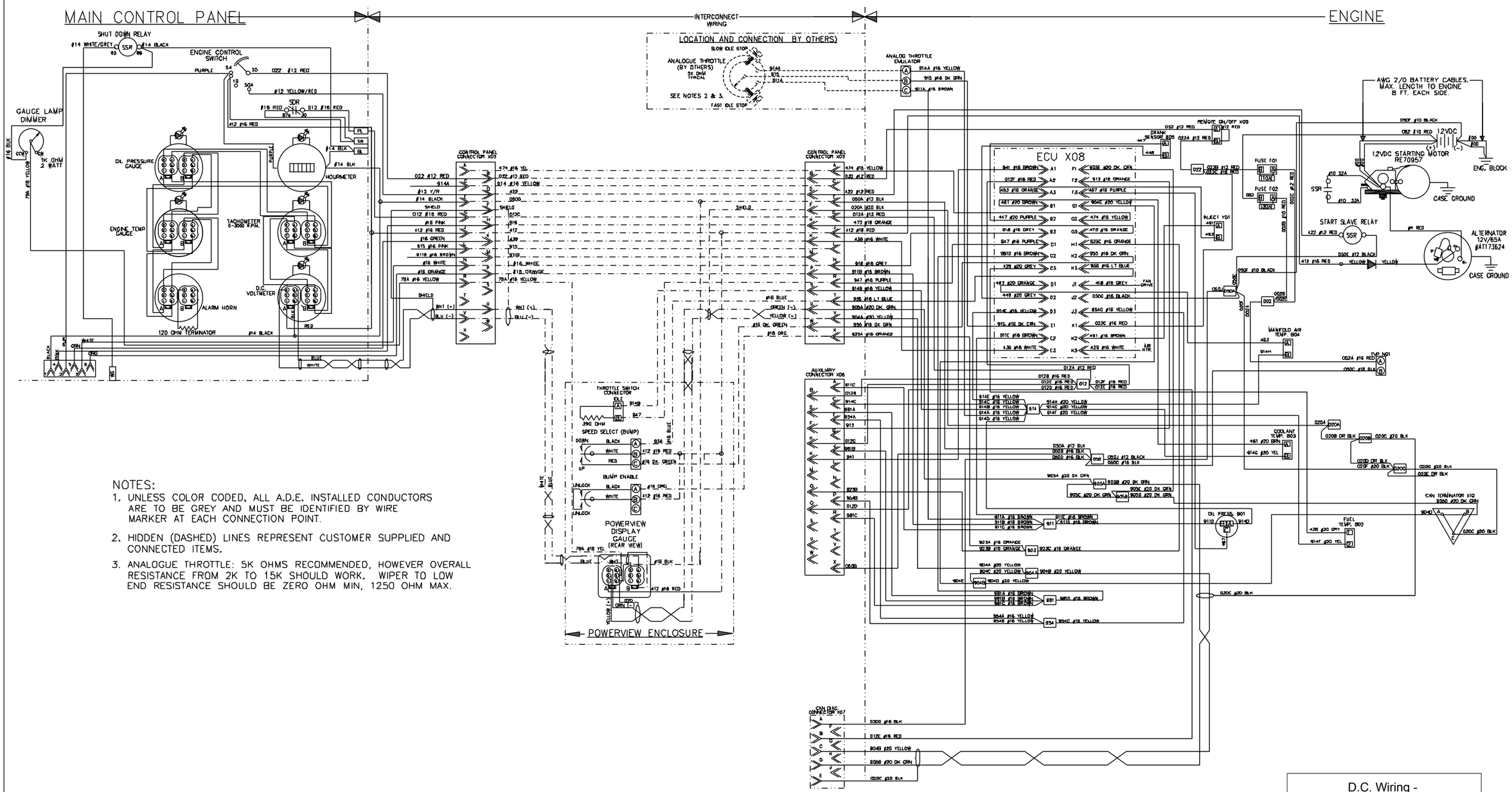
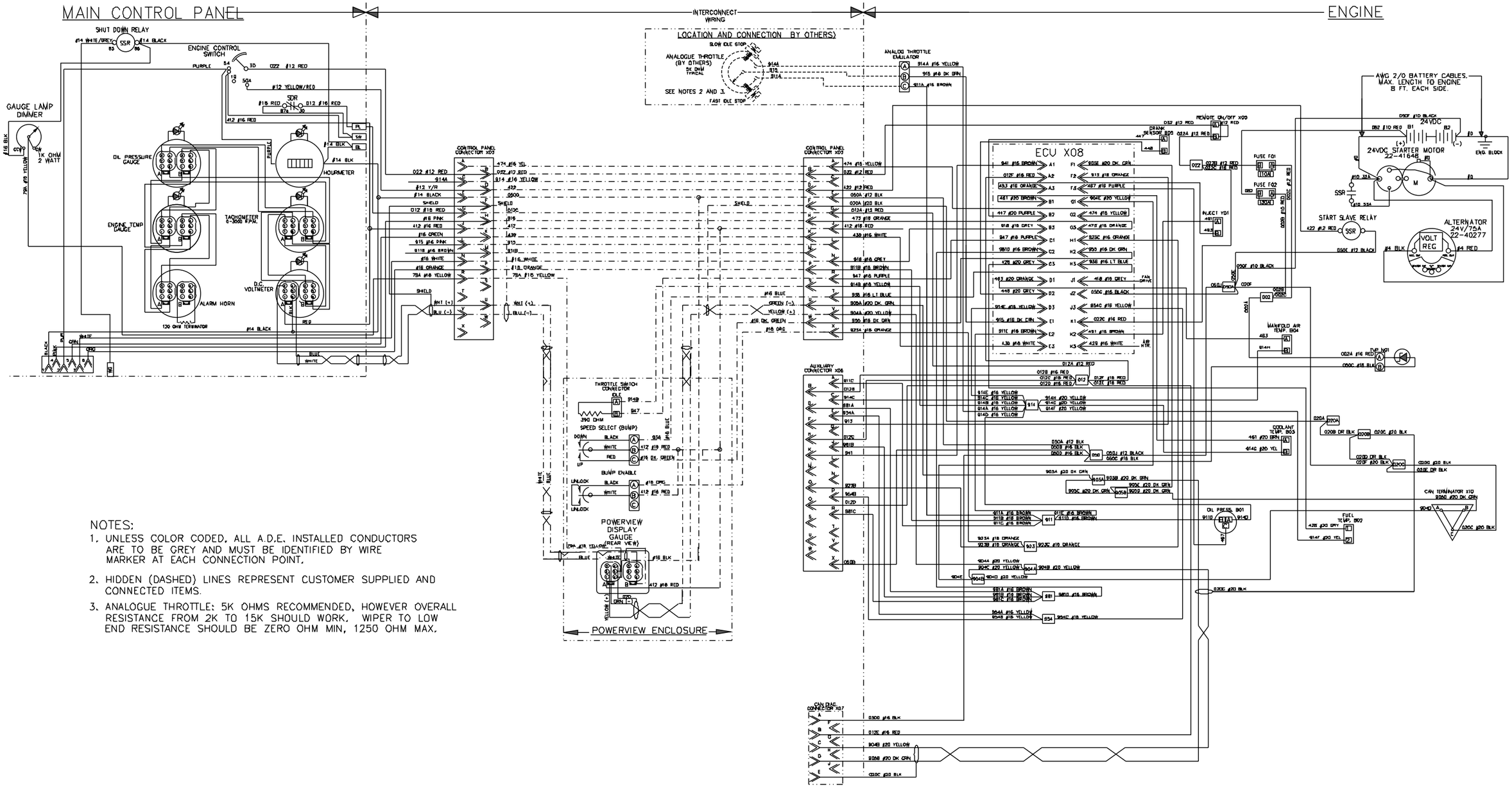
D.C. Wiring -
Standard Ground 24 Volt L1064A
Drawing D-3869



NOTES:

1. UNLESS COLOR CODED, ALL A.D.E. INSTALLED CONDUCTORS ARE TO BE GREY AND MUST BE IDENTIFIED BY WIRE MARKER AT EACH CONNECTION POINT.
2. HIDDEN (DASHED) LINES REPRESENT CUSTOMER SUPPLIED AND CONNECTED ITEMS.
3. ANALOGUE THROTTLE: 5K OHMS RECOMMENDED, HOWEVER OVERALL RESISTANCE FROM 2K TO 15K SHOULD WORK. WIPER TO LOW END RESISTANCE SHOULD BE ZERO OHM MIN, 1250 OHM MAX.

D.C. Wiring -
Standard Ground 12 Volt L1066T
Drawing D-3870A



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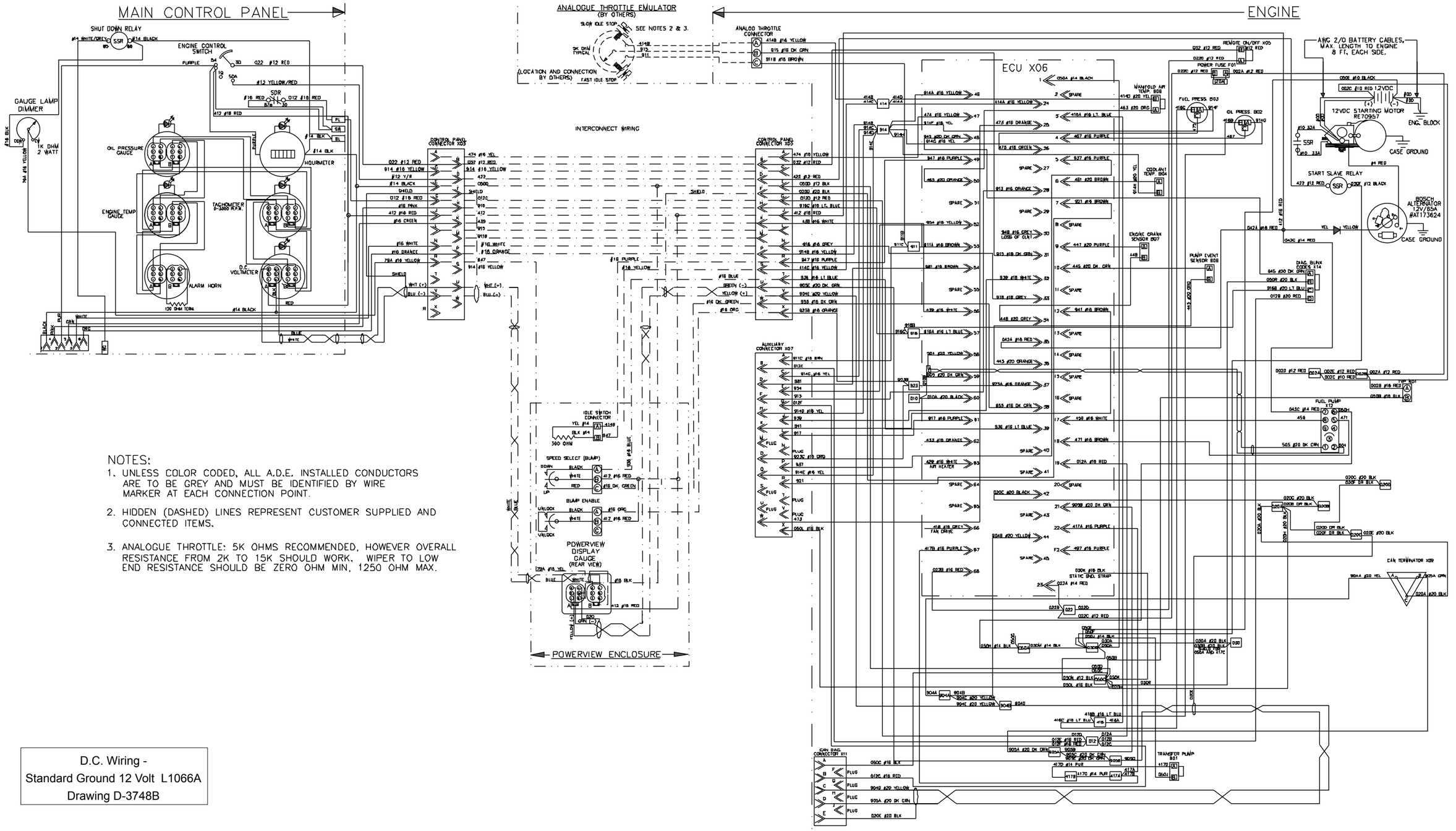
2. HIDDEN (DASHED) LINES REPRESENT CUSTOMER SUPPLIED AND CONNECTED ITEMS.
3. ANALOGUE THROTTLE: 5K OHMS RECOMMENDED, HOWEVER OVERALL RESISTANCE FROM 2K TO 15K SHOULD WORK. WIPER TO LOW END RESISTANCE SHOULD BE ZERO OHM MIN, 1250 OHM MAX.

D.C. Wiring -
Standard Ground 24 Volt L1066T
Drawing D-3871A



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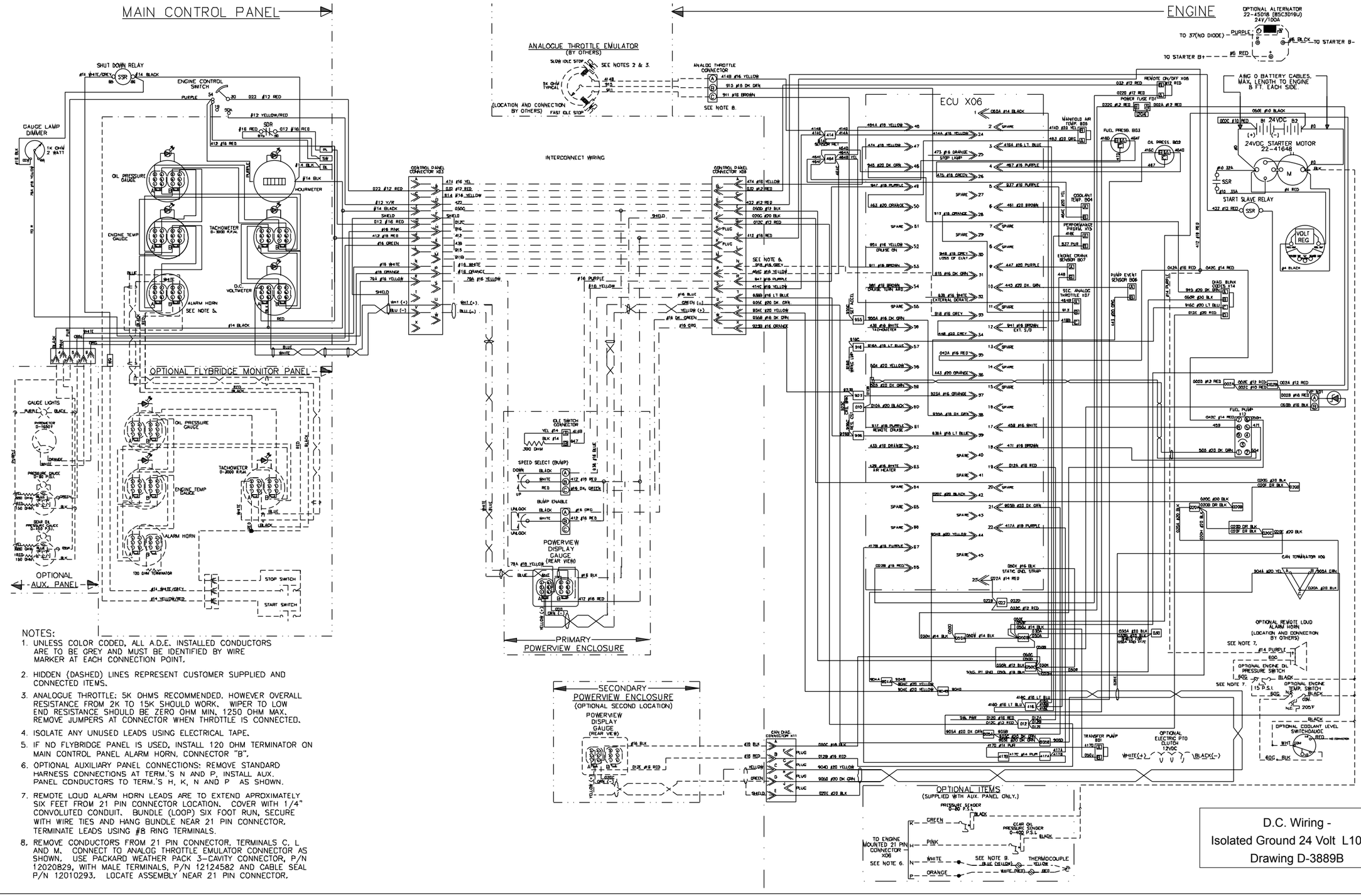
D.C. Wiring -
Standard Ground 12 Volt L1066A
Drawing D-3748B



NOTES:

1. UNLESS COLOR CODED, ALL A.D.E. INSTALLED CONDUCTORS ARE TO BE GREY AND MUST BE IDENTIFIED BY WIRE MARKER AT EACH CONNECTION POINT.
2. HIDDEN (DASHED) LINES REPRESENT CUSTOMER SUPPLIED AND CONNECTED ITEMS.
3. ANALOGUE THROTTLE: 5K OHMS RECOMMENDED, HOWEVER OVERALL RESISTANCE FROM 2K TO 15K SHOULD WORK. WIPER TO LOW END RESISTANCE SHOULD BE ZERO OHM MIN, 1250 OHM MAX. REMOVE JUMPERS AT CONNECTOR WHEN THROTTLE IS CONNECTED.
4. ISOLATE ANY UNUSED LEADS USING ELECTRICAL TAPE.
5. IF NO FLYBRIDGE PANEL IS USED, INSTALL 120 OHM TERMINATOR ON MAIN CONTROL PANEL ALARM HORN, CONNECTOR "B".
6. OPTIONAL AUXILIARY PANEL CONNECTIONS: REMOVE STANDARD HARNESS CONNECTIONS AT TERM.'S N AND P, INSTALL AUX. PANEL CONDUCTORS TO TERM.'S H, K, N AND P AS SHOWN.
7. REMOTE LOUD ALARM HORN LEADS ARE TO EXTEND APROXIMATELY SIX FEET FROM 21 PIN CONNECTOR LOCATION. COVER WITH 1/4" CONVOLUTED CONDUIT. BUNDLE (LOOP) SIX FOOT RUN, SECURE WITH WIRE TIES AND HANG BUNDLE NEAR 21 PIN CONNECTOR, TERMINATE LEADS USING #8 RING TERMINALS.
8. REMOVE CONDUCTORS FROM 21 PIN CONNECTOR, TERMINALS C, L AND M. CONNECT TO ANALOG THROTTLE EMULATOR CONNECTOR AS SHOWN. USE PACKARD WEATHER PACK 3-CAVITY CONNECTOR, P/N 12020829, WITH MALE TERMINALS, P/N 12124582 AND CABLE SEAL P/N 12010293, LOCATE ASSEMBLY NEAR 21 PIN CONNECTOR.

D.C. Wiring -
Isolated Ground 24 Volt L1066A
Drawing D-3889B

Safety at sea depends on careful preparation, product knowledge, and having the right tools and parts. Below is a list of parts Alaska Diesel Electric, Inc. recommends you carry onboard at all times.

Onboard Parts Kits are available from your dealer. “Standard” Kits are suitable for inland and offshore cruising. “World Class” Kits are for world cruising and trans-ocean cruising.

We consider these minimum quantities. Your vessel's operating conditions may require more of a given part. Consult your dealer.

Item	Description	Standard	World Class
1	Lube Oil Filter	4	4
2	Air Filter Element	1	1
3	Fuel Filter	2	2
4	Injector	0	6
5	Thermostat	2	2
6	Thermostat Ring	2	2
7	Relay	0	2
8	Valve Cover Gasket	1	2
9	Gasket Kit Top	0	1
10	Gasket Kit Bottom	0	1
11	Zinc*	6	12
12	Raw Water Pump Impeller*	2	2
13	Raw Water Pump Cover Gasket*	2	2
14	Raw Water Pump*	0	1
15	Workshop Manual	0	1
16	Set of Alternator Belts	1	1
17	Fuel Washer Kit	Std.1	w/c 1

*Heat exchanger cooled engines only

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