OPERATING INSTRUCTIONS, TECHNICAL DESCRIPTION AND MAINTENANCE MANUAL

8000 DWT CSL 200KW

DIESEL ENGINE
MODEL NTA-855 D(M)
380 HP @ 1500 rpm

MANUFACTURED BY

Cummins India Limited

Registered Office : Kothrud, Pune 411 038 (INDIA)

Bulletin No.: 5658868 January 2017

Foreword

Dear Customer,

Congratulations and thank you for purchasing a piece of equipment powered by Cummins. We believe we make the best Diesel engines in the country and each time you purchase a piece of equipment, you reaffirm your confidence. But far more important than the product, is the customer support we provide. Ownership of a Cummins engine, entitles you to,

- The best warranty policy in the industry
- Largest dealer network
- 24 hour customer assistance cell
- Various training program

We hope you will take advantage of all we offer.

We again thank you for your purchase and hope you will write back with lots of suggestions and feedback.

This is an engine operation and maintenance manual, not a repair manual. The design of Cummins engines makes it possible to replace worn or damaged parts with new or rebuilt parts with a minimum of down time. Contact the nearest Cummins dealer for parts replacement as they are equipped and have well informed, trained personnel to perform this service. If your shop is properly equipped to perform either maintenance, unit replacement and/or complete engine rebuild, contact the nearest Cummins dealer to obtain available repair manuals and arrange for training of personnel.

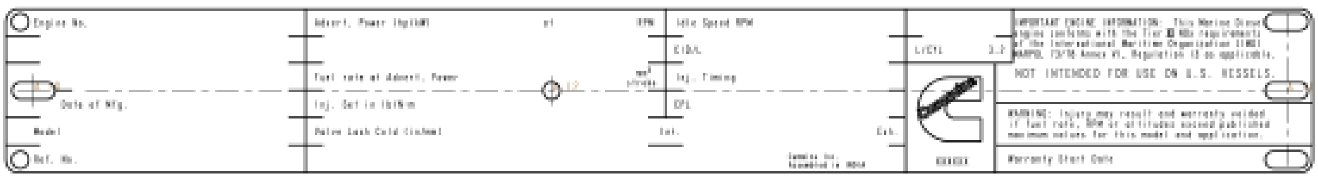
Engine Identification

For model identification of an engine, check the dataplate. The letter and number code indicates breathing (naturally aspirated except when letter “T” for turbocharged is present), cubic inch displacement, application and maximum rated horsepower.

Examples :

NTA-855-D(M)
N = Engine Series.
T = Turbocharged.
A = Aftercooled.
855 = Cubic Inch.
M = Marine Application.
BC = Big Cam.

Engine Data Plate :



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CUMMINS OWNER ASSISTANCE

Cummins India Limited backs its engines with expert service and complete parts support. We built a service network of Cummins dealers, the largest in INDIA devoted exclusively to Cummins diesel engines. We trained our people to provide the Cummins owner with sound advice, expert service and professional treatment at all Cummins locations.

Any problem that you have in connection with the sale, operation or service of your engine can be handled at the nearest Cummins location. Occasionally, you may feel a problem has not been handled to your satisfaction. At those times, we urge you to pursue the problem until you are satisfied.

Not all problems are of engineering nature, several arise from communication gaps or sheer misunderstanding; either or both the parties may be involved in the procedures to see a simple way out. The field person may also be immobilized if he faces a real policy decision.

In all such events, we sincerely request you to take your problem to the higher levels till you are fully satisfied.

We suggest the following points of contact :

1. If problem originates with a salesperson or service technician, talk to the sales or service manager.
2. If problem originates with a sales or service manager, talk to the owner of the service location who is the dealer.
3. If problem originates with a dealer, please call the nearest Cummins India Limited (Distribution Business Unit). Most problems are solved at or below the regional office level. Their phone numbers and addresses are listed. However, before you can, please write down the following information and have it ready.
   - A. Name and location of the Cummins dealer.
   - B. Type and make of equipment.
   - C. Engine model and serial number.
   - D. Total miles/kms. or hours of operation.
   - E. Nature of problem.
   - F. Summary of the current problem arranged in the order of occurrence.

If you still have problems please write to :

Manager Field Service Engineering

Cummins India Limited

Registered Office : Kothrud Pune 411 038 (India)

We do request that above steps be followed in order. Most of the actual work on an engine can be performed at the original location, so please give them a chance to satisfy you first.

CUMMINS ENGINE SERVICE TRAINING COURSES

Services Training Courses are available for customer's technical personnel involved in Cummins Engine Maintenance, Operation and Repair. These courses are conducted on a scheduled basis in Pune Service Training Schools, by

Cummins India Ltd

(Distribution Business Unit)

35/A/1/2, Erandawana, Pune, Maharashtra 411038
Telephone: (91-20) 25431234, 25430066, 25431703
Fax: (91-20) 25439490 Toll Free:-1-800-2332000

Customers, desirous of availing the training facilities may contact the Training Manager, at above address.

The service training courses offered are :

1. Engine Familiarization and Maintenance Course
2. Engine Rebuild Course
3. Cummins PT Fuel System Course
4. Correspondence Course Part I & II.

The service Training School also makes available Service Training Publications pertaining to Cummins Engine Maintenance, Operation Repair. The list is available with,

Training Manager,

Cummins India Ltd

(Distribution Business Unit)

35/A/1/2, Erandawana, Pune, Maharashtra 411038
Telephone: (91-20) 25431234, 25430066, 25431703
Fax: (91-20) 25439490 Toll Free:-1-800-2332000

CUSTOMER ASSISTANCE CELL

Customer Assistance Cell

Have a Question or comment, need information or want assistance for your Cummins Engine or just want to talk to someone who will listen and promptly resolve a problem then please

Dial : 020-25436680 (PUNE)

Fax : 020-25445916 (PUNE)

Toll Free : 1-800-2332000 - BSNL/MTNL or 020-25436680

e-mail : Powermaster-India@Cummins.com

Parts Assistance

When you need help to locate correct part numbers, want a copy of Engine Build Record, need more information on genuine spares or you are eager to know about new development in parts for your engine, Cummins Customer Assistance Cell is there to help you. Also when you want to know the despatch details for parts of under warranty engines, please call us.

Technical Information & Service Assistance

When you need to know the warranty coverage, operation and maintenance practices or repair procedures, want to carry out diagnosis, Customer Assistance Cell will give you the details you need like Fuel Pump & Injector Calibration, Control Parts list, Injection timing details. You will also get details of various types of services offered by Cummins.

Training & Literature

Cummins provides a wide range of training programmes and publishes various types of literature to aid our customers in using their Cummins Engines. Customer Assistance Cell will provide you the training schedule for the year and seat availability. You will also be guided on literature and cut models available for sale.

Service Network

When you need to know our authorised dealer for genuine Cummins parts, service support or to carry out component repairs, Customer Assistance Cell will guide you to the correct location where these services are available. You can also ask for 24 Hour contact information on our nation-wide network of authorized dealers for parts and service support.

Customer Relation

Cummins is dedicated to Customer Satisfaction. If you have a concern, a complaint or suggestion about how we can improve our product and services please contact us, our Customer Assistance Team is waiting to listen to you. Also, when you are pleased with your Cummins engine, we would like to hear from you.

We value your inputs.

Customer Assistance Team

The Customer Assistance Team is available to answer telephone queries from 7.30 A.M. to 8.30 P.M. seven days a week. Our Customer Assistance Cell will ensure that you get prompt response and assistance to your satisfaction. Telephoning us is an easy way to contact us. You can also send a fax, e-mail, or write to us at the Customer Assistance Cell, at Cummins India Limited (Distribution Business Unit).

CUMMINS
CUSTOMER ASSISTANCE CELL

Cummins India Limited
Registered Office : Kothrud, Pune 411 038 (India)

Cummins India Ltd
(Distribution Business Unit)
35/A/1/2, Erandawana, Pune, Maharashtra 411038
Telephone: (91-20) 25431234, 25430066, 25431703
Fax: (91-20) 25439490 Toll Free:-1-800-2332000

24 Hour Emergency Service

In the very unlikely event of you are not receiving the normal prompt attention from our field force, following are the residence telephone numbers of our officers for assistance.

While asking for assistance please provide the following information.

1. **Your Name & Phone or Fax Number.**
2. **Engine Serial Number.**
3. **Name of the Customer.**
4. **Engine Location.**
5. **General Description of Assistance required.**

Cummins India Limited

Registered Office : Kothrud, Pune 411038 (India)
Phones : 25380240, 25385435, 25381105 Fax : (020) 25387125
Visit us at : www.cumminsindia.com

Cummins India Ltd.
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35/A/1/2, Erandawana, Pune, Maharashtra 411038
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Fax: (91-20) 25439490 Toll Free:-1-800-2332000

10 MAINTENANCE STEPS FOR CUMMINS ENGINES

1. **KEEP DIRT OUT OF THE ENGINE.**
2. **MAINTAIN A LUBRICATING FILM ON ALL BEARING SURFACES.**
3. **REGULATE THE ENGINE'S FUEL.**
4. **CONTROL OPERATING TEMPERATURE.**
5. **GUARD AGAINST CORROSION.**
6. **LET THE ENGINE BREATHE.**
7. **PREVENT OVER-SPEEDING.**
8. **KNOW YOUR ENGINE'S CONDITION.**
9. **CORRECT PROBLEMS WHILE THEY ARE SIMPLE.**
10. **SCHEDULE & CONTROL YOUR ENGINE MAINTENANCE.**

Engine Specifications

TABLE 1 : MARINE APPLICATIONS							
Engine Model*	No. of Cyl.	Bore & Stroke Inch (mm)	Displace-ment C.I.D. (Liter)	Engine Breathin	Prime Power	R.P.M.	Typical Generator Output (Kw)
NTA-855-D(M)	6	$5^1/_2$ X 6 (140 X 152)	855 (14.00)	T.A.	380	1500	250

N.A. — Naturally Aspirated
T — Turbocharged
T.A. — Turbocharged Aftercooled.

CERTIFICATION OF MARINE ENGINE

Engines for Marine applications are manufactured for both Main Propulsion, and for G-Drive applications. Engines for marine application manufactured by **Cummins India Limited** are available duly certified by the following mentioned Marine Classification Agencies.

1. LLOYD'S REGISTER OF SHIPPING.
2. AMERICAN BUREAU OF SHIPPING.
3. INDIAN REGISTER OF SHIPPING.
4. BUREAU VERITAS.
5. DET NORSKE VERITAS.
6. KOREAN REGISTER OF SHIPPING
7. GERMANISCHER LLOYD
8. NIPPON KAIJY KYOKAI

Please use the card below to fill in all the information about your engine and send the same to us. This is prepaid.

NO POSTAGE STAMP NECESSARY IF MAILED IN INDIA

CUMMINS CUSTOMER CARE SERVICE

Cummins distributors and dealers are dedicated to provide you with the service you expect from a Cummins engine. Therefore, we invite your comments and suggestions as to how we can improve our service or assist you. You know best how we can serve you better.

Please use this space for your comments and suggestions.

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____

Name __________________ Engine Model ____________

Address __________________ Engine Serial Number __________

City ____________ State __________ Date of Purchase _______

Telephone / Mobile ____________ E-mail ________________

Location of Equipment __________ Number of Hours Done ________

Postage
will be
paid
by
Addressee

BUSINESS REPLY CARD

PERMIT No. 176
Ex-Servicemen's Colony P.O.
PUNE - 411 038.

No Postage
Stamp
necessary
if posted
in India

To,

Customer Assistance Cell
Cummins India Limited
(Distribution Business Unit)
35/A/1/2, Erandawana, Pune - 411038

SECTION : i

Introduction

Section i - Introduction

Section i - Introduction

Section Contents

To the Owner and Operator

Preventative maintenance is the easiest and least expensive type of maintenance. Follow the maintenance schedule recommendations outlined in Maintenance Guidelines (Section 2).

Keep records of regularly scheduled maintenance.

Use the correct fuel, oil, and coolant in your engine as specified in Engine Specifications, Section 10.

Personnel at Cummins Authorized Repair Locations have been trained to provide expert service and parts support. If you have a problem that can**not** be resolved by a Cummins Authorized Repair Location.

About the Manual

This manual contains information needed to correctly operate and maintain your engine as recommended by Cummins India Ltd. Additional service literature can be ordered from your Cummins distributor. For problems with literature orders, contact Cummins India Ltd., Kothrud, Pune 411 038.

This manual does **not** cover vehicle or equipment maintenance procedures. Consult the vehicle or equipment manufacturer for specific maintenance recommendations.

Each section is preceded by a “Section Contents” to aid in locating information.

How to Use the Manual

This manual is organized according to intervals at which maintenance on your engine is to be performed. A table that states the required intervals and the checks to be made is located in Section 2. Locate the interval at which you are performing maintenance. Then follow the steps given in that section for all the procedures to be performed. In addition, all of the procedures done under previous maintenance intervals **must** be performed.

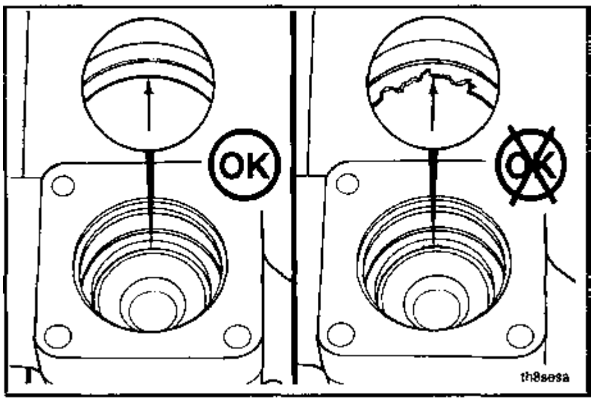
Keep a record of all the checks and inspections made. A record form for recording date, mileage/kilometer or hours, and what maintenance checks were performed is located in Section 3.

Refer to Section 11 for specifications recommended by Cummins India Ltd., for your engine/Specifications and torque values for each engine system are given in that section.

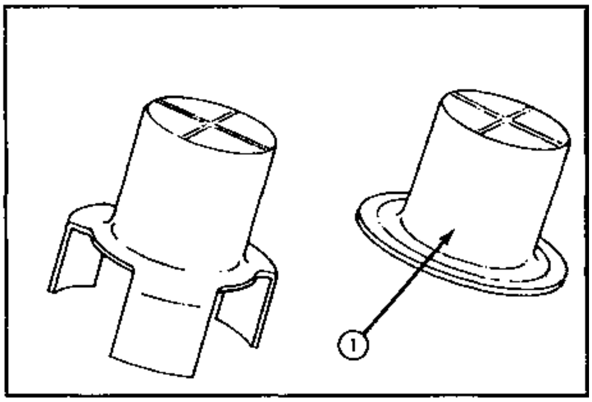
Illustrations

Use the illustrations in this manual as a guide to perform the action or the repair described. Many illustrations are generic and will **not** look exactly like the engine or the parts used in your application. In order to provide clarity to illustrations, some illustrations show parts removed that are **not** related to the specific parts given in the text.

Most of the illustrations contain symbols to indicate an action required or to indicate an **acceptable (OK)** or **unacceptable (not OK)** condition.



The illustrations are intended to show repair or replacement procedures. The illustration can differ from your application, but the procedure given will be the same.



General Safety Instructions

Important Safety Notices

⚠ WARNING ⚠

Improper practices, carelessness, or ignoring the warnings can cause burns, cuts, mutilation, asphyxiation or other personal injury or death.

Read and understand all of the safety precautions and warnings before performing any repair. This list contains the general safety precautions that must be followed to provide personal safety. Special safety precautions are included in the procedures when they apply.

- Work in an area surrounding the product that is dry, well lit, ventilated, free from clutter, loose tools, parts, ignition sources and hazardous substances. Be aware of hazardous conditions that can exist.
- Always wear protective glasses and protective shoes when working.
- Rotating parts can cause cuts, mutilation or strangulation.
- Do not wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery (negative [-] cable first) and discharge any capacitors before beginning any repair work. Disconnect the air starting motor if equipped to prevent accidental engine starting. Put a "Do Not Operate" tag in the operator's compartment or on the controls.
- Use ONLY the proper engine barring techniques for manually rotating the engine. Do not attempt to rotate the crankshaft by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s) causing premature fan failure.
- If an engine has been operating and the coolant is hot, allow the engine to cool before slowly loosening the filler cap to relieve the pressure from the cooling system.
- Always use blocks or proper stands to support the product before performing any service work. Do not work on anything that is supported ONLY by lifting jacks or a hoist.
- Relieve all pressure in the air, oil, fuel, and cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do not check for pressure leaks with your hand. High pressure oil or fuel can cause personal injury.
- To reduce the possibility of suffocation and frostbite, wear protective clothing and ONLY disconnect liquid refrigerant (Freon) lines in a well ventilated area. To protect the environment, liquid refrigerant systems must be properly emptied and filled using equipment that prevents the release of refrigerant gas (fluorocarbons) into the atmosphere. Federal law requires capturing and recycling refrigerant.
- To reduce the possibility of personal injury, use a hoist or get assistance when lifting components that weigh 23 kg [50 lb] or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the correct capacity. Make sure hooks are positioned correctly. Always use a spreader bar when necessary. The lifting hooks must not be side-loaded.
- Corrosion inhibitor, a component of SCA and lubricating oil, contains alkali. Do not get the substance in eyes. Avoid prolonged or repeated contact with skin. Do not swallow internally. In case of contact, immediately wash skin with soap and water. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.
- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and must be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. KEEP OUT OF REACH OF CHILDREN.
- To reduce the possibility of burns, be alert for hot parts on products that have just been turned off, exhaust gas flow, and hot fluids in lines, tubes, and compartments.

- Always use tools that are in good condition. Make sure you understand how to use the tools before performing any service work. Use ONLY genuine Cummins® or Cummins ReCon® replacement parts.
- Always use the same fastener part number (or equivalent) when replacing fasteners. Do not use a fastener of lesser quality if replacements are necessary.
- When necessary, the removal and replacement of any guards covering rotating components, drives, and/or belts should only be carried out be a trained technician. Before removing any guards the engine must be turned off and any starting mechanisms must be isolated. All fasteners must be replaced on re-fitting the guards.
- Do not perform any repair when fatigued or after consuming alcohol or drugs that can impair your functioning.
- Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil.
- Do not connect the jumper starting or battery charging cables to any ignition or governor control wiring. This can cause electrical damage to the ignition or governor.
- Always torque fasteners and fuel connections to the required specifications. Overtightening or undertightening can allow leakage. This is critical to the natural gas and liquefied petroleum gas fuel and air systems.
- Always test for fuel leaks as instructed, as odorant can fade.
- Close the manual fuel valves prior to performing maintenance and repairs, and when storing the vehicle inside.
- Coolant is toxic. If not reused, dispose of in accordance with local environmental regulations.
- The catalyst reagent contains urea. Do not get the substance in your eyes. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. Avoid prolonged contact with skin. In case of contact, immediately wash skin with soap and water. Do not swallow internally. In the event the catalyst reagent is ingested, contact a physician immediately.
- The catalyst substrate contains Vanadium Pentoxide. Vanadium Pentoxide has been determined by the State of California to cause cancer. Always wear protective gloves and eye protection when handling the catalyst assembly. Do not get the catalyst material in your eyes. In Case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. Avoid prolonged contact with skin. In case of contact, immediately wash skin with soap and water.
- The Catalyst substrate contains Vanadium Pentoxide. Vanadium Pentoxide has been determined by the State of California to cause cancer. In the event the catalyst is being replaced, dispose of in accordance with local regulations.
- 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.

Definition of Terms

AFC	Air Fuel Control
API	American Petroleum Institute
ASA	Air Signal Attenuator
ASTM	American Society of Testing and Materials
^{0}C	Celsius
CARB	California Air Resources Board
C.I.D.	Cubic Inch Displacement
cm	Centimeter
CPL	Control Parts List
cSt	Centistokes
DCA	Diesel Coolant Additive
E.C.S.	Emission Control System
EPA	Environmental Protection Agency
^{0}F	Fahrenheit
ft-lb	Foot Pound
GVW	Gross Vehicle Weight
Hg	Mercury
HP	Horsepower
H_2O	Water
in-lb	Inch Pound
kg	Kilograms
km	Kilometers
km/l	Kilometers per Liter
kPa	Kilopascal
l	Liter
m	Meter
mm	Millimeter
MPa	Megapascal
MPH	Miles Per Hour
MPQ	Miles Per Quart
N•m	Newton-meter
OEM	Original Equipment Manufacturer
ppm	Parts Per Million
psi	Pounds Per Square Inch
rpm	Revolutions Per Minute
SAE	Society of Automotive Engineers

Engine Operating Range

⚠ CAUTION ⚠

Operating the engine beyond high idle speed can cause severe engine damage. The engine speed must not exceed 1850 rpm under any circumstances. When descending a steep grade, use a combination of transmission gears and engine or service brakes to control the vehicle and engine speed.

Cummins heavy-duty engines are designed to operate successfully at full throttle under transient conditions down to peak torque engine speed (rpm). This is consistent with recommended operating practices for good fuel economy.

Excessive full throttle operation below peak torque rpm will shorten engine life to overhaul, can cause serious engine damage, and is considered engine abuse. Peak torque rpm varies from 1,100 rpm to 1,500 rpm, depending upon rated engine speed.

Engine Shut-Down

Engine Operation Before Shutdown

It is important to idle the engine 3 to 5 minutes before shutting it down to allow the lubricating oil and water to carry heat away from the combustion chamber, bearings, shafts, etc. This is especially important with turbocharged engines.

The turbocharger contains bearings and seals that are subject to the high heat of combustion exhaust gases. While the engine is running, this heat is carried away by oil circulation; but if the engine is stopped suddenly, the turbocharger temperature can rise as much as 38°C [100°F]. The results of the extreme heat can be seized bearings or loose oil seals.

NOTE: Do **not** idle for excessively long periods.

Long periods of idling are not good for an engine because the combustion chamber temperatures drop so low the fuel can not burn completely. This will cause carbon to clog the injector spray holes and piston rings and can result in stuck valves.

If the engine coolant temperature becomes too low, raw fuel will wash the lubricating oil off the cylinder walls and dilute the crankcase oil so all moving parts of the engine will suffer from poor lubrication.

If the engine is not being used, shut it down.

Practically all failures give some warning to the operator before the parts fail and ruin the engine. Many engines are saved because alert operators heed warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shut down the engine.

NOTES

Section 1 - Operating Instructions

Section 1 - Operating Instructions

Section Contents

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Operating Instructions

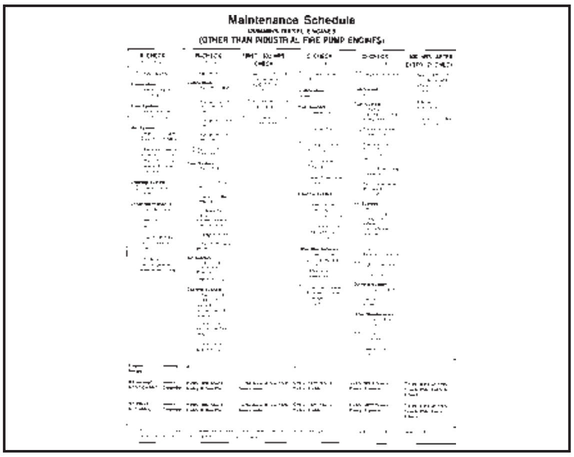
The engine operator must assume responsibility of engine care while engine is being operated. There are comparatively few rules which operator must observe to get best service from a Cummins Diesel Engine.

General - All Applications

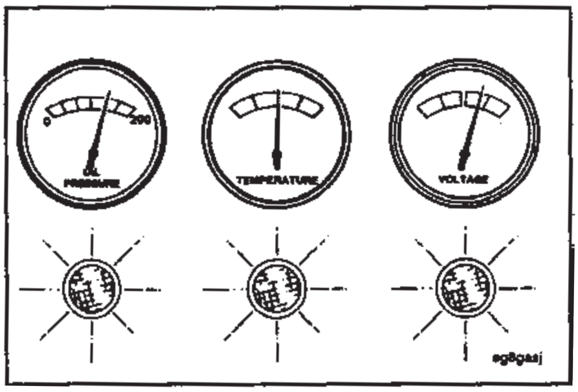
1.0 GENERAL INFORMATION

Correct care of your engine will result in longer life, better performance and more economical operation.

- Follow the daily maintenance checks listed in Maintenance Guidelines, Section 3.

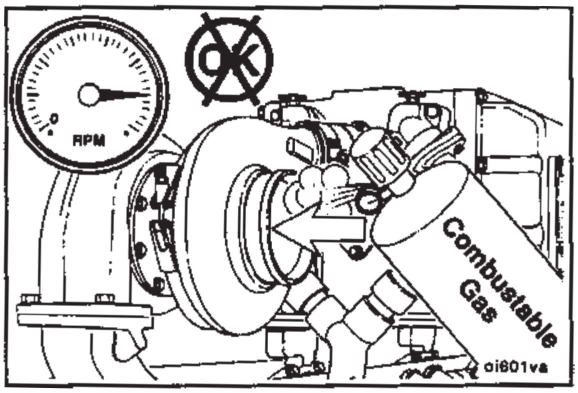


- Check the oil pressure indicators, temperature indicators, warning lights and other gauges daily to make sure they are operational.



WARNING

DO NOT OPERATE A DIESEL ENGINE WHERE THERE ARE OR CAN BE COMBUSTIBLE VAPORS. These vapors can be sucked through the air intake system and cause engine acceleration and over-speeding, which can result in a fire, an explosion and extensive property damage. Numerous safety devices are available, such as air intake shutoff devices, to minimize the risk of overspeeding where an engine, due to its application, might operate in a combustible environment, such as due to a fuel spill or gas leak. Remember, Cummins has no way of knowing the use you have for your engine. THE EQUIPMENT OWNER AND OPERATOR ARE RESPONSIBLE FOR SAFE OPERATION IN A HOSTILE ENVIRONMENT. CONSULT YOUR CUMMINS AUTHORIZED REPAIR LOCATION FOR FURTHER INFORMATION.



1.1 Starting the Engine

The engine requires clean air and fuel to be supplied to the combustion chambers in proper quantities at the correct time.

CAUTION

While starting the engine do not touch the Throttle or Throttle Lever.

Normal Starting Procedure

WARNING

Before starting, check to make sure everyone is clear of engine and equipment, to prevent accidents.

If fuel system is equipped with overspeed stop, push “Reset” button before attempting to start engine.

1.1.1 On units equipped with air activated prelube device, open air valve until oil pressure is registered on oil pressure gauge to activate piston in prelube device which will lubricate all moving parts in engine.

Note : On engines equipped with an oil pressure safety switch, hold the fuel by-pass switch in “start” position until engine oil pressure reaches 7 to 10 psi (48 to 69 kPa); then, move to “run” position.

1.1.2 Set throttle for idle speed and disengage driven Unit.

1.1.3 For marine engines open sea cocks to permit raw water flow through heat exchanger and marine gear oil cooler. Place marine gear in neutral.

CAUTION

Protect the turbocharger during start-up by not opening throttle or accelerating above 1000 rpm until idle speed oil pressure registers on gauge.

1.1.4 Open manual fuel shut-down valve, if so equipped. Ref. Fig. 1-1. Electric shut-down valves operate as switch is turned on. A manual override knob provided on forward end of electric shut-down valve allows valve to be opened in case of electric power failure. To use, turn fully clockwise; return to “run” position after electric repair.

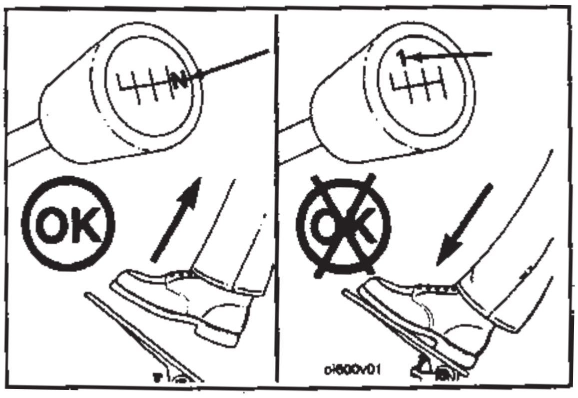
1.1.5 Press starter button or turn switch key to “start” position and crank the engine till it fires.

Ref. Fig. 1-1 : Using manual override knob

CAUTION

To prevent permanent cranking motor damage, do not crank engine for more than 10 seconds continuously. If the engine does not start after about three repeated attempts, with an interval of two minutes between successive starts then the starter should not be operated and the fuel system has to be checked for any faults.

1.1.6 At the initial start or after oil or filter changes and after engine has run for a few minutes, shut it down and wait for 15 minutes for oil to drain back into pan. Check engine oil level again, add oil as necessary to bring oil level to “H” mark on dipstick. The drop in oil level is due to absorption by oil filters.

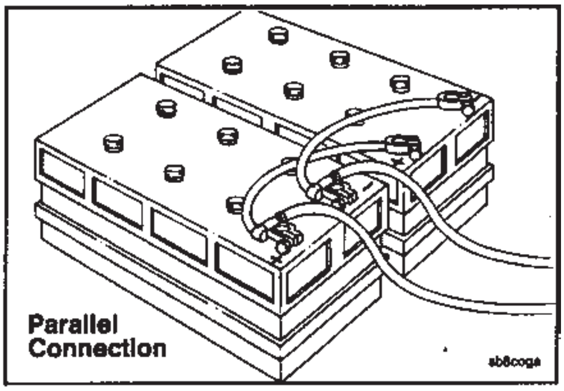


1.2 Normal Starting Procedure (Above O°C [32°F])

- Disengage the driven unit, or if equipped, put the transmission in neutral.
- Start the engine with the throttle in the idle position.

Engines equipped with air starters require a minimum of 480 kPa [70 psi] compressed air pressure.

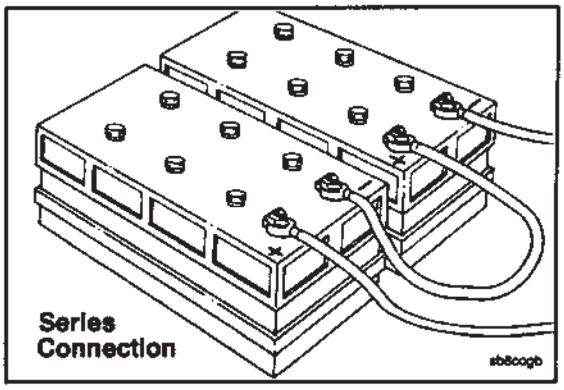
To prevent damage to the starter, do **not** engage the starting motor for more than 30 seconds. Wait two (2) minutes between each attempt to start engine (electrical starting motors only).


Parallel Connection

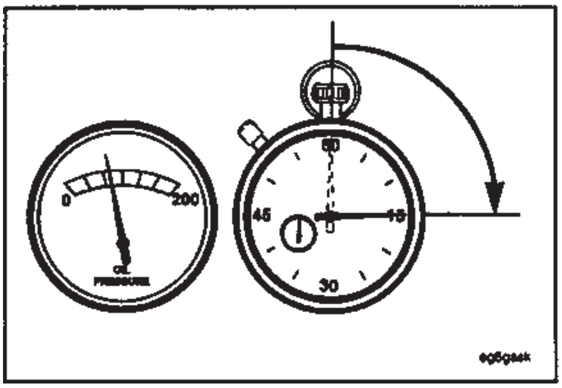
CAUTION

When using jumper cables to start the engine, make sure to connect the cables in parallel; positive (+) to positive (+) and negative (-) to negative (-). When using an external electrical source to start the engine, turn the disconnect switch to the OFF position. Remove the key before attaching the jumper cables.

The accompanying illustration shows a typical parallel battery connection. This arrangement doubles the cranking amperage.

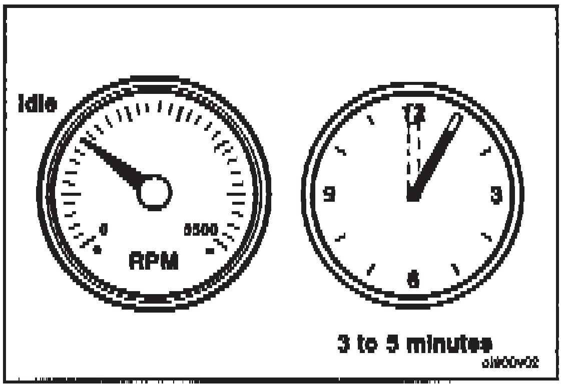

Series Connection

This illustration shows a typical series battery connection. This arrangement, positive to negative, doubles the voltage.

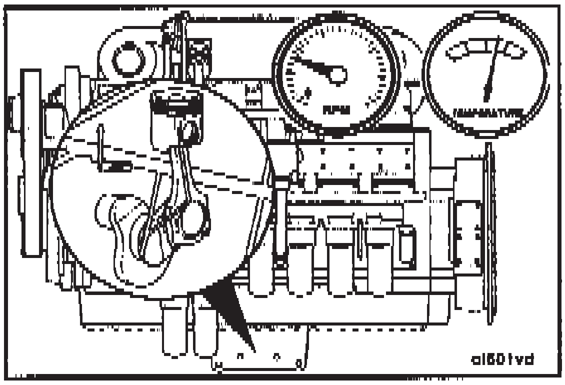


- Engine oil pressure **must** be indicated on the gauge within 15 seconds after starting. If oil pressure is **not** registered within 15 seconds, shut off the engine immediately to avoid engine damage. Confirm the correct oil level in the oil pan.

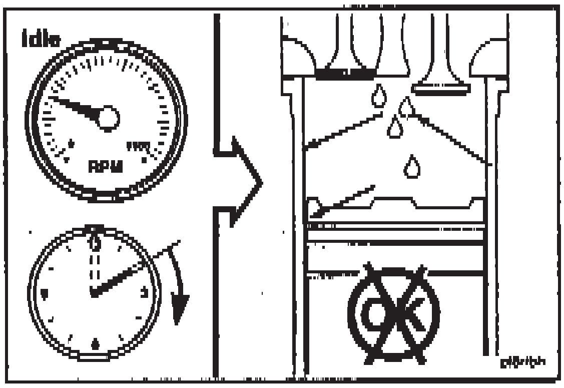
- Idle the engine three (3) to five (5) minutes at approximately 1,000 rpm before operating with a load.



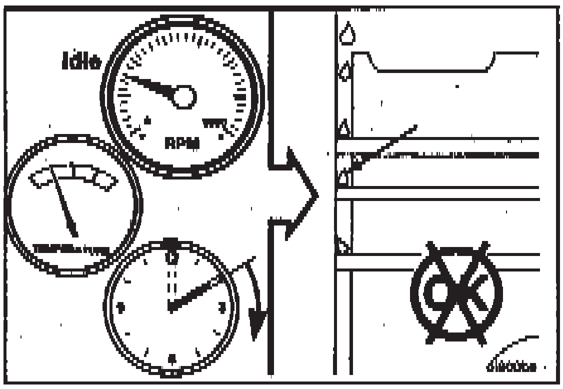
- When starting a cold engine, increase the engine speed (rpm) slowly to provide adequate lubrication to the bearings, and to allow the oil pressure to stabilize.

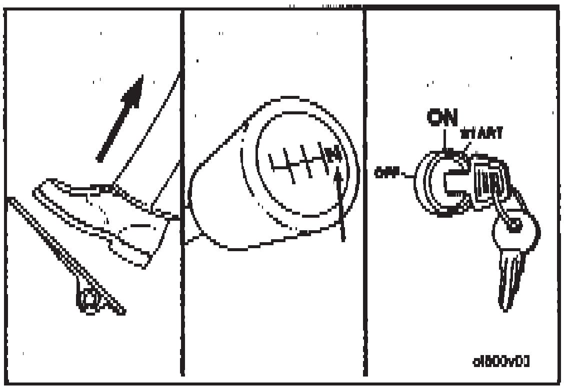


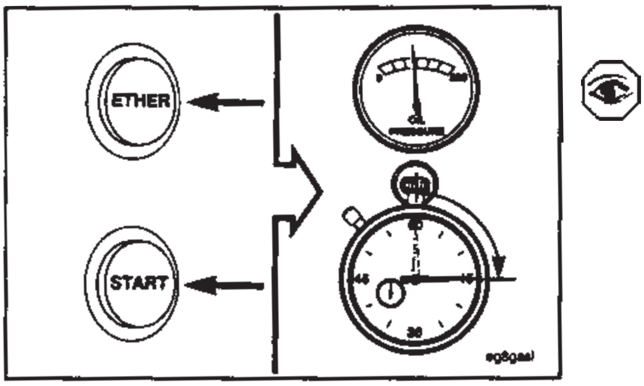
Do **not** idle the engine for excessively long periods. Long periods of idling, more than 10 minutes, can damage an engine because combustion chamber temperatures drop so low the fuel will **not** burn completely. This will cause carbon to clog the injector spray holes and piston rings, and can cause the valves to stick.

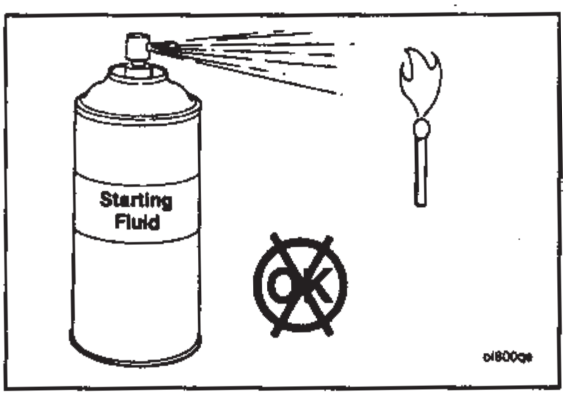


If the engine coolant temperature becomes too low, 60°C [140°F], raw fuel will wash the lubricating oil off the cylinder walls and dilute the crankcase oil; therefore, all moving parts of the engine will **not** receive the correct amount of lubrication.









1.3 Cold Weather Engine Operation

Satisfactory performance of a diesel engine operating in low ambient temperature conditions requires modification of the engine, surrounding equipment, operating practices and maintenance procedures. The colder the temperatures encountered, the greater the amount of modification required and yet with the modifications applied, the engine **must** still be capable of operation in warmer climates without extensive changes. The following information is provided to engine owners, operators and maintenance personnel on how the modifications can be applied to get satisfactory performance from their diesel engines.

1.4 Cold Weather Starting

Using Starting Fluid with Mechanical or Electrical Metering Equipment

- Set the throttle at idle.
- Disengage the driven unit, or if equipped, put the transmission in neutral.
- Activate the switch to open the fuel pump shutoff valve.
- While cranking the engine, inject a metered amount of starting fluid.
- Engine oil pressure **must** be indicated on the gauge within 15 seconds after starting.

Using Starting Fluid without Metering Equipment

WARNING

Do not use volatile cold starting aids in underground mine or tunnel operations due to the potential of an explosion. Check with the local Mines Inspector for instructions.

CAUTION

Do not use excessive amounts of starting fluid when starting an engine. The use of too much starting fluid will cause engine damage.

Due to increased safety hazards and potential for engine damage, Cummins India Limited does **NOT** recommend the use of starting fluid without metering equipment.

There are three basic objectives to be accomplished :

1. Reasonable starting characteristics followed by practical and dependable warm-up of the engine and equipment.
2. A unit or installation which is as independent as possible from external influences.
3. Modifications which maintain satisfactory operating temperatures with a minimum increase in maintenance of the equipment and accessories.

If satisfactory engine temperature is **not** maintained, higher maintenance cost will result due to the increased engine wear, poor performance and formation of excessive carbon, varnish and other deposits. Special provisions to overcome low temperatures are definitely necessary, whereas a change to warmer climate normally requires only a minimum of revision. Most of the accessories will be designed in such a way that they can be disconnected so there is little effect on the engine when they are **not** in use.

The two most commonly used terms associated with preparation of equipment for low temperature operation are **Winterization** and **Arctic specifications.**

Winterization of the engine and/or components so that starting and operation are possible in the lowest temperature to be encountered requires :

a. Use of correct materials.

b. Proper lubrication, low temperature lubricating oils. Refer to Lubricating Oil Specifications, Section V.

c. Protection from the low temperature air. The metal temperature does **not** change, but the rate of heat dissipation is affected.

d. Fuel of a proper grade for the lowest temperature.

e. Heating to be provided to increase the engine block and component temperature to a minimum of -32°C [-25°F] for starting in lower temperatures.

f. Proper external heating source available.

g. Electrical equipment capable of operating in the lowest expected temperature.

Arctic specifications refer to the design material and specifications of the components necessary for satisfactory engine operation in extreme low temperature -54°C [65°F]. Contact Cummins Engine Company, Inc. or the equipment manufacturer to obtain the special items required.

For additional information on cold weather operation, obtain Service Bulletin No. 3379009, Engine Operation in Cold Weather, from the nearest Cummins distributor or dealer.

It is possible to operate diesel engine in extremely cold environments if they are properly prepared and maintained. The correct lubricants, fuels and coolant **must** be used for the cold weather range for which the vehicle is being operated. Refer to the chart below for recommendations in different operating ranges.

Winterize 0° to -23°C [32° to -10°F]	**Winterize -23° to -32°C [-10° to -25°F]**	**Winterize -32° to -54°C [-25° to -65°F]**
Use ethylene glycol antifreeze to protect to -29° C [-20°F]	Use 50 percent ethylene glycol antifreeze, 50 percent water mixture.	Use 60 percent ethylene glycol antifreeze 40 percent water mixture.
Use multi viscosity oils meeting API, CE or CI4+ specifications.	Use multi viscosity oil meeting API, CE or CI4+ specifications.	Use Artic oil meeting API, CE or CI4+ specifications.
Fuel to have maximum cloud and pour points 6°C [10°F] lower than ambient temperature in which engine operates.	Fuel to have maximum cloud and pour points 6°C [10°F] lower than ambient temperature in which engine operates.	Fuel to have maximum cloud and pour points 6°C [10°F] lower than ambient temperature in which engine operates.

1.4.1 Cold Weather Starting Aids

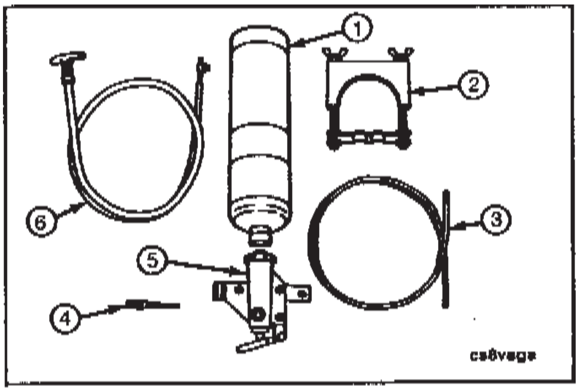
Ether Starting Aids

WARNING

Starting fluid contains ether and is extremely flammable. Misuse or mishandling can cause an explosion. NEVER handle starting fluid near an open flame. NEVER use starting fluid with a preheater, glow plug, flame thrower or other type of electrical starting equipment. Do NOT breathe the fumes as serious injury to the human respiratory system will result. Fuel oil or volatile fuel cold starting aids are NOT to be used in underground mine or tunnel operations.

CAUTION

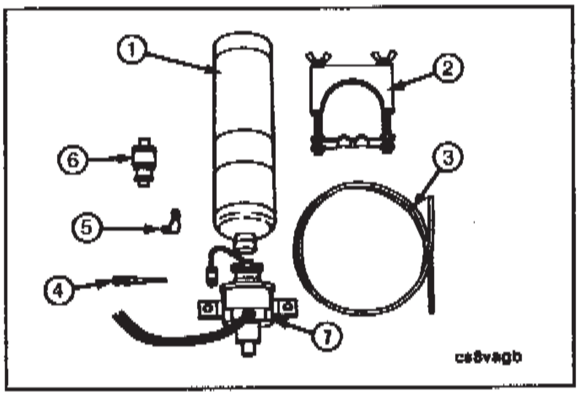
Using too much starting fluid will cause extremely high pressures and detonation in the engine cylinders, resulting in damage to the cylinder parts and bearings. Too much starting fluid can also cause damage from engine overspeed.



1.4.2 Manually Operated Ether Valve

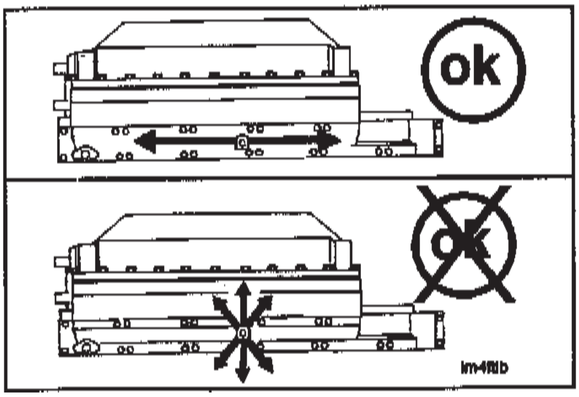
The manually operated ether valve includes the valve body assembly (5), clamp (2), and nylon tube (3). The fuel cylinder (1), atomizer fitting (4) and pull control (6) **must** be ordered separately.

Standard pull or throttle control cables can be used to actuate the manual valve, if desired.



1.4.3 Electrically Operated Ether Valve

The electrically operated ether valve includes the valve body (7), 90 degree elbow (5), clamp (2), push button switch (6), and nylon tube (3). A thermostat is mounted to the cylinder block or coolant passage and stops electrical power to the atomizer solenoid when the engine is warm. See the Parts Catalog for fuel cylinder 91) and fuel atomizer fittings (4). These fittings **must** be ordered separately, as required.



1.4.4 Atomizer Installation Recommendations

The atomizer fittings **must** be mounted in the engine air intake manifold to provide an equal distribution of starting fuel to each cylinder. The atomizer holes are 180 degrees apart and **must** be mounted so the spray is injected the long way of the manifold. If incorrectly installed, the spray goes crosswise of the manifold.

1.4.5 Preheater Glow Plug Type System

The glow plug system supplies heat to the cumbustion chambers, so compression temperatures are sufficient to ignite fuel.

To aid in starting engine when temperature is 10°C (50°F) or below, an intake air preheater is recommended. The Preheater equipment consists of a handpriming pump to pump fuel into intake manifold, and a switch to turn on glow plug which is electrically heated by battery. Fuel burns in intake manifold and heats intake air. Ref. Fig.1.2 for typical Cold Starting Aid Arrangement.

WARNING

Do not use vapor in conjunction with preheater as it could result in a fire.

To use preheater for cold starting:

a. Set throttle in idle position. Turn glow plug toggle switch to ‘ON’ position. Red indicator light must be on.

b. After red light has been on for 20 seconds, start cranking engine. As soon as engine begins rotating, operate preheater priming pump to maintain 80 to 100 psi (552 to 689 kPa) fuel pressure. Use of primer before the 20-second interval will wet glow plug and prevent heating.

c. If engine does not start within 30 seconds, stop cranking. Wait one or two minutes and repeat cranking operation.

d. After engine starts, pump primer slowly to keep engine idling smoothly. In cold weather this may require 4 to 5 minutes or longer. Do not accelerate engine.

e. When the engine has warmed up so it does not falter between primer strokes, stop pumping. Close and lock primer. Turn off glow plug toggle switch. (Red indicator light will go out.)

f. If engine gives no indication of starting during first three full strokes of preheater pump, touch-check intake manifold for heat. If no heat check electrical wiring. If wiring is all right, remove 1/8 inch pipe plug from manifold near glow plug and close glow plug manual switch for 15 seconds and observe glow plug through 1/8 inch pipe plug hole. The glow plug should be white hot; if not, connect wiring to a 6-12 volt (as used) source and check amperage; it should be 30 to 32 (min.) amperes. If glow plug is all right, check manual switch and resistor (if used) and replace if necessary.

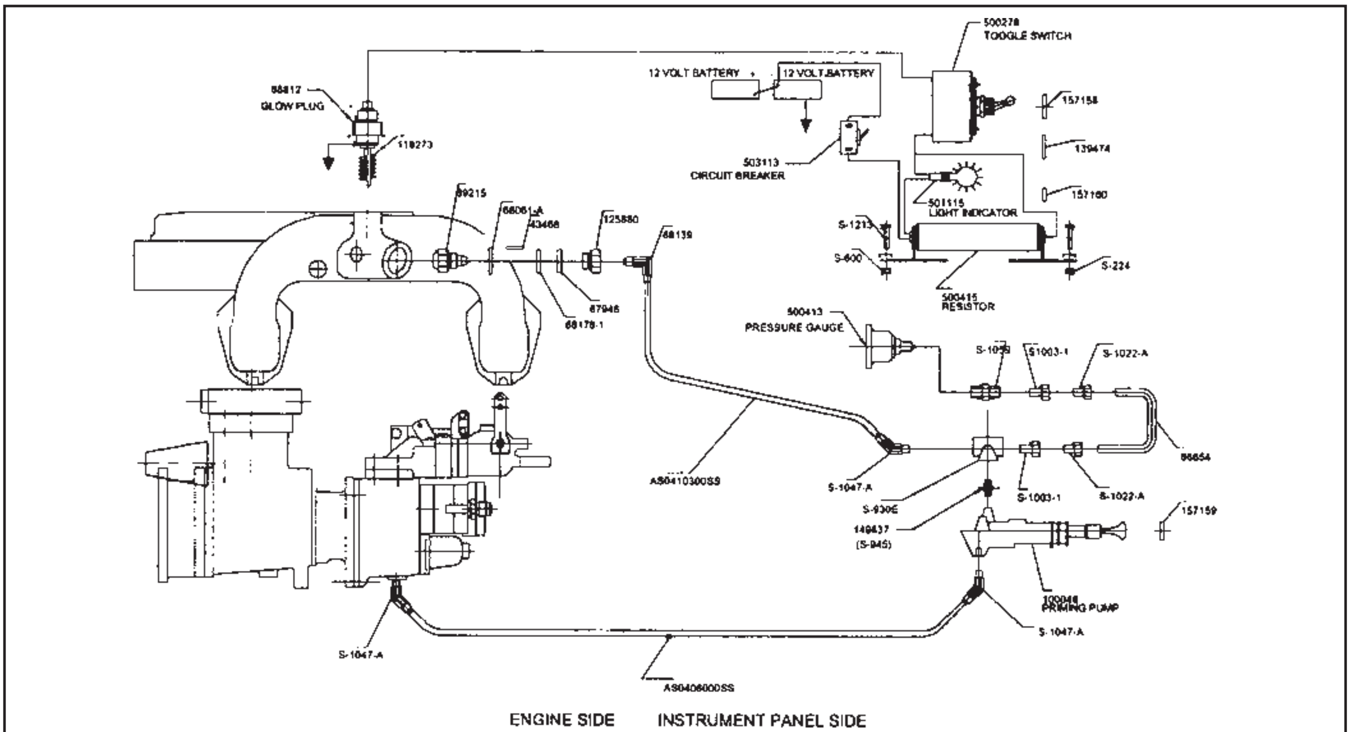
Note : Preheater priming pump, switches and resistor are located at the instrument panel and are to be checked during engine starting.

The cold starting aid approved for use on Cummins Engines, has been based upon starting aid capabilities to –32°C (-25°F).

2.0 ENGINE WARM-UP

When the engine is started, it takes a while to get the lubricating oil film re-established between shafts and bearings and between pistons and liners. The most favourable clearances between moving parts are obtained only after all engine parts reach normal operating temperature. Avoid seizing pistons in liners and running dry shafts in dry bearings by bringing the engine up to operating speed gradually as it warms up.

On some emergency equipment (such as fire pump engines) warm-up may not be necessary due to equipment being housed inside a heated building. For an



Ref. Fig. 1.2. Typical Cold Starting Aid Arrangement engine starting with a parasitic load, such as a fire pump, coolant temperature must be a minimum of 49°C(120°F).

2.1 Speed Pattern for Marine application – Pleasure Boat or Light Duty

For normal cruising operation; maintain engine rpm at approximately 90 percent of rated rpm. This will give adequate power as well as economical fuel consumption.

2.2 Continuous Duty

For continuous duty operation, engine governors are normally set for reduced rpm and fuel rate. Therefore a reduced cruise speed is not necessary.

Marine Gear Operation

Movement of a single lever on the control valve to neutral, forward or reverse controls the marine gear operation. If so desired, the control lever may be interlocked with the throttle; therefore, the marine gear should be shifted to forward or reverse before the throttle is moved from idle position and returned to neutral when the throttle is closed.

WARNING

Never shift the control lever to any position with the engine running faster than 1000 rpm.

Refer to gear manufacturer's manual for procedures, temperatures and recommended oil pressures.

2.3 Oil Temperature

The oil temperature gauge normally should read between 75°C(167°F) and 105°C(221°F). Under full load conditions, an oil temperature of 116°C(240°F) for a short period is not a cause for alarm.

CAUTION

Any sudden increase in oil temperature which is not caused by load increase is a warning of possible mechanical failure and should be investigated at once.

During warm-up period, apply load gradually until oil temperature reaches 60°C(140°F). While oil is cold it does not do a good job of lubricating. Continuous operating or long periods of idle with oil temperatures below 140°F (60°C) may cause crankcase dilution and acids in the lubricating oil which quickly accelerate engine wear.

2.4 Water Temperature

A water temperature of **75°C to 95°C (167° to 203°F)** is the best assurance that working parts of the engine have expanded evenly to the most favourable oil clearances. Maximum engine coolant temperatures should not exceed **95°C (203°F).**

Keep thermostats always in the engine, avoid long periods of idling, and take necessary steps to keep water temperature up to a minimum of **75°C (167°F).** If necessary in cold weather, use radiator shutters or cover a part of the radiator to prevent overcooling.

2.5 Oil Pressure

Normal engine oil pressure at 105 °C(221°F) should be between **3 to 7 kg/cm ^{2}** at rated speed and 1 to 2 kg/cm^2 at low idle speed. If your engine is provided with DFC system, pressure at rated speed should be 2.4 to 3.1 kg/cm^2 and 0.7 kg/cm^2 minimum at idle speed.

Note : Please note that oil pressure will vary with temperature.

Note : Individual engines may vary from above normal pressures. Observe and record pressure when engine is new to serve as a guide for indication of progressive engine condition. (High oil pressure during start-up is not a cause for alarm.) For record purposes these readings are more accurate and reliable when taken immediately after an oil change.

2.6 Engine Exhaust

The engine exhaust is a good indicator of engine operation and performance. A smoky exhaust may be due to a poor grade of fuel, dirty air cleaner, overfueling, or poor mechanical conditions.

If engine exhaust is smoky, corrective action should be taken.

2.7 High Altitude Operation

Some engines, particularly naturally aspirated, lose horsepower when operated at high altitude because the air is too thin to burn as much fuel as at sea level. This loss is about 3 percent for each 1000 ft (304.8 m) of altitude above sea level for a naturally aspirated engine. Operate the engine using a lower power requirement at high altitude to prevent smoke and over-fueling.

2.8 Power Take-Off Application With PT (type G) VS Fuel Pump

The VS fuel pump governor lever is used to change standard governed speed of engine from rated speed to an intermediate power take-off speed.

When changing from standard speed range to power take-off speed with engine idling on standard throttle, operate as follows :

a. Place the VS speed control lever in operating position.

b. Lock the standard throttle in full-open position.

c. Engage power take-off.

To return to standard throttle:

a. Disengage power take-off.
b. Return standard throttle to idle position.
c. Lock the VS speed control lever in maximum speed position.

Stop engine Immediately If Any Parts Fail

Practically all failures give some warning to the operator before the parts fail and ruin the engine. Many engines are saved because alert operators heed warning signs (sudden drop in oil pressure, unusual noises, etc.) and immediately shut down the engine.

Cold-Weather Protection

1. For cold-weather operation, use of permanent type antifreeze with rust inhibitor additives is recommended.

2. Drain cylinder block and heads on all engines by opening petcocks and removing drain plugs as shown in Fig. 1-1. Failure to properly drain engine and accessories may cause serious damage during freezing weather.

3. Immersion-type water and oil heaters are available for engines used in cold-weather operations.

2. Oil Pan Capacities

Table 1-1 : Oil Pan Capacities

Engine C.I.D.	Lub oil Capacity High U.S. gal. (Litres)	Lub oil Capacity Low U.S. gal. (Litres)
855	7 (27)	5 (19)

Capacities listed are for oil pan only on G-drive applications. Total system capacities vary with filter sizes and length of oil line. Please refer to Engine Data Sheet for Oil capacities on other application.

Priming the Lubricating System

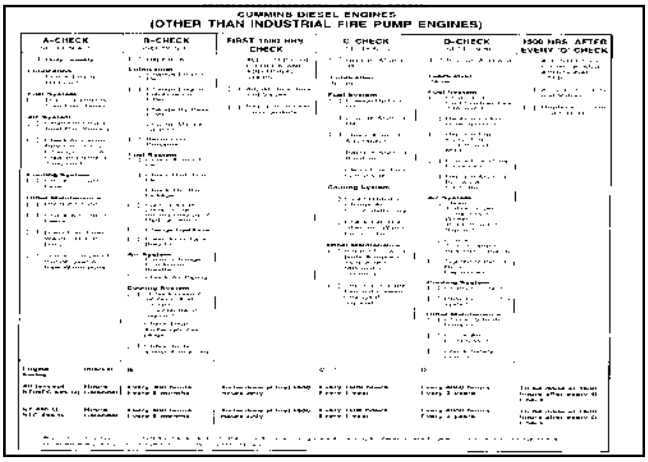


Fig. 1-2. Prelubricating turbo

Note : On turbocharged engines, remove oil inlet line from the turbocharger and prelubricate bearing by adding 2 to 3 oz. (50 to 60 cc) of clean lubricating oil. Reconnect oil supply line.

1. Fill crankcase to “L” (low) mark on dipstick. See “Lubricating Oil Specifications”, Section 10.

2. Remove plug from head of lubricating oil filter housing (Fig’s. 1-3) or filter can to prime system.

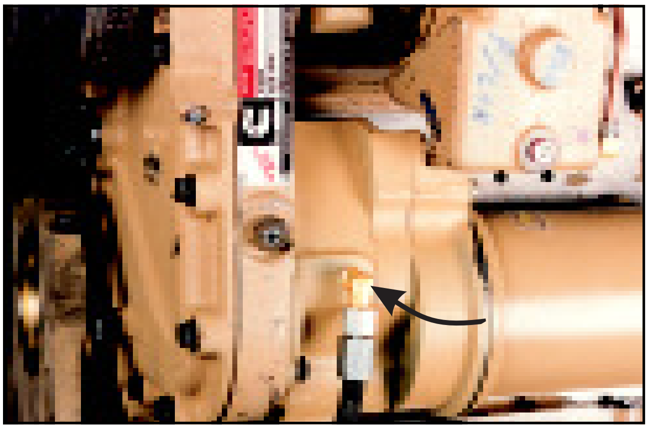


Fig. 1-3. Lubricating oil system priming point

Caution : Do not prime engine lubricating system from by-pass filter.

3. Connect a hand or motor-driven priming pump line from source of clean lubricating oil to plug boss in housing.

4. Prime until a 30 psi (207 kPa) minimum pressure is obtained. Bar engine for 2 or 3 rotations while priming.

5. Crank engine at least 15 seconds (with fuel shut-off valve closed or disconnected to prevent starting), while maintaining external oil pressure at a minimum of 15 psi (103 kPa). Check that oil has reached up to all points in tappets (Remove Tappet covers).

6. Remove external oil supply and replace plug in lubricating oil filter housing, torque 15 to 20 ft-lbs (20 to 27 N•m).

Caution : Clean areas of any lubricating oil spilled while priming or filling crankcase.

7. Fill crankcase to "H" (high) mark on dipstick with oil meeting specifications, listed in Section 10. No change in oil viscosity or type is needed for new or newly rebuilt engines.

A dipstick oil gauge is located on the side of the engine. The dipstick has an "H" (high) and "L" (low) level mark to indicate lubricating oil supply. The dipstick must be kept with the oil pan, or engine, with which it was originally supplied. Cummins oil pans differ in capacity with different type installations and oil pan part numbers.

Fill Marine Gear (for Marine Engines only)

The marine gear is a separate unit and carries its own lubrication. Fill housing according to manufacturer's recommendations.

Start engine and briefly operate the gear in both forward and reverse.

Caution : Never operate marine gear with oil level below "L" mark or above "H" mark on dipstick.

Check Raw Water Pump Oil Level (If oil sump is provided)

(For Marine Engines only)

Check oil level in raw water pump if pump has an oil sump.

1. Remove pipe plug from side of pump.

2. Fill housing with hypoid SAE 90 oil; replace plug.

Check Hydraulic Governor

Many engines used in stationary power applications are equipped with hydraulic-governed fuel pumps which use lubricating oil as an energy medium, same weight as used in engine. Oil level in governor sump must be at full mark on dipstick.

Check Air Connections

Check air connections to compressor and air equipment, as used, and to **air cleaners and air crossovers to assure all are secured.**

Check Engine Coolant Supply

1. Remove the radiator or heat exchanger cap and check engine coolant level. Add coolant as needed.

2. Make visual check for leaks and open water filter shut-off valves.

Prime Sea Water Pump (For Marine Engines Only)

The Gillmec Type pumps require initial priming. The pump will continue to self prime at all subsequent starts unless the pump body has been emptied deliberately. Fill pump body prior to connecting inlet connection.

Note : Prior to initial priming/commissioning ensure that sea water supply line/piping is thoroughly flushed and clean to ensure that system is free from any metal particles or burrs.

Starting the Engine

Starting requires that clean air and fuel be supplied to the combustion chambers in proper quantities at the correct time.

Caution : While starting the engine do not touch the Throttle or Throttle Lever.

Normal Starting Procedure

Warning : Before starting, check to make sure everyone is clear of engine and equipment, to prevent accidents.

If fuel system is equipped with overspeed stop, push "Reset" button before attempting to start engine.

1. On units equipped with air activated prelube device, open air valve until oil pressure is registered on oil pressure gauge to activate piston in prelube device which will lubricate all moving parts in engine.

Note : On engines equipped with an oil pressure safety switch, hold the fuel by-pass switch in "start" position until engine oil pressure reaches 7 to 10 psi (48 to 69 kPa); then, move to "run" position.

2. Set throttle for idle speed and disengage driven Unit.

3. For marine engines open sea cocks to permit raw water flow through heat exchanger and marine gear oil cooler. Place marine gear in neutral.

Caution : Protect the turbocharger during start-up by not opening throttle or accelerating above 1000 rpm until idle speed oil pressure registers on gauge.

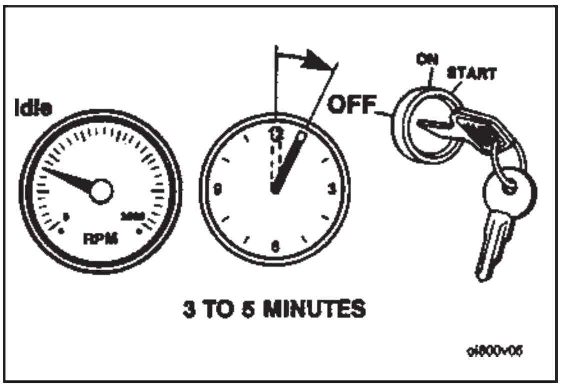
4. Open manual fuel shut-down valve, if so equipped. Fig. 1-5. Electric shut-down valves operate as switch is turned on. A manual override knob provided on forward end of electric shut-down valve allows valve to be opened in case of electric power failure. To use, turn fully clockwise; return to "run" position after electric repair.

5. Press starter button or turn switch key to "start" position and crank the engine till it fires.

Fig. 1-5 : Using manual override knob

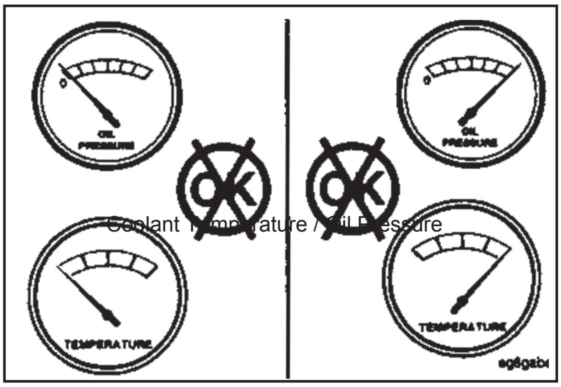
Caution : To prevent permanent cranking motor damage, do not crank engine for more than 10 seconds continuously. If the engine does not start after about three repeated attempts, with an interval of two minutes between successive starts then the starter should not be operated and the fuel system has to be checked for any faults.

6. At the initial start or after oil or filter changes and after engine has run for a few minutes, shut it down and wait for 15 minutes for oil to drain back into pan. Check engine oil level again, add oil as necessary to bring oil level to "H" mark on dipstick. The drop in oil level is due to absorption by oil filters.



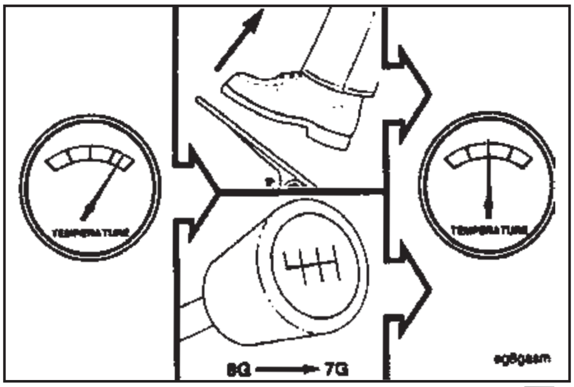
7. OPERATING THE ENGINE

- Allow the engine to idle three (3) to five (5) minutes before shutting it off after a full load operation. This allows adequate cool down of pistons, cylinder liners, bearings and turbocharger components.
- Do not operate the engined at full throttle below peak torque engine speed (RPM) for extended periods (more than 30 sec) of time.



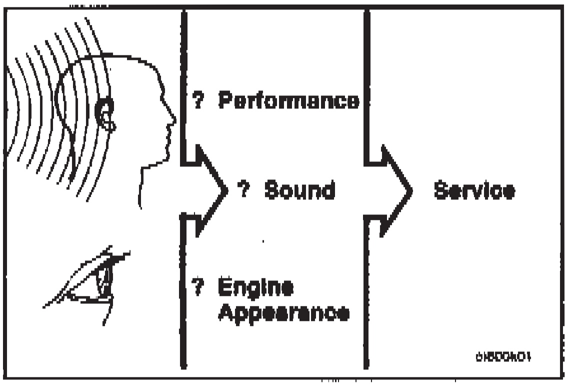
NOTE : Continuous operation with low coolant temperature, below 60°C [140°F], or high coolant temperature, above 100°C [212°F], can damage the engine.

a. Monitor the oil pressure and coolant temperature gauges frequently. Refer to Lubricating Oil system Specifications or Cooling System Specifications, Section V, for recommended operating pressures and temperatures. Shut off the engine if any pressure or temperature does **not** meet the specifications.



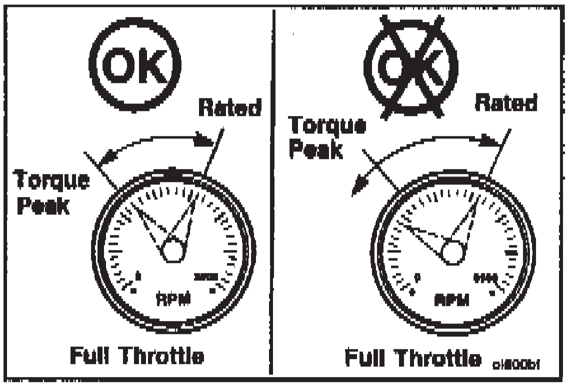
b. If an overheating condition starts to occur, reduce the power output of the engine by releasing the throttle pressure or shifting the transmission to a lower gear or both until the temperature returns to normal operating range. If engine temperature does **not** return to normal, shutoff the engine and refer to Troubleshooting, Section T, or contact a Cummins Authorized Repair Location.

- Most failures give an early warning. Look and listen for changes in performance, sound or engine appearance that can indicate service or engine repair is needed. Some changes to look for are as follows :
  - Engine misfires
  - Vibration
  - Unusual engine noises
  - Sudden changes in engine operating temperature or pressure
  - Excessive smoke
  - Loss of power
  - An increase in oil consumption
  - An increase in fuel consumption
  - Fuel, oil or coolant leaks.

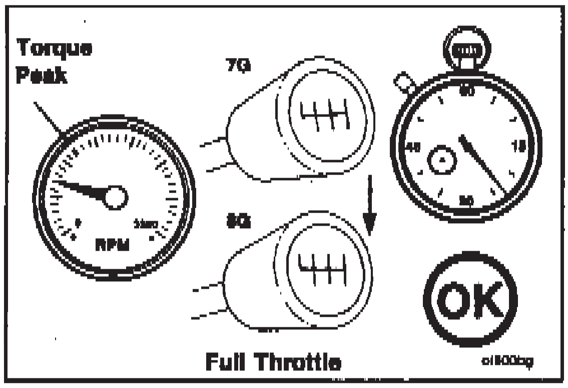


7.1 Engine Operating Range

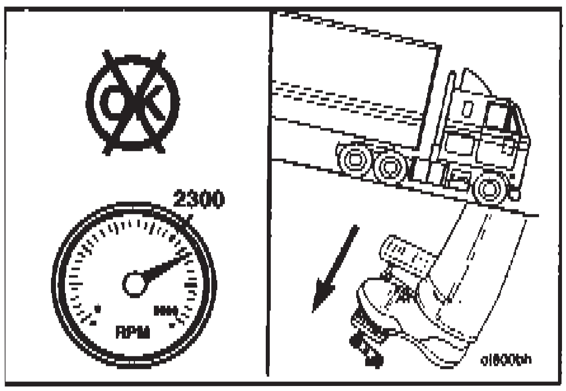
Excessive full throttle operation below peak torque rpm (lugging) will shorten engine life to overhaul, can cause serious engine damage and is considered engine abuse. Cummins engines are designed to operate successfully at full throttle under transient conditions down to peak torque engine speed.

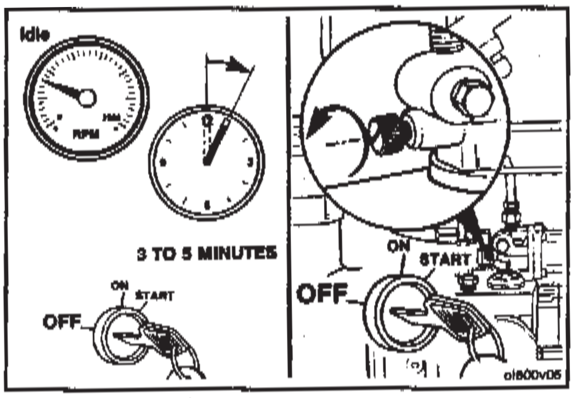


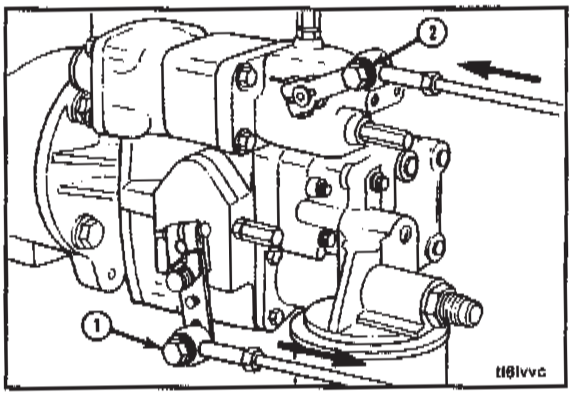
Operation of the engine below peak torque rpm can occur during gear shifting due to the difference of ratios between transmission gears, but engine operation **must not** be sustained more than 30 seconds at full throttle below peak torque rpm.

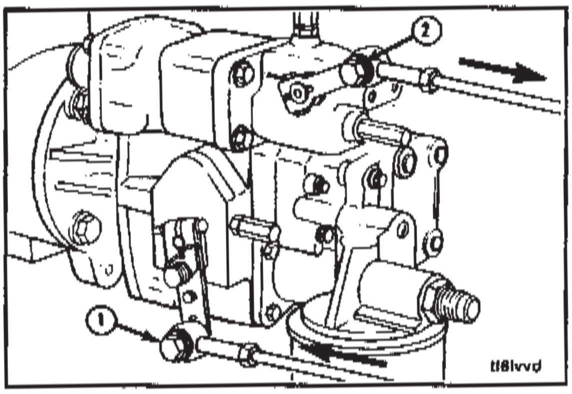


> **CAUTION**
>
> Operating the engine beyond high idle speed can cause severe engine damage. The engine speed MUST NOT exceed 2,400 rpm under any circumstances. When descending a steep grade, use a combination of transmission gears or vehicle braking systems to control the vehicle and engine speed.









Ref. Fig. 1-13. Power Take-off Application

8. ENGINE SHUT-DOWN

- Allow the engine to idle 3-5 minutes after a full load operation before shutting it off. This allows the engine to cool gradually and uniformly.
- Turn the ignition key switch to the OFF position. If the engine fails to stop running, rotate the manual fuel shutoff thumb screw **counter-clockwise** to make sure the valve is **not** being held open by the manual override screw.

8.1 Idle Engine A Few Minutes Before Shut-Down

It is important to idle an engine 3 to 5 minutes before shutting it down to allow lubricating oil and water to carry heat away from the combustion chamber, bearings, shafts, etc. This is especially important with turbocharged engines.

The turbocharger contains bearings and seals that are subject to the high heat of combustion exhaust gases. While the engine is running, this heat is carried away by oil circulation, but if the engine is stopped suddenly, the turbocharger temperature may rise above 360°F. The results of extreme heat may be seized bearings or loose oil seals.

8.2 Do Not Idle Engine for Excessively Long Periods

Long periods of idling are not good for an engine because combustion chamber temperatures drop so low the fuel may not burn completely. This will cause carbon to clog the injector spray holes and piston rings and may result in stucked valves.

If engine coolant temperature becomes too low, raw fuel will wash lubricating oil off cylinder walls and dilute crankcase oil so all moving parts of the engine will suffer from poor lubrication.

If the engine is not being used, shut it down.

8.3 Turn Switch Key to 'Off' Position to Shut Down the Engine

The engine can be shut-down completely by turning off the switch key on installations equipped with an electric shut-down valve, or by turning the manual shut-down valve knob. Turning off the switch key which controls the electric shut-down valve always stops the engine unless override button on shut-down valve has been locked in open position. If manual override on electric

Engine Preservation Procedure

Introduction

On any engine not in service, whether installed in equipment or waiting to be installed, the unpainted surfaces and various internal passages are subject to rust and corrosion.

Every engine going out of factory is processed and is suitable for storage upto six months from the date of despatch. However sometimes engines are required to be stored for more than six months, also on many occasions engines as installed in equipment are not put in service. Hence it is necessary to process such engines for storage. Based on above the procedure for preservation can be catagorised as below.

i) Engine preservation procedure for engines to be stored upto six months, from the date of engine shipment from factory.

ii) Engine preservation procedure to be carried out for engine storage beyond six months from date of shipment from factory.

iii) Engine preservation procedure for engines installed in equipment.

NOTE :
The rate of corrosion varies with climatic condition. Variance in climatic condition makes it very difficult to state the length of time an engine can be stored without rust and corrosion damage. However the procedures outlined below are useful for various climatic conditions except for arctic conditions and very low temperatures. For such conditions, please refer to Cummins India Limited for engine storage requirements.

1) Engine preservation procedure for engines to be stored upto six months, from the date of engine shipment from factory.

NOTE :

Every engine going out of factory is processed for storage upto six months. Hence no additional processing is required except proper storage, as given on next page.

i) If engine has to be stored in the engine box, as received from factory

SR NO	DESCRIPTION
a	Store engine box along with kit boxes, in enclosed place protected from water / rain water, dust etc.
b	Tag all these boxes indicating following, **ENGINE SHIPMENT DATE :** **THE ENGINE HAS BEEN TREATED FOR PRESERVATION FOR A PERIOD OF SIX MONTHS FROM THE ENGINE SHIPMENT DATE MENTIONED ABOVE.**
c	Do not stack any material on engine box to avoid damage to engine / engine box.

ii) If engine has to be stored with out engine box, and / or skid.

SR NO	DESCRIPTION
a	Store engine along with kit boxes, in enclosed place protected from water / rain water, dust etc.
b	Tag all these boxes indicating following, **ENGINE SHIPMENT DATE:** **THE ENGINE HAS BEEN TREATED FOR PRESERVATION FOR A PERIOD OF SIX MONTHS FROM ENGINE SHIPMENT DATE MENTIONED ABOVE.**
c	Ensure that all engine openings and opening on kit items such as radiators, air cleaners, silencers etc. are covered by water proof protective caps / plastic tapes.
d	Do not rotate the engine, as engine is in dry condition.

2) Engine preservation procedure to be carried out for engine storage beyond six months from date of shipment from factory.

The engine system wise details of the process are described below.

Cooling System Passage :

SR NO	DESCRIPTION	REMARKS
a	Prepare engine for Ensis, Long Storage Process.	Fabricate and install a plate to close the water pump inlet connection.
b	Fill the cooling system with Ensis oil RUSTILO DW 901, (Castrol India make) up to thermostat outlet connection, using external priming pump trolley.	Leave the drain cocks open until all air is completely vented out. Progressively close the cocks until the ensis oil flows from the thermostat housing.
c	Keep the Ensis oil in the engine for 5 minutes and then drain it completely, from engine.	Remove the fabricated plate at water pump inlet and close the opening by plastic cap. (Collect the drained oil in clean container for reuse.)

ii) Fuel Passage:

No external treatment is required.

iii) Lubricating Oil Passage:

SR NO	DESCRIPTION	REMARKS
a	Prepare engine for Lub oil priming.	Use lub oil priming pump for priming.
b	Prime the engine with engine lub oil 15W40. (CI4+ category)	Use engine Lub oil trolley for priming. Circulate the lub oil till the lub pressure gauge shows 1 kg / cm sq. pressure. It will take max five min. to reach this lub oil pressure.**Bar the engine during the process.**
c	Drain the Lub oil from the oil pan.	

NOTE :

a) **The above procedure for engine preservation is to be carried out / repeated at the end of every six months during the storage period. The procedure may have to be done at OEM works or at customer's place depending upon location of engine.**

b) **Loosen the belt tension on fan belt, alternator belt, water pump belt and other accessories driven by belt.**

c) **Tag the engine indicating preservation process date and due date for next preservation (6 months period).**

ENGINE PRESERVATION PROCESS
DATE :

THE ENGINE HAS BEEN TREATED FOR PRESERVATION FOR A PERIOD OF SIX MONTHS.

DUE DATE FOR NEXT PRESERVATION PROCESS (IF NOT INSTALLED IN THE EQUIPMENT).
DATE :

3) **Engine preservation procedure for engines installed in equipment.**

Many times, the engines shipped from factory are installed on the equipment or Genset within six months from date of shipment from factory. However these engines as installed in the equipment are not put in the service for a long period. For such engines the engine coolant and engine lub oil is generally filled in the engine. Hence no special ensis process is required, but periodic running of engine as given below is mandatory requirement.

Run the engine once in every week for 5 to 10 min. at Low Idle rpm. "B" check to be carried out at every six months as mentioned in Section 6.

4) **Preparing a preserved (treated) engine for putting in service.**

When an engine is removed from storage and put into service the operation listed below should be performed.

i) Clean off all accumulated dirt from exterior of engine

ii) Remove all protective caps, tape and wrappings from connections such as Breathers, Fuel in and out, connection, Water in and out connections etc.

iii) Use suitable solvent, cleaner or degreaser to remove rust preventive compound from unpainted external surfaces of the engine

iv) Refill oil pan with fresh lubricating oil. Replace the fuel, lub oil filters and lub oil bypass filters, only in case wherein engine is stored beyond six months from the date of shipment.

v) Check and correct the engine belt tensioning.

vi) Refer Section 1 for engine starting instructions.

vii) In case of any doubts, contact Cummins Distribution& Business unit / Dealer.

Down-Hill Operation

The Cummins Diesel Engine is effective as a brake on downhill grades, but care must be exercised not to overspeed the engine going downhill. The governor has no control over engine speed when it is being pushed by the loaded vehicle. Overspeeding will cause severe damage to the engine.

Section 2 -
Maintenance Operations

Section 2 - Maintenance Operation

Section Contents

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Maintenance Operations

Maintenance is the key to lower operating costs. A diesel engine requires regularly scheduled maintenance to keep it running efficiently.

Maintenance Operation

1. PREVENTIVE MAINTENANCE

Preventive maintenance is the easiest and least expensive type of maintenance. It permits the Maintenance Department to do the work at a convenient time.

a. A Good Maintenance Schedule Depends on Engine Application

Actual operating environment of the engine governs the maintenance schedule. The suggested check-sheet on the following page indicates some checks have to be performed more often under heavy dust or other special conditions.

b. Using the Suggested Schedule Check Sheet

The maintenance schedule check-sheet is designed as a guide until adequate experience is obtained to establish a schedule to meet a specific operation.

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for hours of operation, or calendar of time.

A maintenance schedule should be established using the check-sheet as a guide; the result will be a maintenance program to fit a specific operation.

The check-sheet shown can be reproduced by any printer. The person making each check can then indicate directly on the sheet that the operation has been completed. When a complete column (Under A. B, C, etc.) of checks is indicated, the engine will be ready for additional service until the next check is due.

c. Storage for Engines Out of Service

If an engine remains out of service and its use is not immediately forthcoming, special precautions should be taken to prevent rust as per procedure given in Section 1.

Maintenance Schedule

CUMMINS DIESEL ENGINES

FOR NTA-855-D(M) MARINE ENGINE

Maintanance Schedule

Cummins Diesel Engines

Equipment No. _______________
Mechanic ___________________
Time Spent _________________
Parts Order No. _____________

Engine Serial no. _____________
Hours, Calender ______________
Check Performed _____________
Date ________________________

Check each operation as performed.

Daily (Section 3)	300 Hours or 6 Mons. (Section 4)	1500 Hours or 1 Year (Section 5)	6000 Hours or 2 Years (Section 6)	Seasonal (Section 7)	Other (Section 8)
	Repeat Daily Check	**Repeat Previous Intervals**	**Repeat Previous Intervals**		
❑ Check ship's log ❑ Check engine: • Oil Level • Coolant level (If make up coolant is required, DCA4 concentration **must** be checked.) • Fuel Level ❑ Visually check engine for damage, leaks, loose or frayed belts and listen for unusual noises ❑ Drain water/sediment from fuel tanks and fuel filters/water separator. ❑ Clean raw water strainer ❑ Check Engine Monitor System ❑ Record all operating temprature and pressure in ship's log. ❑ Cooling system inspection ❑ Marine Gear oil level check ❑ See Note (5)	❑ (2) Change engine oil ❑ Change filters • Oil full flow • Oil by-pass • Fuel filter • Water filter • Fuel Water Seperator ❑ Check coolant • Check engine coolant D.C.A. concentration level. Add make-up D.C.A. if required. ❑ Check Antifreeze concentration ❑ Clean/change • Crankcase breather ❑ Check batteries ❑ Check all belts ❑ Check belt tension ❑ (1) Check air cleaner: • Check piping, hoses, and clamps • Check restriction indicator • Replace air cleaner element as required.. ❑ (4) Check heat exchanger zinc plugs ❑ Wiring Inspection	❑ Steam clean engine ❑ (3) Adjust cross-heads, valves and injectors ❑ Check engine protection system ❑ Check/replace hoses as required ❑ Tighten mounting bolts ❑ Check crankshaft end clearance ❑ Inspect • Raw water pump ❑ (5) Change • Marine gear oil ❑ Flush • Marine gear oil cooler • Heat exchanger	❑ Clean and calibrate injectors and fuel pump ❑ Inspect/check the following assemblies: • Turbocharger • Vibration damper • Water pump ❑ Clean and flush cooling system • Replace coolant ❑ Calibrate engine protection system ❑ Thermostat and seals replacement ❑ Throttle Travel checking • (VS) Throttle linkage adjustment	❑ Replace hose as required ❑ Clean engine/marine gear ❑ Check safety controls ❑ Prepare engine for winter storage if required ❑ Check cold start aids	❑ Clutch or Marine Gear ❑ Switches ❑ Fuel tanks ❑ Turbocharger ❑ Throttle and gear cables

Note: Under circumstances where hours of operation are not accumulated at a fast rate, use calendar time. In other words, use hours, or calendar time, whichever comes first. The above schedule keeps repeating as time goes beyond 2 years.

(1) **Cummins Engine Company, Inc., recommends the use of dry type air cleaners.**

(2) Refer to Section V for alternate method of determining safe oil drain intervals.

(3) Cummins has found that engines in most applications will not experience significant valve/injector train wear after an initial adjustment is made at 1500 hours. After this adjustment, it is recommended that the valves and injectors not be adjusted again previous to injector calibration at the 6000 hour or 2 year interval, if required.

(4) Depending upon the quality of electrical bonding and water conditions, increased maintenance of the zinc plugs may be required.

(5) Check the marine gear manufacturer's operators manual for specifications, oil change intervals and recom- mendations. Some manufacturers require changing the marine gear oil for the first time after 50 hours of operation, then at one year intervals. Some also require the oil to be changed if the gear has **not** been operated for over 6 months.

MAINTENANCE SCHEDULE FOR STARTER AND ALTERNATOR

PRODUCT	DAILY MAINTENANCE	WEEKLY MAINTENANCE	MONTHLY MAINTENANCE	QUARTERLY MAINTENANCE
BS5 Starter	Check tightness of Battery and circuit connections Check visually battery electrolyte level.	Check battery specific gravity.	Top up *DE Shield reservoir with Multi grade 20W40 (API-CD) oil.	Remove **CE cover and smear Molybdenum Sulphide grease over CE bearing pin. Clean the brush dust inside the starter and secure CE cover properly. Apply Elcoprine sealing compound around cover. Check the tightening torque of all fasteners.
SM130 PE Starter	Same as BS5 starter	Same as BS5 starter	Top up DE and CE Shield with Multi grade 20W40 (API-CD) oil. Check tightening torque of all fasteners.	Lubricate pinion on shaft with MOS2 grease OKS-410
AC5 Alternator	Check belt tension. Check tightness of output and WL terminal connections.	——	Check battery terminal voltage while charging. Clean and apply petroleum jelly for battery terminals.	Check tightening torque of all fasteners. Check the smoothness of ball bearings.

* DE - Drive end
** CE - Commutator end

GENERAL INSTRUCTIONS :

Ensure the panel switch is not stickily.
Do not crank the starter more than 20 seconds.
If the clutch slip noise is heard, do not try to start the engine.
Check whether Warning Lamp 'goes off' when the engine is started.
Before starting the engine, check warning Lamp glows when the engine is started.
Ensure the correct wattage of Warning Lamp. The wattage of the bulb to be 2.2 Watt.

Engine Log Book

ENGINE STARTED AT ________ HRS. _______ HRS. ________ HRS. HOURS RUN TILL YESTERDAY _______________ GENSET ROOM

ENGINE STOPPED AT ________ HRS. _______ HRS. ________ HRS. HOURS RUN TODAY ________________________ TEMPERATURE________

TOTAL ____________________ HRS _______ HRS. ________ HRS. TOTAL HOURS ______________________________ DATE : _______________

ENGINE							ALTERNATOR					
				(HEAT EXCHANGER RAW WATER)								
TIME (HRS.)	L.O.P.	L.O.T.	W.T.	TEMP. - IN	TEMP. - OUT	PRESS	VOLTAGE	CURRENT	HZ	PF	KW	KWh

DIESEL FILLED __________LTS. __________HRS.__________LTS.__________HRS.

LUB OIL TOP UP __________LTS. __________HRS.__________LTS.__________HRS.

OBSERVATION REGARDING SMOKE CONDITION, LEAKAGES IF ANY, ENGINE SOUND ETC.

Maintenance due after______________________Hrs.__________Carried out detail.

SAMPLE FOR REFERENCE ONLY

SCHEDULED MAINTENANCE

Schedule 1, Schedule II

The maintenance schedules should be used to establish maintenance practices for Cummins standby or continuous duty generator sets.

Schedule I is used with standby applications. (Refer page 3.7)

Standby rated generator sets are for supplying electric power in the event of normal utility power failure. **No overload capability is available for this rating. This rating may be used for continuous service for as long as the emergency may last.** This rating conforms with the BS 5514 / ISO 3046 1987 overload rating and DIN “B” 6270.

Schedule II is used with continuous duty applications. (Refer page 3.8)

Continuous duty rated generator sets are for supplying electric power in lieu of commercially purchased power. Intermittent overloads up to the standby rating are allowable. This rating may be used for continuous service in commercial applications and it conforms with BS 5514 / ISO 3046 1987 and DIN “A” 6270 for generator set applications.

Using The Suggested Schedule Check Sheet

Actual operating environment of the engine governs the maintenance schedule. The suggested check sheet indicates some checks have to be performed more often under heavy dust or other special conditions.

The maintenance schedule check sheet is designed as a guide until adequate experience is obtained to establish a schedule to meet a specific operation.

A detailed list of component checks is provided through several check periods; also a suggested schedule basis is given for hours of operation, or calendar of time.

A maintenance schedule should be established using the check sheet as a guide; the result will be a maintenance program to fit a specific operation.

Cummins Standby Generator Sets

Cummins standby generator sets may be required to start and come on line in 10 seconds or less.

These engines must be equipped with engine coolant heaters capable of maintaining coolant temperature at a minimum of 100°F (38°C).

Engines subject to ambient temperatures 0°C and below must also be equipped with a lubricating oil heater. When using a lubricating oil heater Immersed in oil, the maximum temperature of heater surface in contact with oil, should be less than 300°F (149°C) to minimize formation of hard carbon on the heating element.

Standby units should be operated once a week under a minimum of 25% of rated KW load for at least thirty minutes. During this test, the engine must reach normal operating temperature.

Cummins Continuous Duty Generator Sets

Continuous duty generator sets may be equipped with a cold starting aid. Maintenance procedure for these devices can be found in the seasonal maintenance section.

Stand-By Duty Generator Set Maintenance

Schedule I

Engine Systems	Schedule I		Checks: Daily	A Weekly	Monthly	B 6 Mos./ 300* Hrs.	Annual
Lubricating	Check:	— For Leaks	●	●	●	●	●
		— Operation of Oil Heater	●	●	●	●	●
		— Engine Oil Level		●	●	●	●
		— Hydraulic Governor Oil Level		●	●	●	●
	Change:	— Full Flow Filter				●	●
		— By-Pass Filter				●	●
		— Engine Oil				●	●
		— Hydraulic Governor Oil				●	●
Cooling	Check:	— For Leaks	●	●	●	●	●
		— For Radiator Air Restriction			●	●	●
		— Operation of Coolant Heater	●	●	●	●	●
		— Hose and Connections			●	●	●
		— Coolant Level		●	●	●	●
		— Anti-Freeze and Concentration of Coolant			●	●	●
		— Belt Condition and Tension			●	●	●
		— Fan Hub. Drive Pulley and Water Pump					●
		— Heat Exchanger Zinc Anode Plugs				●	●
		— Motor operated Louvers			●	●	●
	Change:	— Water Filter				●	●
	Clean:	— Water Separator	●			●	
		— Cooling System				●	
Air Intake	Check:	— For Leaks			●	●	●
		— Air Cleaner Restriction		●	●	●	●
		— Piping and Connections				●	●
	Clean:	— Crankcase Breather				●	●
		— Or Change Air Cleaner Element				●	●
Fuel	Check:	— For Leaks	●	●	●	●	●
		— Fuel Level			●	●	●
		— Governor Linkage				●	●
		— Fuel Lines and Connections				●	●
		— Fuel Transfer Pump			●	●	●
	Drain:	— Sediment from Tanks				●	●
	Change:	— Fuel filters				●	●
		— Float Tank Breather					●
Exhaust	Check:	— For Leaks			●	●	●
		— For Exhaust Restriction			●	●	●
	Drain:	— Condensate Trap			●	●	●
	Torque:	**— Exhaust Manifold and Turbocharger Capscrews**					●
Electrical	Check	— Battery Charging System		●	●	●	●
		— Battery Electrolyte level and Specific Gravity			●	●	●
		— Safety Controls and Alarms				●	●
Engine Related	Check:	— For Unusual Vibration		●	●	●	●
		Tighten Mounting Hardware					●
	Clean:	— Engine					●
Main Generator	Check:	— Air Inlet and Outlet for Restriction			●	●	●
		— Windings and Electrical Connections					●
		— Operation of Generator Heater Strips					●
	Grease:	— Bearing					●
		Measure and Record Generator Winding Resistance					●
	Check/Clean:	— Generator				●	●
Switch gear	Check:	— Start Switch in Automatic	●	●	●	●	●
		— Instrumentation					●
		— Power Distribution Wiring and Connections				●	●
		— power Circuit Breaker				●	●
		— Transfer Switch			●	●	
Operational Procedures	perform:	— Operational Load Test		●	●	●	●
		— Generator Load Bank Test					●
	Check:	— Service Tool Availability			●	●	●

Continuous Duty Generator Set Maintenance

Engine Systems		Schedule II	Checks A: Daily	B: 6 Mos./ 300* Hrs.	C: 1 Year/ 1500 Hrs.	D: 2 Years/ 6000 Hrs.	Annual
Lubricating	Check:	— For Leaks	●	●	●	●	●
		— Operation of Oil Heater					●
		— Engine Oil Level	●	●	●	●	●
		— Hydraulic Governor Oil Level	●	●	●	●	●
	Change:	— Full Flow Filter		●	●	●	●
		— By-Pass Filter		●	●	●	●
		— Engine Oil		●	●	●	●
		— Hydraulic Governor Oil		●	●	●	●
Cooling	Check:	— For Leaks	●	●	●	●	●
		— For Radiator air Restriction	●	●	●	●	●
		— Operation of Coolant Heater					●
		— Hose and Connections	●	●	●	●	●
		— Coolant Level	●	●	●	●	●
		— Anti-Freeze and Concentration of Coolant		●	●	●	●
		— Belt Condition and Tension	●	●	●	●	●
		— Fan Hub. Drive pulley and Water Pump		●	●	●	●
		— Heat Exchanger Zinc Anode Plugs					●
	Change:	— Water Filter		●	●	●	●
	Clean:	— (Water Separator)	●				
		— Cooling System			●		
Air Intake	Check:	— For Leaks	●	●	●	●	●
		— Air Cleaner Restriction	●	●	●	●	●
		— Piping and Connections		●	●	●	●
	Clean:	— Crankcase Breather		●	●	●	●
		— Or Change Air Cleaner Element		●	●	●	●
Fuel	Check:	— For Leaks	●	●	●	●	●
		— Governor Linkage		●	●	●	●
		— Fuel Lines and Connections		●	●	●	●
	Drain	— Sediment from Tanks	●	●	●	●	●
	Change:	— Fuel Filters		●	●	●	●
	Clean:	— Float Tank Breather	●	●	●	●	●
		— and Calibrate Injectors				●	
		— and/or Calibrate Fuel Pump				●	
		Adjust Injectors and Valves			●	●	
Exhaust	Check:	— For Leaks	●	●	●	●	●
		— For Exhaust Restriction			●	●	●
	Clean:	— Turbocharger Comp. Wheel and Diffuser				●	
	Check:	— Turbocharger Bearing Clearances				●	
		— Torque Exhaust Manifold and Turbocharger Capscrews				●	●
Engine Related	Check:	— For Unusual Vibration	●	●	●	●	●
		— Vibration Damper				●	
		— Crankshaft End Play					●
		Tighten mounting Hardware				●	
	Clean:	— Engine				●	
	Grease:	— Fan Pillow Bloc Bearings		●	●	●	●
Electrical	Check:	— Battery Charging System				●	
		— Batter Electrolyte Level Specific Gravity		●	●	●	●
		— Grow Plug					●
		— And Clean Magnetic Pickup Unit			●	●	
		— Safety Control and Alarms			●	●	
Main Generator	Check:	— Air Inlet and Outlet for Restriction	●	●	●	●	●
		— Windings and Electrical Connections	●	●	●	●	●
		— Operation of Generator Heater Strips					●
	Grease:	— Bearing			●	●	
	Clean:	— Generator					●
Switchgear	Check:	— Power Distribution Wiring and Connections	●	●	●	●	
		— Power Circuit Breaker			●	●	
		—Transfer Switch			●	●	
Operational Procedures	Perform:	— Generator Load bank Test					●

NOTES

Section 3 -
“A” Maintenance Checks – Daily/Weekly

Section 3 - “A” Maintenance Checks - Daily

Section Contents

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"A" Maintenance Checks – Daily / Weekly

Make a Daily Report of Engine Operation to the Maintenance Department

The engine must be maintained in top mechanical condition if the operator is to get optimum satisfaction from its use. The maintenance department needs daily running reports from the operator to make necessary adjustments in the time allotted and to make provisions for more extensive maintenance work as the reports indicate the necessity .

Comparison and intelligent interpretation of the daily report along with a practical follow-up action will eliminate practically all failures and emergency repairs.

Report to the Maintenance Department any of the following conditions:

1. Low lubricating oil pressure.
2. Low power.
3. Abnormal water or oil temperature.
4. Unusual engine noise.
5. Excessive smoke.
6 Excessive use of coolant, fuel or lubricating oil.
7. Any fuel, coolant or lubricating oil leaks.

Check Engine

Check Engine Oil Level

1. Check oil level with dipstick oil gauge located on the engine. Fig. 3-1. For accurate readings, oil level should not be checked for approximately 15 minutes after engine shut-down. Keep dipstick with the oil pan with which it was originally shipped. Keep oil level as near "H" (high) mark as possible.

Caution: Never operate the engine with oil level below the "L" (low) mark or above the "H" (high) mark.

Fig. 3-1. Checking engine oil level

2. If necessary, add oil of the same quality and brand as already in the engine. See Section 10.

Check Belts

Visually check belts for looseness. If there is evidence of belt slippage adjust as follows :

Using appropriate gauge, Fig. 3-2 check and / or adjust belts to tension as indicated in Table 4-1.

In-line Engine Water Pump Belts (No Idler)

1. Eccentric Water pump adjustment.
   a. Loosen water pump clamp ring to allow pump body to turn.
   b. Loosen pump body by pulling up on belts. A sharp jerk may be required
   c. Insert bar in water pump body slots and rotate pump body counterclockwise to tighten belts.

Note : Do Not adjust to final tension at this time.

   d. Snug clamp ring capscrew farthest from belts, on exhaust side to 5 ft-lbs (7 N•m).
   e. Snug two capscrews above the first one to 5 ft-lbs (7 N•m).

Fig. 3-2. Checking belt tension with ST-1138

f. Finish tightening by tightening alternate link in 5 ft-lbs (7 N- m) increments to a final torque of 12 to 15 ft-lbs (16 to 20 N•m).

g. Check belt tension.

Final belt tension was not obtained by adjustment alone. The water pump body was pulled straight by snugging the capscrews in the order described, thus increasing belt tension to final value.

Table 3-1: Belt Tension (Pounds)

Belt Width Inches	Belt Gauge No.	* New Belt Tension ± 10	** Belt Tension After Run-in ± 10
Standard "V" Belt			
1/2	ST-1274	140	100
11/16	ST-1138	140	100
3/4	ST-1138	140	100
7/8"	ST-1138	140	100
Poly-V			
6 Rib	ST-1293	150	130

* New belts must be re-tensioned to values listed under "New Belt Tension".

** Used belts should be retensioned to values listed under "Belt tension after run-in"

In-line Engine Water Pump Belts (With Idler)

1. Loosen locknut securing idler pulley to bracket or water pump. Fig. 3-3.
2. Tighten water pump idler pulley bolt till sufficient tension is obtained. Retighten locknut securing idler pulley to idler bracket to 45 to 55 ft. lbs.
3. Check belt tension as per Table 3-1.

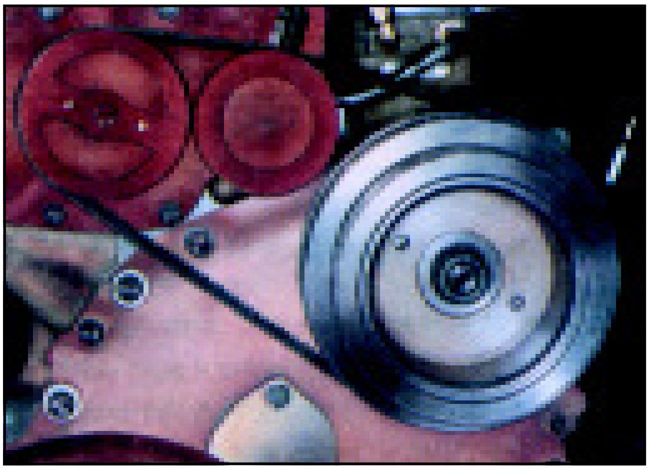


Fig. 3-3. Water pump with idler on NH/NT series engine

Fan Drive Belts

1. Loosen large locking nut using rachet spanner 3244252 on fan hub shaft or capscrews securing fan hub shaft to mounting bracket. The fan hub will fall out of line when this is done.
2. Turn the adjusting screw to increase belt tension.
3. Tighten the locknut or capscrews until the fan hub is straight. Snug the nut to maintain hub in proper alignment with the fan hub bracket.

Caution : Do not adjust to full tension with the adjusting screw, this would result in over-tightening.

4. Belt tension should read as indicated in Table 4-1 on applicable gauge.
5. Tighten NH/NT Engines locknut to 350 ft-lbs using ratchet spanner 3244252. Tighten the four 1/2 inch capscrews Fig. 4-5 on NT FFC Engines to 75 to 85 ft-lbs (101 to 115 N•m)
6. Recheck belt tension.
7. Back out adjusting screw one-half turn to prevent breakage

Generator/Alternator Belts

Belt tension should be as indicated in Table 3-1 when measured with the applicable gauge.

Belt Installation

If belts show wear or fraying replace as follows :

1. Always shorten distance between pulley centers so belt can be installed without force.

Never roll a belt over the pulley and never pry it on with a tool such as a screwdriver. Either of these methods will damage belts and cause early failure.

2. Always replace belts in complete sets. Belts riding depth should not vary over 1/16 in (1.6 mm) on matched belt sets.

3. Pulley misalignment must not exceed 1/16 in (1.6 mm) for each ft (0.3 m) of distance between pulley centers.

4. Belts should not bottom on pulley grooves nor should they protrude over 3/32 in (2.4 mm) above top edge of groove.

5. Do not allow belts to rub any adjacent parts.

6. Adjust belts to proper tension.

Readjusting New Belts

All new belts will loosen after running for 5 minutes and must be readjusted to “belt tension after run-in” Ref. Table 3-1.

Check for Damage

Visually check fuel system, etc., including AFC fuel pump, for misadjustment or tampering; check all connections for leaks or damage. Check engine for damage; correct as necessary.

Check Engine Coolant Level

Keep the cooling system filled to the operating level. Check the coolant level daily or at each fuel fill point. Investigate for causes of coolant loss. Check the coolant level only when the system is cool.

Drain Sediment from Fuel Tanks / Fuel Filter / Water Separator

Loosen the fuel tank drain cock or plug, if used, and drain approximately 1 cup of fuel to remove water and sediment. Close the drain cock or plug.

If more moisture than usual is present when checking the fuel tanks, it may be advisable to install a water separator.

Contact the nearest Cummins Dealer for a water separator that meets requirements.

Drain plugs are located in the bottom of some fuel filter cases and in the sump of some fuel supply tanks. More condensation of water vapor occurs in a partially filled fuel tank than in a full one. Therefore, fuel supply tanks should be kept as nearly full as possible. Warm returning fuel from the injectors heats the fuel in supply tank. If the fuel level is low in cold weather, the fact, that upper portion of the tank is not being heated by returning fuel, tends to increase condensation. In warm weather both the supply tank and the fuel are warm. In the night, however, cool air lowers the temperature of the tank much more rapidly than the temperature of the fuel. Again this tends to increase condensation.

The general construction of the fuel and water separator is as shown in Fig 3-6. It uses centrifuging principle for separating out the water or sludge from diesel. The water or sludge is collected in the bottom of the polycarbonate plastic can and is drained out manually by operating the drain valve provided at the bottom of the can. For this operation, the engine should be shut down and upper handle is required to be unscrewed so as to induct atmospheric pressure on the can. After draining out water/sludge, close the drain valve and tighten the top ‘T’ handle.

When vacuum drop is 8.00 inches (203.2 mm) of mercury column replace the filter assembly.

Cummins India Limited has also developed a water separator which can be used with the existing fuel filter assembly. This water separator should be connected in between fuel tank and fuel filter with suitable hoses. For construction of this water separator refer Fig. No. 3-6. The instructions to drain water/ sludge are given on its Decal. These decals are applied on the filter container/plastic can. The instructions should be read and followed precisely to get the satisfactory performance from this filter and water separator unit. Cummins India Limited recommends that fuel filter & water separators be checked and drained daily (more often if extreme conditions exist until the precise condition of the fuel is known). Only after this evaluation you can determine the service interval that can safely be used for your particular application without exceeding the water reservoir capacity.

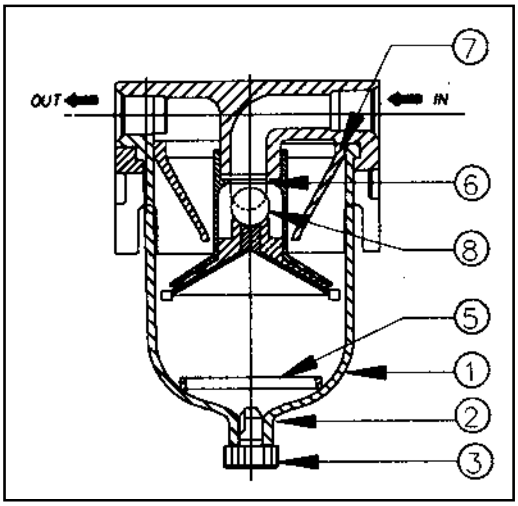


Fig. 3-4 Water separator

Ref. No.	Description	Ref. No.	Description
01	Bowl	05	Float
02	Seal O ring	06	Seal (ball check)
03	Valve drain	07	Seal ring
		08	Ball check

Fill Marine Gear

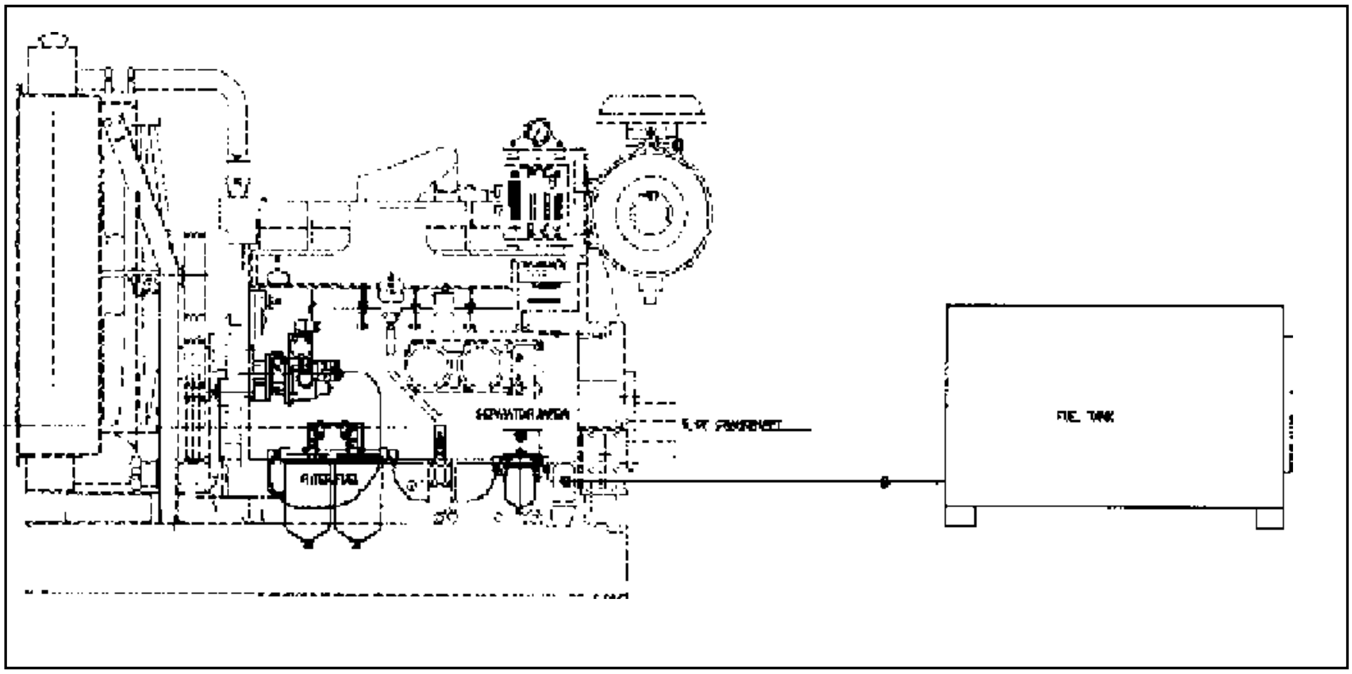
The marine gear is a separate unit and carries its own lubrication. Fill housing according to manufacturer's recommendations.

Caution : Never operate marine gear with oil level below "L" mark or above "H" mark on dipstick.

Check Raw Water Pump Oil Level (If oil sump is provided) (For Marine Engines only)

Check oil level in raw water pump if pump has an oil sump.

1. Remove pipe plug from side of pump.
2. Fill housing with hypoid SAE 90 oil; replace plug.



Typical Layout for Water Separator & Fuel Filter on Engine

Section 4 -
“A” Maintenance Checks – Weekly

Section 4 - "A" Maintenance Chec ks - Weekly

Section Contents

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"A" Maintenance Checks – Weekly

Check Air Cleaner

Clean Pre-Cleaner and Dust Pan

Under extremely dirty conditions an air pre-cleaner may be used. Clean pre-cleaner jar and dry-type air cleaner dust pans daily or more often, as necessary, depending on operating conditions.

Check Inlet Air Restriction

Vacuum Indicator

A mechanical restriction indicator is available to indicate excessive air restriction through a dry type air cleaner. This unit can be mounted in air cleaner outlet or on vehicle instrument panel. The red flag (Fig. 4-1) in window gradually rises as cartridge loads with dirt. After changing or replacing cartridge, reset indicator by pushing reset button .

Fig. 4-1. Air inlet restriction indicator

Air restriction on turbocharged / aftercooled engines must not exceed 25 inches (635 mm) of water column.

Air restriction for naturally aspirated engines must not exceed 20 inches (508 mm) of water column.

Clean or Replace Air Cleaner Elements

Many air filter manufacturers discourage the practice of cleaning air cleaner elements. The paper of filter element gets weakened as a result of cleaning and can lead to rupture / microscopic damages. Also inspection of the filter element after cleaning is difficult. Hence, it is suggested to replace the filter element for longer engine life before first overhaul. However, if you decide to clean your filter element following are the suggestions -

1. Clean only outer element. Never remove inner element for cleaning. Inner element should be removed only for the replacement.
2. Outer element should be removed for the cleaning only when red band appears on the vacuum indicator. It is observed that elements are cleaned frequently to keep the system clean. But this practice leads to damage to the paper element as well as problems associated with handling and too frequent opening and closing the air intake system.

Suggested procedure to clean the outer element

Always use clean, dry air on a dry filter element. The air pressure should not exceed 60 PSI. Direct the compressed air through the filter element from the clean side i.e. inside to outside, running the nozzle up and down the filter element.

Don't bring the nozzle in contact with the paper of filter element, as damage is likely to occur.

Do not direct the air jet from outside to inside. This will make the dirt to penetrate the paper, allowing the dirt to go into the clean side, damaging the engine. Penetration of dirt will make tiny holes, reducing the efficiency.

Handle the element carefully. Do not strike the element against hard surface to loosen the accumulated contaminants.

Cleaning will reduce the dust holding capacity of the filter element. Replace the outer element after 4/5 cleanings or as soon as the red band appears even after cleaning.

Inspection of the element after cleaning. (Ref. Fig 4.2)

If small holes or parts are found on element when it is checked with an electric bulb after cleaning and drying, replace the element.

Do not use element whose folds or gasket or seal is damaged.

Caution : Holes, loose end seals, dented sealing surfaces and other forms of damage render cleaner in-operative and require immediate element replacement.

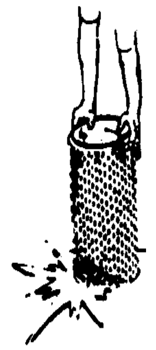
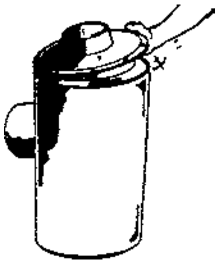


Fig. 4.2 Element checking with electric bulb

AIR CLEANER SERVICE TIPS

Don't remove element for inspection.



Such a check will always do more harm than good. Ridges of dirt on the gasket sealing surface can drop on the clean filter side when the gasket is released. Stick with the regular maintenance schedule, or, if you service by restriction, believe the gauge or restriction indicator. Get a new indicator if you don't trust your current one.

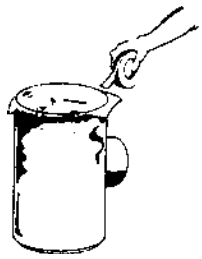
Never rap a filter to clean it.

Rapping hard enough to knock off dust damages the filter and destroys your engine protection. Deeply embedded dirt is never released by tapping. It is always safer to keep operating until you can change to a fresh Filter.

Never judge the filter's life by looking at it......
Measure the airflow restriction.

A dirty-looking filter may still have plenty of life left, while carbon contamination is not visible to the eye. You can't see the dirt that's embedded deep within the filter paper. Your best bet for lowest filter maintenance costs and best engine performance is to follow a restriction gauge. It's a smart, low-cost investment.

Never leave an air cleaner open longer than necessary.

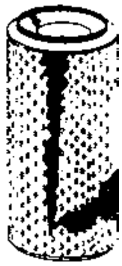


Your open air cleaner is a direct entry to the engine! Keep it protected during Filter changes. If the housing is not going to be reassembled immediately, cover the opening. The only way to be sure nothing got in, is to make sure nothing can get in!

Don't ignore a worn or damaged gasket in the housing.

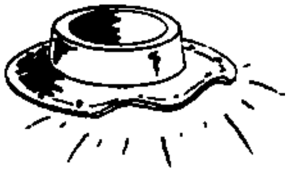
If your air cleaner has a cover gasket, replace it with a new one. Always check to be sure that no piece of the old gasket remains in the housing and that the gasket is not worn. If your filter model calls for a new gasket with each use, never reuse the old one.

Don't use a damaged or bunched filter.



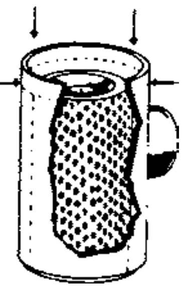
Never install a dented or punctured filter because it cannot protect properly against contamination. A dent can make a firm seal impossible or can indicate damaged media. A filter with bunched pleats saps engine power and fuel dollars.

Never use a warped cover on a housing.



Replace it with a new cover as soon as possible. A warped or damaged cover cannot make a proper seal. Also check to ensure that there is no damage to the air cleaner housing that could cause a leak.

Never substitute an incorrect element model number.



Filters may look almost identical, but even a fraction of an inch difference in size can prevent a good seal or affect cfm delivery. It's always better to use the dirty filter until you can get the correct one.

7-STEP FILTER ELEMENT REPLACEMENT

1. Remove the old element gently 'Baby' that dirty filter, until you get ii clear of the housing. Accidentally bumping it while still inside means dropped dirt and dust that will contaminate the clean side of your filter housing, before the new filter element has a chance to do its job.

2. Always clean the inside of the housing carefully Dirt left in the air cleaner housing spells death for your engine. Use a clean, damp cloth to wipe every surface clean. Check it visually to make sure it's clean before putting in a new filter.

3. **Always clean the gasket sealing surfaces of the housing**

   An improper gasket seal is one of the most common causes of engine contamination. Make sure that all hardened dirt ridges are completely removed, both on the bottom and top of the air cleaner.

4. **Check for uneven dirt patterns**

   Your old filter has valuable clues to dust leakage or gasket sealing problems. A pattern on the element clean side is a sign that the old filter element was not firmly sealed or that a dust leak exists. Identify the cause of that leak and rectify it before installing a new filter.

5. **Press your fresh gasket to see that it springs back**

   Make sure your new filter is made with a highly compressible gasket that springs back (promptly) when finger pressure is released. A high quality gasket is one of the most important parts of the filter.

6. **Make sure the gash seats evenly**

   If you don't feel the gasket seating evenly for a perfect seal, you don't have protection. Re-check to see if the sealing surface in the housing is clean, and ensure that the filter is the correct model. It may be too short for the housing.

7. **Ensure air-tight fit on all connections and ducts**

   Check that all clamps and flange joint are tight, as well as the air cleaner mounting bolts. Seal any leaks irnmediately — leaks mean dirt is directly entering your engine

PROPER SERVICING IS ESSENTIAL

Proper air cleaner servicing results in maximum engine protection against the ravages of dust. Proper servicing can also save you time and money by maximizing filter life and air cleaning efficiency.

Two of the most common problems are:

A) *Over Servicing.* New filters increase in dust cleaning efficiency as dust builds up on the media. Don't be fooled by filter appearance! The filter should look dirty. By using proper filter measurement tools, you will use the full life of the filter at maximum efficiency.

B) *Improper Servicing.* Your engine is vulnerable to abrasive dust contaminants during the servicing process. The most common cause of engine damage is careless servicing procedures.

By following the steps listed above, you can avoid unnecessary risk to the engine.

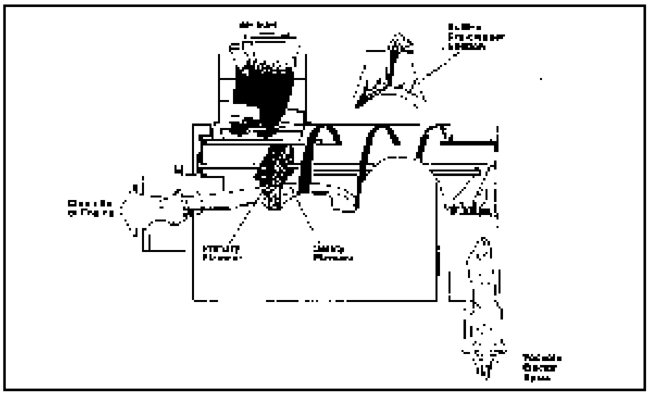


Fig. 4-3. Air cleaner (light duty)

To change element:

1. Loosen clamp assembly which holds cup assembly to body air cleaner.
2. Remove cup assembly.
3. Loosen wing nut of outer element and remove it.
4. Loosen wing nut of inner element and remove it.

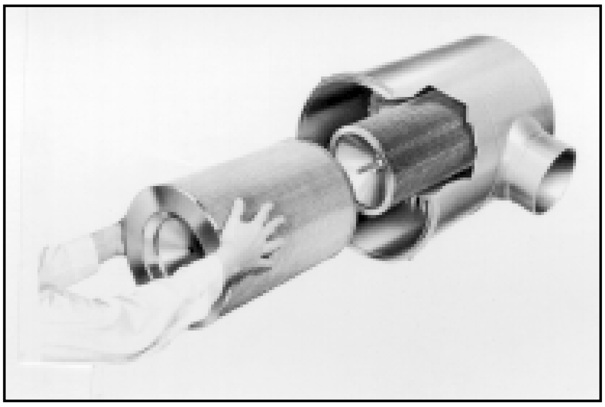


Fig 4.4. Removing elements.

Heavy duty air cleaners have pre-cleaners with cyclone tube in addition to elements.

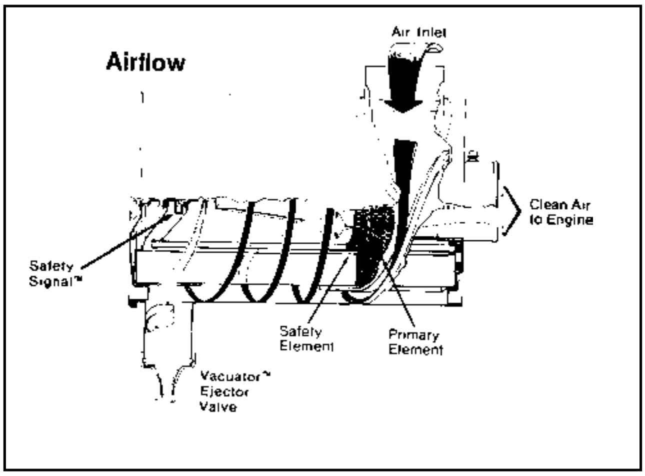


Fig. 4-5. Air cleaner (heavy duty)

Cleaning and Inspection of precleaner (Heavy duty)

1. Clean pre-cleaner openings of all soot, oil film and any other objects that may have become lodged in openings. Remove any dust or dirt in lower portion of pre-cleaner and aspirator tubing. Inspect inside of air cleaner housing for foreign material.

2. Inspect dirty precleaner for soot or oil. If there is soot inside cyclone tubes, check for leaks in engine exhaust system, exhaust "blow-back" into air intake and exhaust from other equipment. If precleaner appears "oily", check for fumes escaping from crankcase breather. Excessive oil mist shortens life of any dry-type precleaner.

3. Inspect clamps and flexible hose or tubing to be sure all fittings are airtight on cleaners with exhaust aspirators.

Drain Air Tanks

In cold weather, condensed moisture in air tanks and lines may freeze and make controls useless.

Drain air tanks to keep all water out of the compressed air system.

Section 5 -
“B” Maintenance Checks –
300 hrs / 6 months

Section 5 - “B” Maintenance Checks - 300 hrs. / 6 months

Section Contents

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"B" Maintenance Checks– 300 hrs / 6 months

B-Check

At each "B" Maintenance Check, perform all the "A" Checks in addition to the following. This check should be carried out at every 300 hour of operation or at every six month.

LUBRICATING OIL SYSTEM

Lubricating Oil Change Intervals

Note : If the lubricating oil is drained from the oil pan to make an engine repair, new oil must be used. Do not use oil after it has been drained from the oil pan.

Maintaining a proper "B" maintenance check interval is a very important factor in preserving the integrity of an engine. Lubricating oil contamination is the direct result of engine operation and load factor involved. The amount of contamination generated depends on the amount of fuel the engine consumes. At each "B" check interval it is recommended to change the full-flow filter and the by-pass filter.

The total lubricating system upto capacity in litres can be determined by adding high level of the lubricating oil in the oil pan and the capacities of the full-flow and bypass filters.

Lubricating Oil Analysis

Lubricating oil and filter change period can be determined by laboratory tests of used oil. The analysis used are for the purpose of determining the amount of contamination in the oil; not for predicting potential engine failures. It is recommended that new engines be operated through at least one oil change interval of 300 hrs/6 months prior to initiating a Used Oil Analysis Program.

In order to initiate a Used Oil Analysis Program for a large number of engines they should be grouped by basic model, rated horsepower and type of service. The horsepower range of a group should not exceed 25. NH, V and K models must be in separate groups. Use common nomenclature for engines. After the engines have been grouped, a sub-group consisting of 10 percent of the total engines in each group should be selected for the Used Oil analysis program. If a group consists of less than 50 engines but more than 25 engines the sub-group size should be 8 engines. The selection of engines for each sub-group should be completely random.

Oil samples should be taken from each of the engines in the sub-groups at every 48-operating-hour interval. This sampling frequency may be varied somewhat as dictated by the operation. The sampling frequency should not be extended beyond 60 hours for equipment safety reason or reduced below 40 hours because of the added analytical costs.

This sampling process should continue until the results of the analysis of the samples indicate that any one of the condemnation limits listed in Table 6-1 has been reached or exceeded until the desired oil change interval extension is reached. This process should be continued cautiously since the engines in the sub-groups are subject to permanent damage because of the over-extended oil change interval. The analytical work on the samples and the examination of the analytical results should be done as quickly and carefully as possible to prevent serious engine damage.

1. Sample valve method
2. Vacuum Pump method
3. Oil drain method

Table 5-1 : Oil Contamination Guidelines

Property	Guidelines
Viscosity change @ 100°C (ASTM D-445)	± 1 SAE Viscosity grade or 4 cSt from the new oil
Fuel Dilution	5 Percent
Total acid number (TAN) (ASTM D-664)	2.5 number increase from the new oil value, maximum
Total base number (TBN) (ASTM D-2896)	2.5 minimum or, one half original (New Oil) value or equal to TAN
Water content ASTM (D-95)	0.2 percent maximum
Potential Contaminants :	
Silicon (Si)	15 ppm increase over new oil
Sodium (Na)	20 ppm increase over new oil
Boron (B)	25 ppm increase over new oil
Potassium (K)	20 ppm increase over new oil
Soot	1.5 percent mass of used oil maximum

NOTE : The contamination guidelines presented above are guidelines only. This does not mean values that fall on the acceptable side of these guidelines be interpreted as indicating the oil is suitable for further service.

*ASTM (The American Society for Testing and Materials) publishes these methods in their Annual Book of Standards, Part 23. Other methods should not be used without consulting Cummins India Limited.

**SAE Viscosity grades are published by the Society of Automotive Engineers in their annual SAE Handbook as SAE Recommended Practice J300d, and are shown in Table 1 of this bulletin.

To determine whether the maximum oil change interval has been reached the properties in Table 6-1 should be determined by the laboratory methods specified. This table also specifies contamination limits to be used for determining the useful life of lubricating oils. This group of analysis and the methods are not generally part of the oil analyses offered by most commercial used oil analysis laboratories.

When any one of the contamination limits is exceeded on any one sample an oil change should be performed on all engines in the sub-group. The hours at which the sample for which a contamination limit was exceeded is the oil change interval at which 10 % or more (depending on sub-group size) of the group are using lubricating oil which has exceeded its useful life. This sampling and analysis process should be repeated once to confirm the oil change interval. When this process is complete the entire group of engines can be placed on the new oil change interval.

This method of establishing an oil change interval will determine a different interval for each group of engines. It is not possible to provide maintenance on several different schedules or if one desires to schedule the oil change to coincide with other maintenance, the more conservative (or shorter) maintenance schedule should be used.

Please contact your Cummins Service Representative if you need assistance or have any questions about utilizing this method of determining an oil change interval.

Oil Sample Collection

Three methods are commonly used to collect oil samples for analysis. They are :

1. **Sample Valve Method :** A valve is installed on the dirty side of the filter. When collecting a sample, the valve is wiped clean; and after the engine is brought up to operating temperature, the valve is opened. Stagnant oil is allowed to flow out, and a sample can be collected from the oil stream being pumped by the engine at idle.

2. **Vacuum Pump Method :** A length of tubing, measured against the dipstick, long enough to reach 25.4 to 51 mm (1 to 2 inches) below the oil level in the sump is attached to a hand operated vacuum pump. Immediately after stopping the engine at operating temperature, pump the sample into a clean, dry bottle. Always replace the tubing after each sampling to avoid the possibility of sample cross-contamination.

3. **Oil Drain Method :** Clean the area around the drain plug to avoid foreign contamination. Immediately after stopping the engine at operating temperature, remove the drain plug. After approximately 8 liters (2 gallons) of oil have streamed out, collect the sample from the continuous stream.

Change Engine Oil

Factors to be checked and limits for oil analysis are listed below. Oil change at “B” Check, as shown in the maintenance chart is for average conditions.

1. Bring engine to operating temperature, shut down engine, remove drain plug from bottom oil pan, and drain oil.

2. Install drain plug in oil pan.

3. Fill the crankcase to “H” (high level) mark on the dipstick.

4. Start engine and visually check for oil leaks.

5. Shut down the engine; allow 15 minutes for oil to drain back into the pan; recheck the oil level with the dipstick. Add oil, as required.

Note : Use lubricating oil, meeting specifications listed in Section 10, and genuine Cummins filters on engines.

Change Lubricating Oil Filter Elements

1. Loosen centre bolt securing lub oil filter to lubricating oil pump.

Fig. 5-1. Changing lub pump mounted filter element.

2. Remove filter element, cut it open and check for metal particles, if found check for source. Discard "O" ring and element. Insert new filter element into the can.

3. Install new rectangular seal on the pilot located on the lub pump.

4. Install can and element assembly with it's mounting bolt and washers.

5. Remove NPTF plug on can, fill clean oil and replace the plug.

6. Torque the can retaining bolt to 30 to 35 ft. lbs. (41 to 47 N•m).

7. Run the engine, check for leaks, recheck engine oil level; add oil as necessary to bring the oil level to "H" mark on the dipstick.

Note : Always allow oil to drain back to the oil pan before checking the level. This may require 15 minutes.

Change Super Lub Oil By-Pass Filter Element

1. Loosen four capscrews from head and remove head super L.O. by-pass filter.

Fig. 5-2. Super L.O. Bypass filter

2. Takeout element and remove ring sealing between head and shell.

3. Replace ring sealing and element. Fill filter with some oil and reassemble.

4. Run the engine, check for leaks, shut down the engine. Add oil as necessary to bring the oil level to the "H" mark on the dipstick.

Clean/Change Crankcase Breather

There are two types of breathers used on CIL engines. Element type breather on naturally aspirated engines and baffle type breather on turbocharged engines. In element type breather used on naturally aspirated engines element is to be changed. **It is not to be cleaned.** On turbocharged engines baffels from breather are to be cleaned.

Element type Breather

1. Remove the wing nut (1 Fig. 5-3), lock washer (2) and plain washer (3).

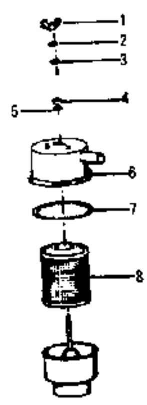

Fig. 5-3. Crankcase Breather-Element type.

2. Remove washer (4) and gasket (5).

3. Lift off the cover (6) and lift out the breather element (8).

4. Discard element, clean cover (6) and body. Inspect the body and cover for cracks, dents or breaks.

5. Install a new breather element (8).

6. Inspect gasket (7). Replace if necessary. Install the rubber gasket (7) in the Cover (6); position the cover assembly to the body.

7. Inspect gasket (5). Replace if necessary. Install the gasket (5), washer (4), (3), (2) and wing nut (1). Tighten securely.

Baffel type Breather – Cleaning and Inspection

Procedure for removing and inspection is similar to element type breather.

After removing baffels. Clean them in suitable solvent. Inspect and replace if necessary.

Install baffels back to the position and assemble the breather assembly as described under element type breather.

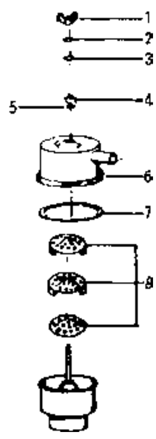

Fig. 5-4. Crankcase breather—Baffel type

Check Oil Levels
Check Aneroid Oil

1. Remove the pipe plug from the hole marked as Lub Oil.

2. Fill with engine lubricating Oil to the level of the pipe plug hole. Reinstall the pipe plug.

Check Hydraulic Governor Oil Level

Keep the level half-way up on the inspection glass or to the high-level mark on the dipstick. **Use the same grade oil as used in the engine.**

COOLING SYSTEM

Effective January, 1998 Cummins engines are provided with Borate base coolant (Coolant Additive Concentrate - (CAC). Cummins engines prior to January, 1998 are provided with Corrosion Resistor arrangement. To ensure adequate corrosion protection checking coolant at every B Check is essential. The checking procedures are detailed below :

1. Check Coolant Additive Concentrate

Coolant Additive Concentrate (CAC) is Borate base chemical compound. When mixed with water in pre-determined quantity, and used as coolant in diesel engine protects internal coolant passages against corrosion, rusting and pitting.

During engine operation the chemicals from CAC are depleted. Coolant Additive Concentrate is added during 'B' check of engine to maintain the concentration level and to replenish the depleted chemicals in following steps. (Refer Annexure Table for CAC requirement at 'B' check for Genset application).

a. Open radiator top tank / heat exchanger expansion tank cap & add Coolant Additive Concentrate.

b. If Coolant Additive Concentrate cannot be accommodated into the cooling system, drain appropriate amount of coolant from the system. This drained coolant can be used for top up if collected & stored in clean container.

c. Do not overfill.

Please refer to Section 10 for coolant checking details.

2. Check Heat Exchanger Zinc Plugs

Check zinc plugs in heat exchanger and change if badly eroded. Frequency of change depends upon chemical reaction of raw water circulated through heat exchanger.

FUEL SYSTEM

Change Fuel Filter Element

Loosen capscrew (1) which holds shell to head. Discard 'O' rings (2) and (3). Similarly discard element fuel filter (4). Install new 'O' rings (2) and (3). Install new element. Fill can with fuel and assemble shell to head with capscrew (1).

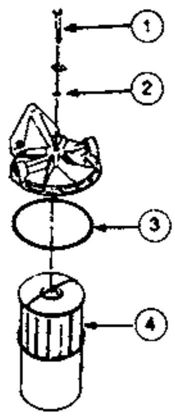

Fig. 5-5. Changing fuel filter element.

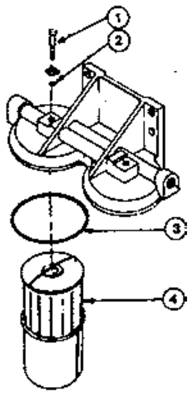

Fig. 5-6. Changing duel elements.

Clean fuel tank breather

Remove and clean fuel tank breather.

Check Throttle Linkage

Operate linkage with hand to check for freeness. Adjust, if necessary.

Check air piping

Visually inspect hoses, pipes for damages / cracks and clamps for looseness. Correct if necessary.

NOTES

Section 6 -
First 1500 Hrs. Check

Section 6 - 1500 Hrs. Maintenance Checks

Section Contents

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First 1500 Hrs. Check

At first 1500 hrs. Check, first perform all "A", "B" and "C" Checks and the following :

Adjust Injectors and Valves

It is essential the injectors and valves be in correct adjustment at all times for the engine to operate properly. One controls engine breathing; the other controls fuel delivery to the cylinders.

Final operating adjustments must be made using correct values as stated.

Caution: Be sure the injector and valve set markings, wherever located, are in proper alignment with the indicator mark.

Engine Temperatures

The following temperature conditions provide the necessary stabilization of engine components to allow for an accurate valve and injector adjustment.

Cummins India Limited recommends that valve and injector plunger adjustments be made when the engine is cold. The engine must be at any stabilized temperature of 60°C(140°F) or below.

A resetting after the engine is warm is not recommended

Warning: Use only proper engine barring techniques for manually rotating the engine. The barring can be done either from accessory drive or from barring mechanism provided on flywheel housing. Do not attempt to rotate the engine by pulling or prying on the fan. This practice may damage fan blade(s) and cause premature fan failure resulting in serious personal injury or property damage.

Injector Adjustment Procedure on 495 engines Using Service Tool ST-1170 (R.H. Engine only) (Dial Indicator Method)

N-855, C.L.D. ENGINES, INJECTOR AND VALVE ADJUSTMENT (DIAL INDICATOR METHOD)

Before adjusting the injectors, torque the cylindrical injector, hold down capscrews in alternate steps to 10 to 12 ft-lbs (14 to 16 N•m). With flange injectors torque the hold-down capscrews in alternate steps to 12 to 14 ft-lbs (16 to 18 N•m). Tighten the fuel inlet and drain connections to 20 to 25 ft-lbs (27 to 34 N•m) in the flange injectors.

Maintenance Adjustment

1. Bar the engine until "A" or 1-6 "VS" mark on the pulley, Fig. 6-1, is aligned with the pointer on the gear case cover. In this position, both valve rocker levers for cylinder No. 5 must be free (valves closed). The injector plunger for cylinder No. 3 must be at top of its travel; if not, bar the engine through 360 degrees. realign the mark with the pointer.

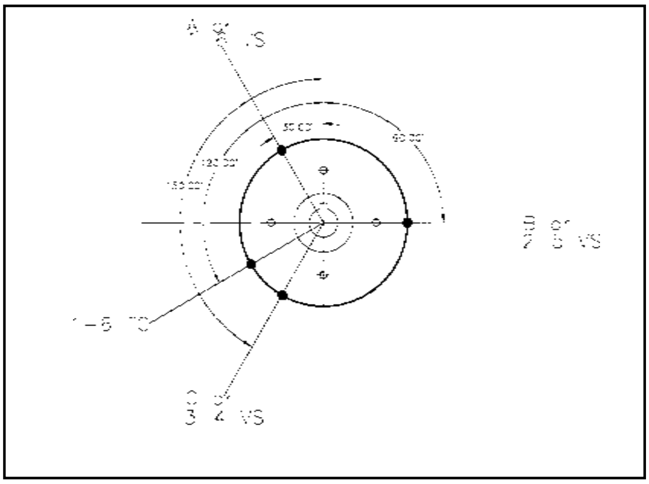


Fig 6-1. Accessory drive pulley marking—N-855

2. Set up ST-1170 Indicator Support with the indicator extension on the injector plunger top at No. 3 cylinder, Fig. 6-2. Make sure that the indicator extension is secured in the indicator stem and not against the rocker lever.

Note : Cylinder No. 3 for injector setting and cylinder No. 5 for valve setting are selected for illustration purposes only. Any cylinder combination may be used as a starting point. See Table 6-1.

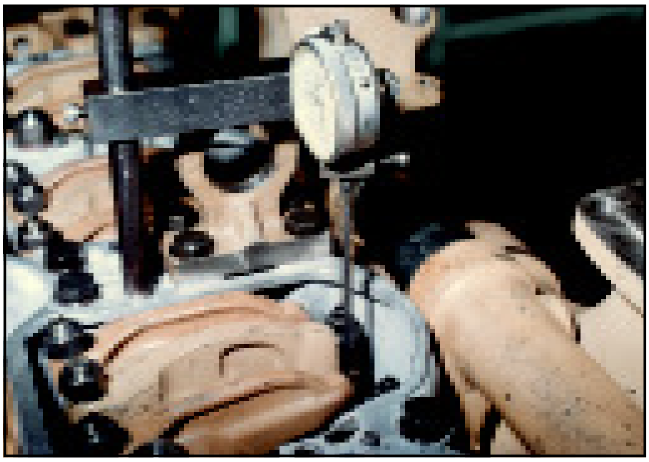


Fig. 6-2. Extension in contact with plunger

Table 6-1 : Injector and Valve Set Position N-855 Engines

Bar in Direction	Pulley Position	Set Cylinder injector	Valve
Start	A or 1-6VS	3	5
Adv. To	B or 2-5VS	6	3
Adv. To	C or 3-4VS	2	6
Adv. To	A or 1-6VS	4	2
Adv. To	B or 2-5VS	1	4
Adv. To	C or 3-4VS	5	1

3. Using ST-1193 Rocker Lever Actuator, Fig. 6-3, or equivalent, bar the lever toward the injector until the plunger is bottomed to squeeze the oil film from the cup. Allow the injector plunger to rise, then bottom again. Set the indicator at zero (0). Check the extension contact with the plunger top.

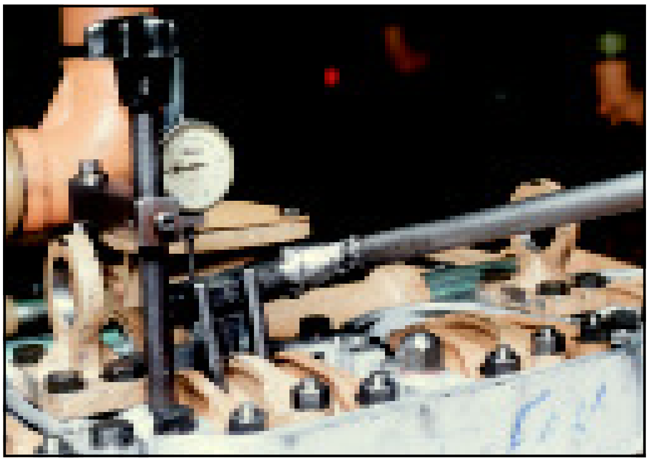


Fig. 6-3. Actuating rocker lever

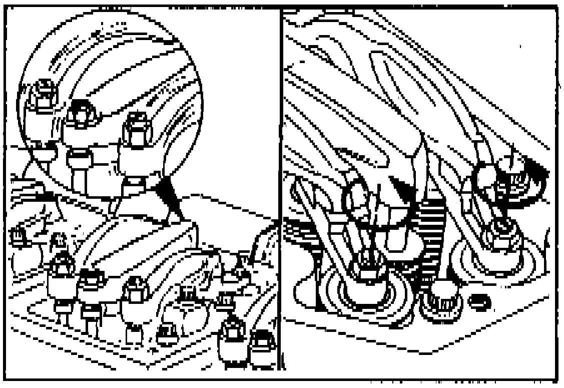
4. Bottom the plunger again, release the lever; the indicator must show travel as indicated in Table 6-2. Adjust as necessary.
5. If loosened, tighten the locknut to 40 to 45 ft-lbs (54 to 61 N•m) and actuate the injector plunger several times as a check of the adjustment. Tighten to 30 to 35 ft-lbs (41 to 47 N•m) when using ST-669 Adapter.
6. Adjust valves on cylinder No 5 to values in Table 6-2. Torque locknuts to same value as injectors. Move to next cylinder as indicated in Table 6-1 and repeat adjustment.
7. Discard old rocker cover gaskets and use new gaskets. Mount rocker covers and tighten capscrews to 16 to 23 N•m (12 to 17 ft-lb).

Table 6-2 : Adjustment Limits Using Dial Indicator Method Inch (mm), for N-855 Engines

Oil Temp.	Injector Plunger Travel Inch (mm)	Valve Clearance Inch (mm)	
	Adj. Value	Intake	Exhaust
Aluminium Rocker Housing			
Cold	0.170 (4.32)	0.011 (0.28)	0.023 (0.58)
Cast Iron Rocker Housing			
Cold	0.175 (4.45)	0.013 (0.33)	0.025 (0.63)
NT-855 (Big Cam only — Non Top-Stop)			
	0.228 (5.79)	0.011 (0.28)	0.023 (0.58)

Note : Check engine dataplate for injector and valve setting.

Crossheads - Adjustment

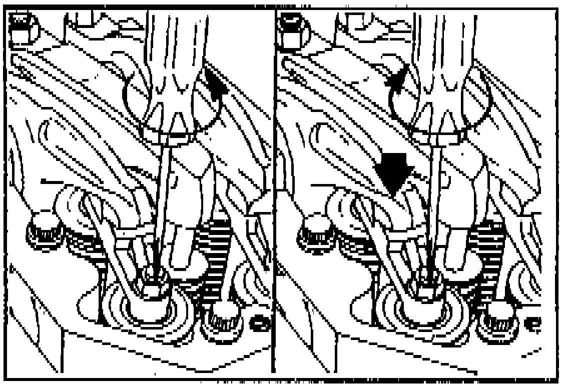


NOTE : Crosshead adjustment must always be made before attempting to adjust the valves.

NOTE : If your engine has stemless crossheads no adjustment is required.

Adjust the crossheads on the cylinder that has both valves closed.

Loosen the crosshead adjusting screw lock nuts on the intake and exhaust valve crossheads.

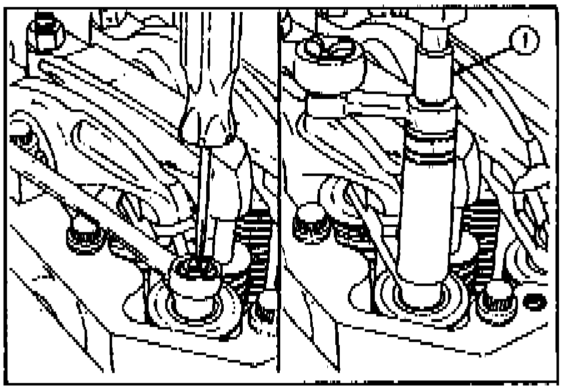


Use the following procedure to adjust both the intake and the exhaust crossheads.

Turn the adjusting screw out at least on turn.

Hold the crosshead down against its guide.

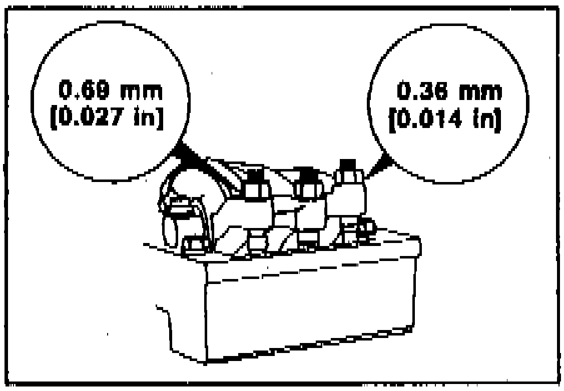
Turn the adjusting screw in until it touches the top of the valve stem but does **not** raise the crosshead.



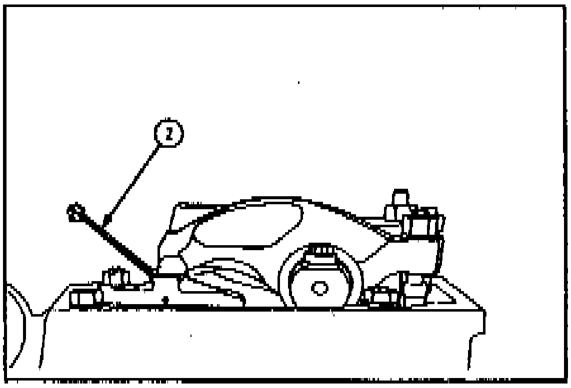
Hold the adjusting screw in this position. The adjusting screw **must not** turn when the lock nut is tightened to its torque value. Tighten the lock nut. The following torque values are given with and without Part No. ST-669, Torque Wrench Adapter (1) :

	Torque Values	
	N•m	ft-lb
With Adapter	35	25
Less Adapter	40	30

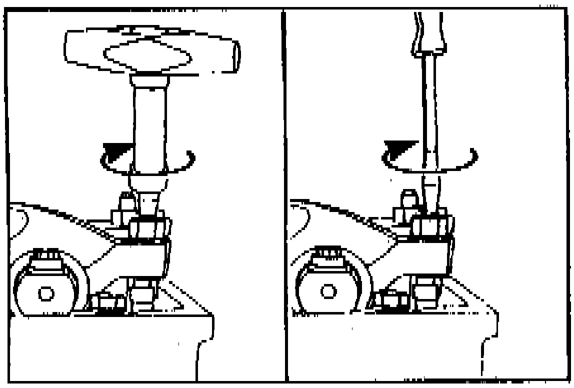
Valves - Adjustment



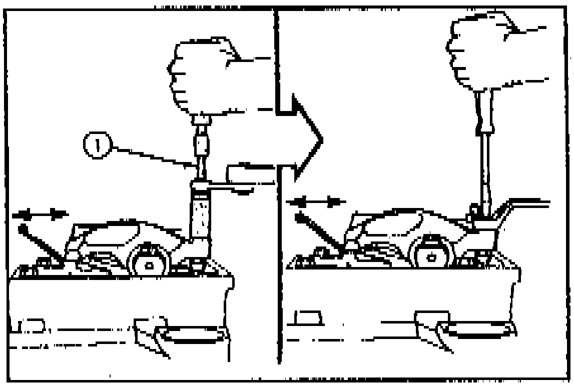
Valve Adjustment (Initial Set)		
mm		In
0.69	Exhaust	0.027
0.36	Intake	0.014



Select a feeler gauge for the correct valve lash specification. Insert the gauge (2) between the rocker lever and the crosshead.



Use a screwdriver and turn the adjusting screw ONLY until the lever touches the feeler gauge.



The adjusting screw **must not** turn when the lock nut is tightened. Tighten the lock nut to the value indicated below.

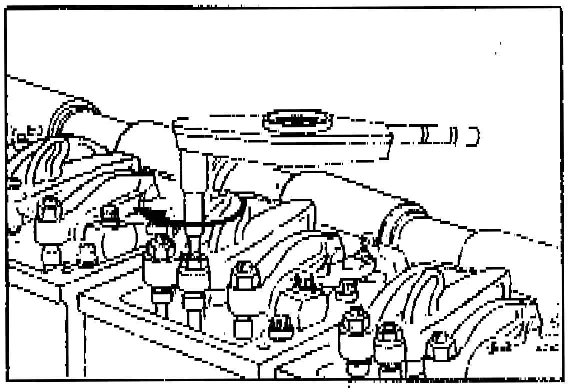
With Torque wrench Adpt.

Part No. ST-669(1)	45N•m (35 ft-lb)
Without Adapter	60 N•m (45 ft-lb)

The feeler gauge **must** slide backward and forward with only a slight drag. Attempt to insert a feeler gauge that is 0.03 mm [0.001 in] thicker. The valve lash is **not** correct when the thicker gauge will fit.

Repeat the adjustment process until the clearance is correct on both the intake and the exhaust valves on the cylinder being adjusted.

OBC Injectors — Adjustment



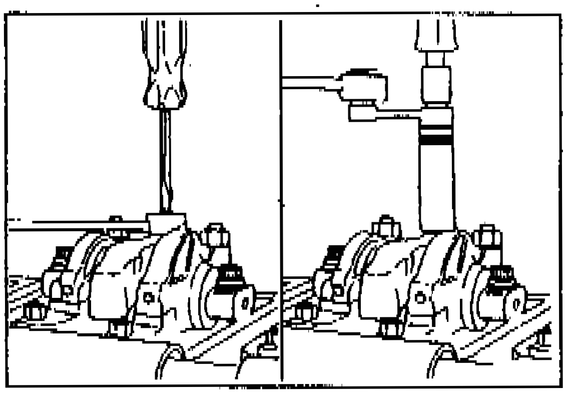
Use a dial type torque wrench to tighten the injector rocker lever adjusting screw. If the screw causes chattering during setting, repair the screw and lever as required.

Hold the torque wrench in a position that allows you to look in a direct line at the dial. This is to make sure the dial will be read accurately.

Tighten the adjusting screw to 11 N•m [100 in-lb] to make sure the parts are in alignment and to squeeze the oil out of the valve train.

Loosen the adjusting screw at least one turn. Tighten the adjusting screw to 10 N•m [90 in-lb].

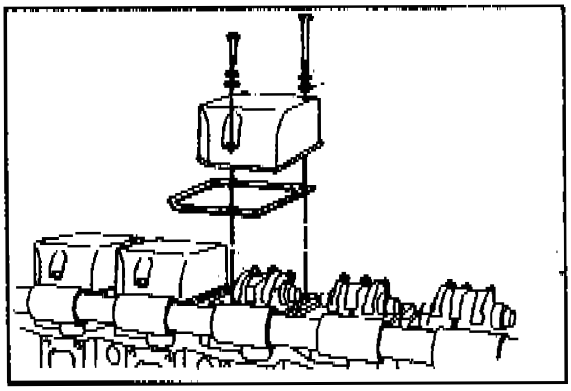
The torque wrench **must** be calibrated, have a resolution of 0.28 N•m [2.5 in-lb], and have a range of 17 to 23 N.m [150 to 200 in-lb]. Do **not** use a clicker-type torque wrench.



Hold the adjusting screw in this position. The adjusting screws **must not** turn when the lock nut is tightened.

Tighten the lock nut to the following values :

With Torque Wrench Adapter, Part No. ST-669	45 N•m [35 ft-lb]
Without Adapter	60 N•m [45 ft-lb]



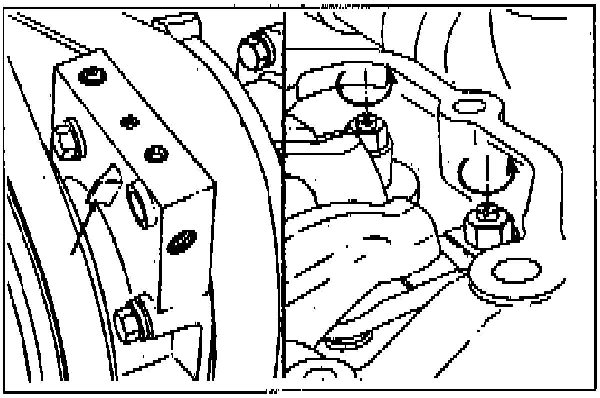
If the barring device was used, allow the spring to push the shaft and clear the ring gear. Install the clip.

Discard used gasket and use new gasket under the rocker cover.

Install the rocker lever cover and all related components.

Torque Value : 40 N•m (30 ft-lb)

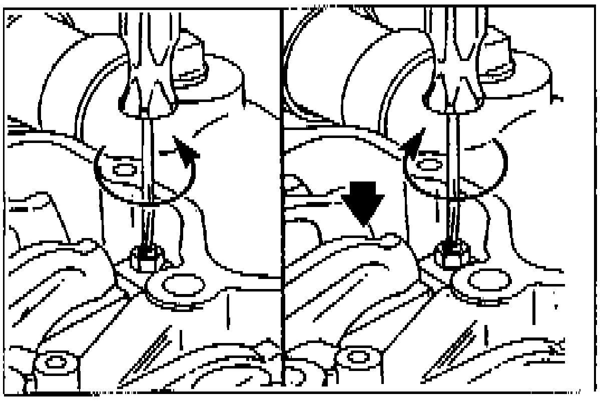
Crosshead Adjustment Procedure



NOTE : Crosshead adjustment must always be made before attempting to adjust the valves.

With “A” valve set mark aligned with the pointer on the gear cover and both valves closed on cylinder No. 5, loosen the crosshead adjusting screw lock nuts on the intake and the exhaust valve crossheads for cylinder No. 5.

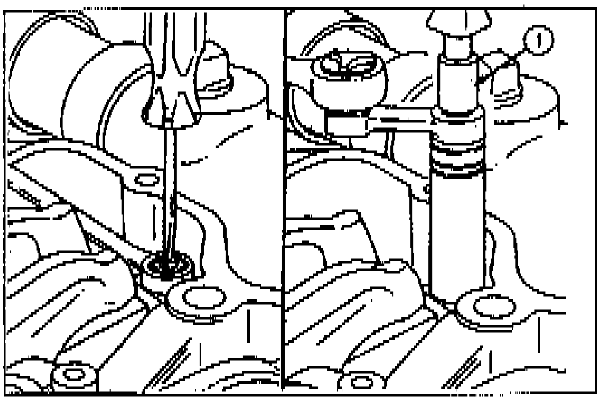
NOTE : Use the following procedure to adjust both the intake and the exhaust crossheads :



Turn the adjusting screw out at least one turn.

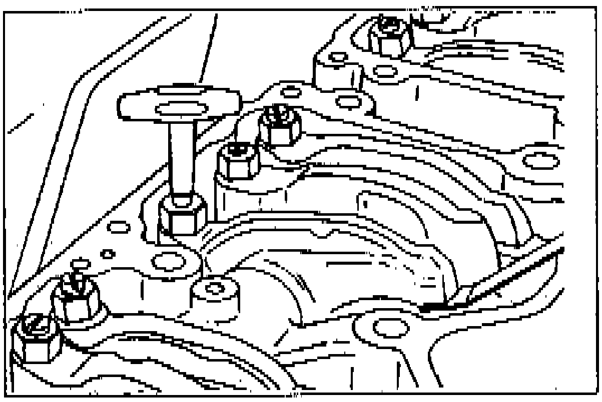
Hold the crosshead down against its mating valve stems.

Turn the adjusting screw in until it touches the top of the valve stem but does **not** raise the crosshead.



Hold the adjusting screw in this position. The adjusting screw **must not** turn when the lock nut is tightened to its torque value. Tighten the lock nut. The following torque values are given with and without torque wrench adapter (1), Part No. ST-669 :

	Torque Values	
	N•m	**ft-lb**
With torque wrench adapter, Part No. ST-669 (1)	34	25
Without adapter	41	30

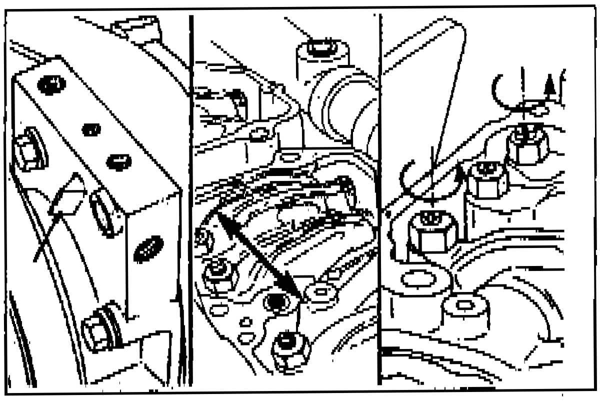


Adjust the intake and the exhaust valves on No. 5 cylinder **before** rotating the accessory drive to the next valve set mark.

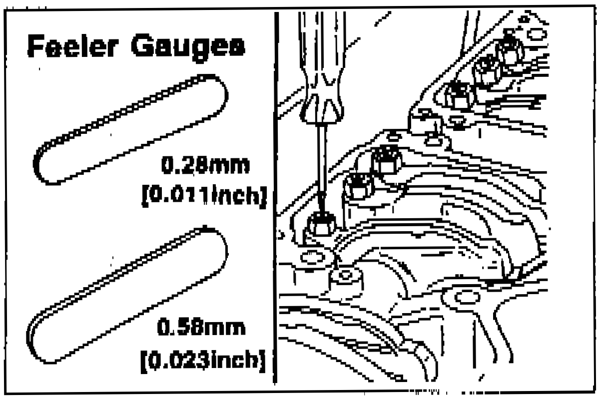
Refer to “Valve Adjustment Procedures.”

Valve Adjustment Procedure

With the “A” valve set mark aligned with the pointer on the gear cover and both valves closed on cylinder No. 5, loosen the lock nuts on the intake and the exhaust valve adjusting screws.



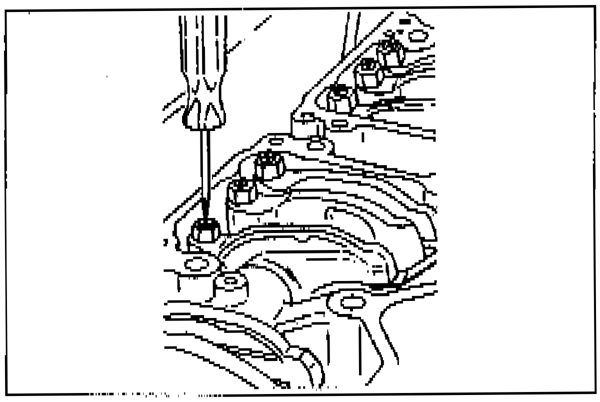
Select a feeler gauge for the correct valve lash specification.



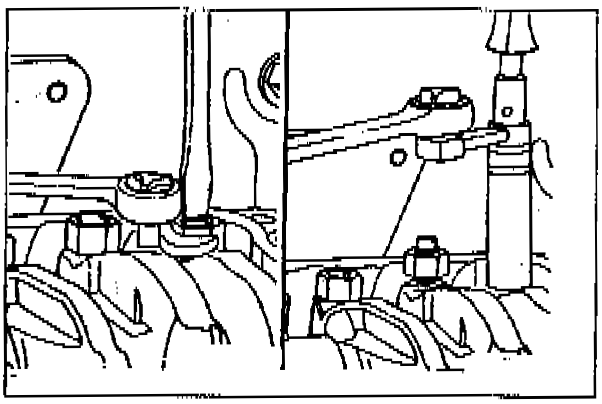
Valve Lash Specifications	
Intake	**Exhaust**
0.28 mm [0.011 inch]	0.58 mm [0.023 inch]

Insert the feeler gauge between the top of the crosshead and the rocker lever pad.

Tighten the adjusting screw until a slight drag is felt on the feeler gauge.

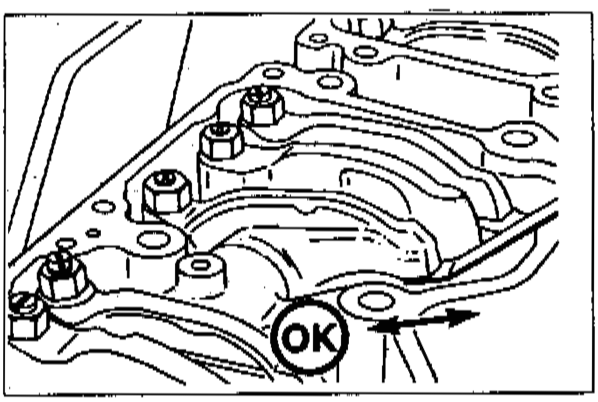


Hold the adjusting screw in this position. The adjusting screw **must not** turn when the lock nut is tightened. Tighten the lock nut.

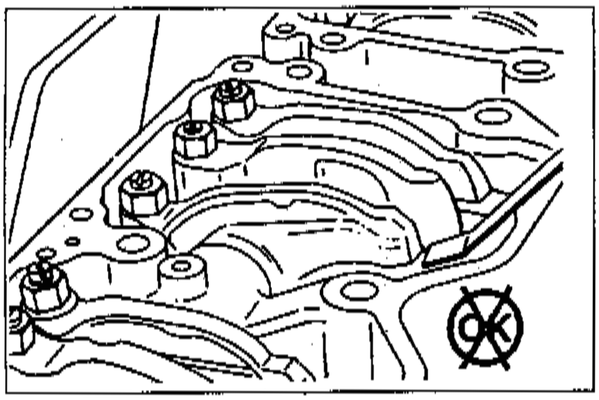


Torque Values :

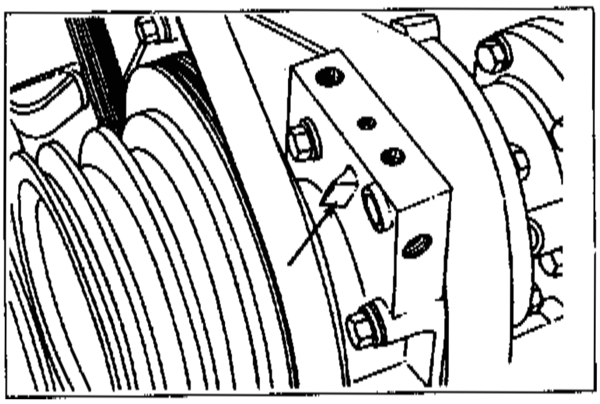
With torque wrench adapter, Part No. ST-669	47 N•m [35 ft-lb]
Without adapter	61 N•m [45 ft-lb]



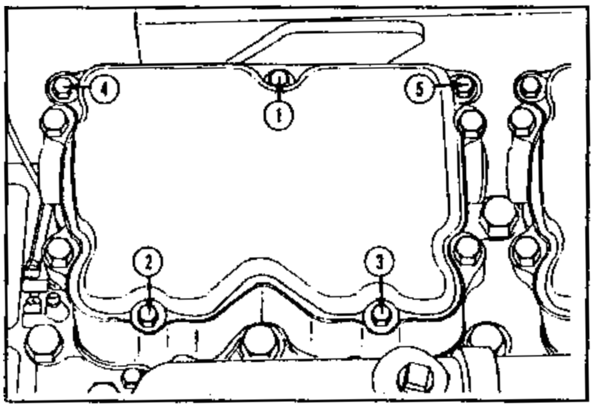
After tightening the lock nut to the correct torque value, check to make sure the feeler gauge will slide backward and forward between the crosshead and the rocker lever with only a slight drag.



If using the feel method, attempt to insert a feeler gauge that is 0.03 mm [0.001 inch] thicker between the crosshead and the rocker lever pad. The valve lash in **not** correct when a thicker feeler gauge will fit.



After adjusting the crossheads and the valves on cylinder No. 5, rotate the accessory drive and align the next valve set mark with the pointer.



Discard used gasket and use new gasket under rocker cover.

Install the rocker housing covers. Tighten the capscrews in each cover in the sequence shown.

Torque Values for Rokcer Housing :

Type of Rocker Housing	Manual Torque Range
Aluminium Casting Iron Casting	72.5+/-2.5 ft/lbs 80+/-5 ft/lbs

Torque Values for Rokcer Cover :

Sr.No.	Type of Capscrew	Torque Values
i)	5/16Capscrew	20-25 ft/lbs
ii)	1/4 Capscrew	105 +/-5 ft/lbs
iii)	3/8 Capscrew	20-25 ft/lbs

"C" Maintenance Checks

At each "C" Maintenance Check, first perform all "A", and "B" Checks in addition to the following :

Change Aneroid Oil

1. Remove fill plug 1 from the hole marked "Lub oil".
2. Remove the drain plug (2) from the bottom of the aneroid.
3. Replace the drain plug (2), fill the aneroid with clean engine lubricating oil. Replace the fill plug (1).

Replace Aneroid Breather

Remove and replace the aneroid breather.

Change Hydraulic Governor Oil

Change oil in the hydraulic governor sump at each "C" Check.

Use the same grade of oil as used in the engine. See "Lubricating Oil Specifications".

Note : When temperature is extremely low, it may be necessary to dilute the lubricating oil with enough fuel oil or other special fluid to ensure free flow for satisfactory governor action.

Check fan hub, Idler and water pump

Check fan hub end clearance. Clearance values are given below. Hub must rotate freely. Check idler hub and idler water pump for free rotation.

Clean Radiator externally

Blow air through the radiator core in opposite direction to the normal flow of air, to remove dirt and dust.

Inspect Units

Inspect units like Alternator, Generator, Starter. Replace as required.

Check evacuator valve

Check evacuator valve on air cleaner. Change if required.

"C" Maintenance Checks

At each "C" Maintenance Check, first perform all "A", and "B" Checks in addition to the following :

Change Aneroid Oil

1. Remove fill plug 1 from the hole marked "Lub oil".
2. Remove the drain plug (2) from the bottom of the aneroid.
3. Replace the drain plug (2), fill the aneroid with clean engine lubricating oil. Replace the fill plug (1).

Replace Aneroid Breather

Remove and replace the aneroid breather.

Change Hydraulic Governor Oil

Change oil in the hydraulic governor sump at each "C" Check.

Use the same grade of oil as used in the engine. See "Lubricating Oil Specifications".

Note : When temperature is extremely low, it may be necessary to dilute the lubricating oil with enough fuel oil or other special fluid to ensure free flow for satisfactory governor action.

Check fan hub, Idler and water pump

Check fan hub end clearance. Clearance values are given below. Hub must rotate freely. Check idler hub and idler water pump for free rotation.

Clean Radiator externally

Blow air through the radiator core in opposite direction to the normal flow of air, to remove dirt and dust.

Inspect Units

Inspect units like Alternator, Generator, Starter. Replace as required.

Check evacuator valve

Check evacuator valve on air cleaner. Change if required.

"C" Maintenance Checks

At each "C" Maintenance Check, first perform all "A", and "B" Checks in addition to the following :

Change Aneroid Oil

1. Remove fill plug 1 from the hole marked "Lub oil".
2. Remove the drain plug (2) from the bottom of the aneroid.
3. Replace the drain plug (2), fill the aneroid with clean engine lubricating oil. Replace the fill plug (1).

Replace Aneroid Breather

Remove and replace the aneroid breather.

Change Hydraulic Governor Oil

Change oil in the hydraulic governor sump at each "C" Check.

Use the same grade of oil as used in the engine. See "Lubricating Oil Specifications".

Note : When temperature is extremely low, it may be necessary to dilute the lubricating oil with enough fuel oil or other special fluid to ensure free flow for satisfactory governor action.

Check fan hub, Idler and water pump

Check fan hub end clearance. Clearance values are given below. Hub must rotate freely. Check idler hub and idler water pump for free rotation.

Clean Radiator externally

Blow air through the radiator core in opposite direction to the normal flow of air, to remove dirt and dust.

Inspect Units

Inspect units like Alternator, Generator, Starter. Replace as required.

Check evacuator valve

Check evacuator valve on air cleaner. Change if required.

"C" Maintenance Checks

At each "C" Maintenance Check, first perform all "A", and "B" Checks in addition to the following :

Change Aneroid Oil

1. Remove fill plug 1 from the hole marked "Lub oil".
2. Remove the drain plug (2) from the bottom of the aneroid.
3. Replace the drain plug (2), fill the aneroid with clean engine lubricating oil. Replace the fill plug (1).

Replace Aneroid Breather

Remove and replace the aneroid breather.

Change Hydraulic Governor Oil

Change oil in the hydraulic governor sump at each "C" Check.

Use the same grade of oil as used in the engine. See "Lubricating Oil Specifications".

Note : When temperature is extremely low, it may be necessary to dilute the lubricating oil with enough fuel oil or other special fluid to ensure free flow for satisfactory governor action.

Check fan hub, Idler and water pump

Check fan hub end clearance. Clearance values are given below. Hub must rotate freely. Check idler hub and idler water pump for free rotation.

Clean Radiator externally

Blow air through the radiator core in opposite direction to the normal flow of air, to remove dirt and dust.

Inspect Units

Inspect units like Alternator, Generator, Starter. Replace as required.

Check evacuator valve

Check evacuator valve on air cleaner. Change if required.

"C" Maintenance Checks

At each "C" Maintenance Check, first perform all "A", and "B" Checks in addition to the following :

Change Aneroid Oil

1. Remove fill plug 1 from the hole marked "Lub oil".
2. Remove the drain plug (2) from the bottom of the aneroid.
3. Replace the drain plug (2), fill the aneroid with clean engine lubricating oil. Replace the fill plug (1).

Replace Aneroid Breather

Remove and replace the aneroid breather.

Change Hydraulic Governor Oil

Change oil in the hydraulic governor sump at each "C" Check.

Use the same grade of oil as used in the engine. See "Lubricating Oil Specifications".

Note : When temperature is extremely low, it may be necessary to dilute the lubricating oil with enough fuel oil or other special fluid to ensure free flow for satisfactory governor action.

Check fan hub, Idler and water pump

Check fan hub end clearance. Clearance values are given below. Hub must rotate freely. Check idler hub and idler water pump for free rotation.

Clean Radiator externally

Blow air through the radiator core in opposite direction to the normal flow of air, to remove dirt and dust.

Inspect Units

Inspect units like Alternator, Generator, Starter. Replace as required.

Check evacuator valve

Check evacuator valve on air cleaner. Change if required.

Section 7 -
“D” Maintenance Checks

Section 7 - “D” Maintenance Checks
6000 Hrs. / 2 Years

Section Contents

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“D” Maintenance Checks

At each “D” Maintenance Check, perform all “A”, “B” and “C” checks in addition to those following. Most of these checks should be performed by a Cummins Distributor or Dealer and where Cummins Shop Manuals are available for complete instructions.

Clean and Calibrate Injectors

Clean and calibrate the injectors regularly to prevent restriction of fuel delivery to the combustion chambers. Because of the special tools required for calibration, most owners and fleets find it more economical to let a Cummins Distributor do the cleaning and calibration operations.

To clean and calibrate the injectors, refer to Bulletin No. 3243607 and revisions thereto.

Caution : There must be only one (1) seal seat used in each injector “well”. Use of more than one seal seat per injector will change the injector protrusion and cause combustion inefficiency.

Clean and Calibrate Fuel Pump

Check the fuel pump calibration of the engine if required. See the nearest Cummins Distributor or Dealer for values.

Clean and Calibrate Aneroid

1. Remove the flexible hose or tube from the aneroid cover to the intake manifold
2. Remove the lead seal (if used), screws and aneroid cover.
3. Remove the bellows, piston, upper portion of the two piece shaft and the spring from the aneroid body.

Note : Count and record the amount of thread turns required to remove the upper shaft, piston and bellows from the lower shaft.

4. Place the hex portion of the shaft in a vise, snug tighten the vise, remove the self-locking nut, retaining washer and bellows.
5. Clean the parts in an approved cleaning solvent.
6. Position the new bellows over the shaft to the piston, secure with retaining washer and self-locking nut. Tighten the self-locking nut to 20 to 25 ft-lb (27 to 34 N•m) torque.
7. Install the spring, shaft, piston and bellows assembly into the aneroid body. As the two piece shaft is re-assembled, turn the upper portion of the shaft the same amount of thread turns as recorded during disassembly.

Caution : The amount of thread turns during installation must correspond with turns during removal to avoid changing the aneroid setting.

8. Align the holes in the bellows with the corresponding capscrew holes in the aneroid body.
9. Position the cover to the body; secure with flat washers, lock washers and fillister head screws.
10. Install a new seal. Calibration, if required, must be performed by a Cummins Distributor on a fuel pump test stand.
11. Reinstall the flexible hose or tube from the aneroid cover to the intake manifold.

Clean Cooling System

The cooling system must be clean to do its work properly. Scale in the system slows down heat absorption from water jackets and heat rejection from the radiator. Use clean water that will not clog any of the hundreds of small passages in the radiator or water passages in the block. Clean the radiator cores, heater cores, oil cooler and block passages that have become clogged with scale and sediment by chemical cleaning, neutralizing and flushing.

Chemical Cleaning

If rust and scale have collected, the system must be chemically cleaned. Use a good cooling system cleaner and follow the manufacturer's instructions.

Pressure Flushing

When pressure flushing the radiator, open the upper and lower hose connections and screw the radiator cap on tight. Use the hose connection on both the upper and lower connections to make the operation easier. Attach a flushing gun nozzle to the lower hose connection and let water run until the radiator is full. When full, apply air pressure gradually to avoid damage to the core. Shut off the air and allow the radiator to refill; then apply air pressure. Repeat until the water coming from the radiator is clean.

Caution : Do not use excessive air pressure while starting the water flow. This could split or damage the radiator core.

Sediment and dirt settle into pockets in the block as well as the radiator core. Remove the thermostats from the housing and flush the block with water. Partially restrict the lower opening until the block fills, Apply air pressure and force water from the lower opening. Repeat the process until the stream of water coming from the block is clean. **Inspect Water Pump, Fan Hub and Idler Pulley.**

Inspect the water pump shaft, fan hub and idler for wobble and evidence of grease leakage. Refer to the engine shop manual for rebuild and lubricating procedure for these assemblies.

Rebuild pre-lubricated water pumps, fan hubs and idler assemblies are available from Cummins Distributor.

Inspect Turbocharger

Check Turbocharger Bearing Clearance

Check bearing clearances. This can be done without removing the turbocharger from the engine, by using a dial indicator to indicate the end-play of the rotor shaft and a feeler gauge to indicate the radial clearance. Consult C.D.S.&S. service engineer for checking procedure using dial indicator.

Clearance Values :

Turbo	Axial	Radial
4LGK/HC3B	0.001 to 0.004 inch (0.025 to 0.102 mm)	0.0074 to 0.0208 (0.188 to 0.528 mm)
HC5A	0.002 to 0.0049 inch (0.050 to 0.124 mm)	0.0191 to 0.0294 inch (0.485 to 0.746 mm)

Inspect Vibration Damper

Check the damper for evidence of fluid loss, dents and wobble. Visually inspect the vibration damper's thickness for any deformation or raising of the damper's front cover plate.

1. If a lack of space around the damper will not permit a visual inspection, run a finger around the inside and the outside of the front cover plate. If any variations or deformations are detected, remove the vibration damper and check as follows.

2. Remove paint, dirt and grime from the front and rear surface of the damper in four (4) equal spaced areas. Clean the surface with paint solvent and fine emery cloth.

3. Using a micrometer measure and record the thickness of the dampers at the four (4) areas cleaned in Step 2. Take the reading approximately 0.125 inch (3.18 mm) from the outside edge of the front cover plate.

4. Replace the damper if the variation of the four (4) readings exceed 0.010 inch (0.25 mm).

Viscous vibration dampers should be checked visually, for any leakages or physical damage when removed.

At any time the engine experiences the following problems, check vibration Damper. Replace if necessary.

a. Gear train failure

b. Accessory drive shaft failure

c. Crankshaft failure

d. Damper mounting capscrew failure

e. Flywheel mounting capscrew failure.

Viscous vibration dampers should be replaced at our recommended change interval regardless of condition. Gelation of the damper's silicon fluid occurs after extended service because of the high shear rates and resulting high temperatures imposed on the fluid during normal damper operation and, if the damper has not failed at this time, its failure is imminent.

Viscous Vibration Damper
Thickness Specifications — Inch (mm)

Damper Part No.	Maximum Allowable Thickness	Recommended Change Interval — Hours
3101655	1.663 (42.24)	24000

Air Compressor

All air compressors have a small amount of oil carry over which lubricates the piston rings and moving parts. When this oil is exposed to normal air compressor operating temperatures over a long period of time, it will form varnish or carbon deposits. Cummins India Limited recommends air compressor inspections every 6000 hours or two years. If the following inspections are ignored, the air compressor piston rings will be affected by high operating temperatures, and will not seal properly.

Note : The following steps can be made with the air compressor on the engine.

Discharge Inspection

1. Inspect the entire system for air leaks. Repair as necessary.
2. Bleed down the air tanks until there is no pressure in the air system.
3. Remove the air in and air out connections from the air compressor.
4. Inspect the air discharge line from the air compressor. If the total carbon deposit thickness (Fig. 7-2) inside the air discharge line exceeds 1/16 inch, remove the head and clean the air passages thoroughly. Also remove and clean or replace the discharge line. Contact the nearest Cummins Distributor or refer to Cummins Bulletin 3379056, "Air Equipment Rebuild Manual" for removing the air compressor head.
5. Disconnect the discharge line at the first connection after the air compressor. If the total carbon deposit thickness exceeds 1.16 inch, clean or replace the complete line.
6. Continue the procedure until the first (wet) tank or a non-coated connection is reached.

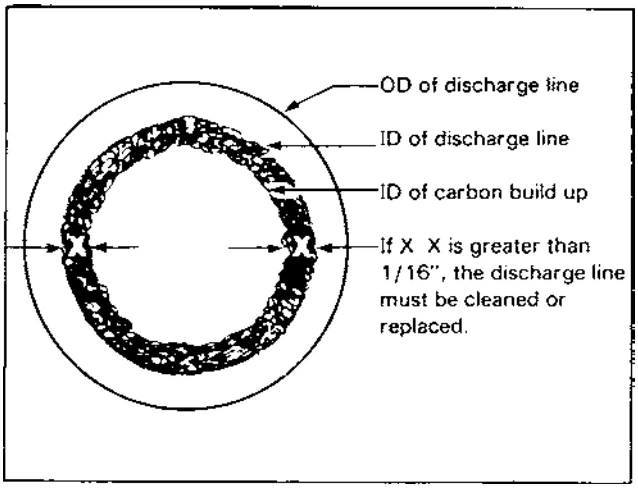

Fig. 7-2. Air discharge line

Intake Inspection

1. Remove the capscrews, flat washers and lock washers securing the unloader valve assembly to the cylinder head cover. Remove the unloader valve assembly and spring from the cylinder head and cover.
2. Remove the three-prong unloader from the unloader body.
3. Remove the O-ring and packing seal from the unloader body and discard.
4. Remove the intake valve, seat and spring.
5. Remove the exhaust valve assembly. Remove and discard the O-rings from the exhaust valve seat.
6. Inspect the air inlet in the cylinder head cover. Also inspect the exhaust valve and seat and the intake valve and seat. If the parts have carbon deposits on them, replace the parts. If the parts do not have carbon deposits, reinstall them with new O-rings and unloader seals.

If the air compressor requires major repair or additional troubleshooting, see Cummins Bulletin 3379056, or contact the nearest Cummins Distributor.

1500 Hrs. After Every 'D' Check

Perform all steps of "C" check.

Adjust Injectors and Valves as described under "First 1500 Hrs. Check" (Ref. page 6-1).

Section 8 -
Seasonal Maintenance Checks

Section 8 - Seasonal Maintenance Checks

Section Contents

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Section 8

There are some maintenance checks which may or may not fall exactly into suggested maintenance schedule due to hours of operation but are performed once or twice each year.

Seasonal Maintenance Chec ks

Replace Hose (As Required)

Inspect the oil filter and cooling system hose and hose connections for leaks and/or deterioration. Particles of deteriorated hose can be carried through the cooling system or lubricating system and restrict or clog small passages, especially radiator core and lubricating oil cooler, and partially stop circulation. Replace as necessary.

Check Pre-heater Cold-Starting Aid

Remove the 1/8 inch pipe plug from the manifold, near the glow plug and check the operation of the Pre-heater as described in Section 1.

Check Thermostats and Seals

Remove the thermostats from the thermostat housings and check for proper opening and closing temperature. Most Cummins Engines are equipped with either medium 77° to 85°C(170° to 185°F) or low 71° to 79°C(160° to 175°F) and in a few cases high-range 82° to 91°C(180° to 195°F) thermostats, depending on engine application.

Steam Clean Engine

Steam is the most satisfactory method of cleaning a dirty engine or piece of equipment. If steam is not available, use an approved solvent to wash the engine.

All electrical components and wiring should be protected from the full force of the cleaner spray nozzle.

Checking Mountings

Tighten Mounting Bolts and Nuts (As Required)

Engine mounting bolts will occasionally work loose and cause the engine supports and brackets to wear rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews.

Torque Turbocharger Mounting Nuts (As Required)

Torque all turbocharger mounting capscrews and nuts to be sure that they are holding securely. Torque the mounting bolts and supports so that vibration will be at a minimum. Fig. 8-1.

Check Fan and Drive Pulley Mounting

Check the fan to be sure it is securely mounted; tighten the capscrews as necessary. Check the fan for wobble or bent blades.

Check the fan hub and crankshaft drive pulley to be sure they are securely mounted. Check the fan hub pulley for looseness or wobble; if necessary, remove the fan pilot hub and tighten the shaft nut. Tighten the fan bracket capscrews.

Check Crankshaft End Clearance

The crankshaft of a new or newly rebuilt engine must have end clearance as listed in Table 9-1. A worn engine must not be operated with more than the worn limit end clearance shown in the same table. If the engine is disassembled for repair, install new thrust rings.

Table 8-1 : Crankshaft End Clearance—Inch (mm)

Engine Series	New Minimum	New Maximum	Worn Limit
H, NH, NT	0.007 (0.18)	0.018 (0.45)	0.022 (0.56)

CAUTION

Do not pry against the outer damper ring

The check can be made by attaching an indicator to rest against the damper or pulley, while prying against the front cover and inner part of the pulley or damper. End clearance must be present with the engine mounted in the unit and assembled to the transmission or converter.

Check Raw (Sea) Water Pump

Maintenance and service periods for raw water pump must be adjusted to agree with the type of application to which it is subjected.

If coolant being pumped through the raw water pump is relatively free of sediment, corrosive chemicals, foreign material and abrasives such as sand or mud, normal maintenance periods are sufficient.

Accelerated maintenance periods are necessary to compensate for undesirable operating conditions.

1. Check all pipes and fittings for leaks. Tighten as necessary.

2. Remove cover plate to drain pump.

3. Lift out impeller and check for cracks, breaks or damage. Replace impeller if necessary.

Note : If impeller is subjected to extreme temperatures, either hot or cold, impeller life is shortened and inspection periods must be adjusted accordingly.

4. Clean out all sediment.

5. Install new cover plate gasket and install cover on pump.

Note : A 0.015 inch (0.38 mm) gasket should be used to maintain proper impeller-to-cover clearance.

6. No lubrication is necessary when sealed bearings are used.

CAUTION

Check to be sure raw water pump is primed.

Section 9 -
In-Frame Overhaul/
Major Engine Overhaul

In-Frame Overhaul / Major Engine Overhaul

In-Frame Overhaul/Major Engine Overhaul

Operating conditions of the engine, normally dictate when the engine is in need of an in-Frame overhaul or a major overhaul. Oil consumption, excessive drop of oil pressure at idling, oil dilution, excessive blow-by, unusual noise, vibrations and exhaust smoke should be analyzed in determining the next course of action.

At this time, perform all previous checks and inspect the following:

Accessory Drive
Bearings
Cylinder Head
Cylinder Liners
Front Gear Train
Rear Gear Train
Lubricating Oil Pump
Pistons
Connecting Rods
Piston Rings
Crankshaft Journals
Camshafts
Cam Followers
Accessory Drive Seal
Front and Rear Crankshaft Seals
Oil Cooler

Rebuild instructions, new parts or exchange parts are available from any Cummins Distributors or Dealers.

NOTES

Section 10 -
Specifications and Torque

Section 10 - Lubricant, Fuel and Coolant Specifications

Section Contents

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Lubricant, Fuel and Coolant Specifications

Providing and maintaining an adequate supply of clean high quality fuel, lubricating oil, grease and coolant in an engine is one way of ensuring long life and satisfactory performance.

Lubricant, Fuel and Coolant Specifications

Viscosity Recommendations

The viscosity of an oil is a measure of its resistance to flow. The Society of Automotive Engineers has classified engine oils in viscosity grades: Oils that meet the low temperature (–18°C [0°F]) requirement carry a grade designation with a “W” suffix. Oils that meet both the low and high temperature requirements are referred to as multigrade or multiviscosity grade oils.

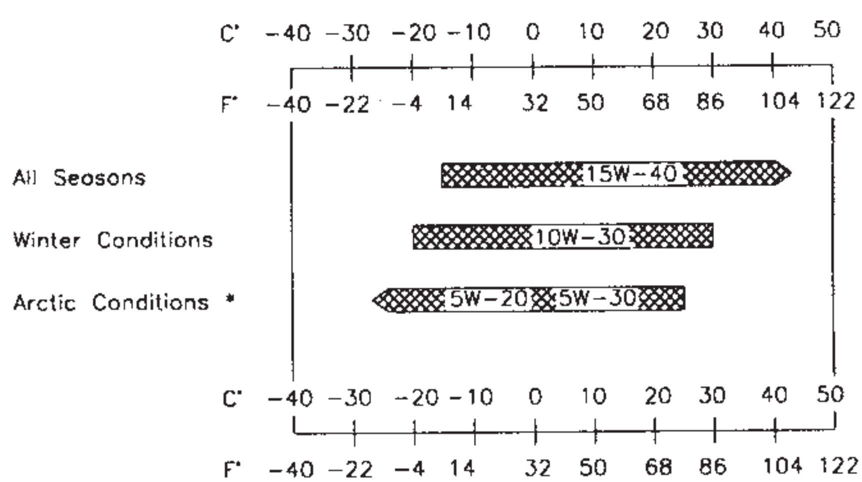
Multigraded oils are generally produced by adding viscosity index improver additives to retard the thinning effects, a low viscosity base oil will experience at engine operating temperatures. Multigraded oils that meet the requirements of the API classifications, are recommended for use in Cummins engines.

Cummins recommends the use of multigraded lubricating oil with the viscosity grades shown in Table 10-1 which shows Cummins Viscosity grade recommendations at various ambient temperatures. The only viscosity grades recommended are those shown in this table.

Cummins has found that the use of multigraded lubricating oil improves oil consumption control, improved engine cranking in cold conditions while maintaining lubrication at high operating temperatures and may contribute to improved fuel consumption. Cummins does not recommend the use of single grade lubricating oils.

The primary criterion for selecting an oil viscosity grade is the lowest temperature the oil will experience while in the engine oil sump. Bearing problems can be caused by the lack of lubricating during the cranking and start up of a cold engine when the oil being used is too viscous to flow properly. Change to a lower viscosity grade of oil as the temperature of the oil in the engine oil sump reaches the lower end of the ranges shown in Table 10-1.

Table 10-1 : Cummins Recommended SAE Oil Viscosity Grades vs Ambient Temperatures



Note : For temperature consistently below (-25°C [-13°F]) refer to lub oil manufacturer for recommendations.

Engine Oil Recommendations for Cummins Engines

Quality of Lubricating oil is one of the key drive factors to decide the performance, Durability and total cost of operation of diesel engine. Hence we have always been recommending the best available / suitable engine oil to be used in our engine.

Cummins India Limited has been continuously upgrading the products to incorporate latest technology such as low temp. aftercooling, two stage turbocharging, electronics, air to air charge air cooling, high power to weight ratio etc. for meeting customer expectations of engine performance, durability and cost of operation.

Lubricating oil have also undergone various improvements to meet the requirements of these changes in diesel engine technology. With this, SAE 15W40 grade Lubricating oil with API CI4+ classification is now available in India from most of oil companies. This is the best engine oil currently available in India suitable for Cummins engines. However we recommend to use Valvoline Cummins Premium Blue for Cummins engine.

This provides several advantages such as,

- Reduced wear and tear.
- Better high temp oxidation stability
- Optimum Lub oil consumption.
- Lesser crown land deposits on piston and valves.
- Better emission control
- Better cleanliness of internal passages and components.
- Less sludge formation due to improved dispersancy.
- Increased control on acid formation resulting in less corrosion of bearings and other components.

Cummins India Limited strongly recommends the use of SAE 15W40 Lub oil with API CI4+, CES 20071 & CES 20076 classification for all Cummins engines to get the various advantages and optimum performance from the engine.

As a comparative advantage we strongly recommend following brand of lube oil for Cummins engines.

Valvoline Cummins Premium Blue, API CI4+, CES 20071 & CES 20076.

This oil have a minimum TBN of 10.5 to counteract the higher sulphur content of high speed diesel available in India.

⚠ CAUTION ⚠

Beware of the spurious oils in the market. Bad oil quality is detrimental to engine performance. Hence oil should always be procured from the original manufacturer or the authorised distributor.

Lubricating oil to be used in the engine must meet all qualities as per manufacturer's specifications. Cummins India recommends audit checks of fresh engine oil to ensure the quality of oil. Facility to check suitability of oil for using it in the engine is available with Cummins service network.

If in doubt about the quality of lub oil, contact lub oil manufacturing company / Cummins service network and get oil analysed in laboratories.

Do not intermix different brands of oil as two different brands of oils may not be compatible with each other. It is there fore recommended that the brand which is used for initial fill / oil change, should only be used for top-up. Different brand of oil may be used after draining all the existing oil i.e., at the oil drain interval and after flushing the lub oil system with new brand of oil.

Note

The responsibility of meeting oil quality lies with the oil manufacturer & Cummins will not be responsible for problems occurring on engines due to poor quality of oil.

Grease Recommendations

Cummins India Limited Pune, recommends the use of grease meeting the specifications of MIL-G-3545, excluding those of sodium or soda soap thickeners. Contact lubricant supplier for grease meeting these specifications.

TEST	TEST PROCEDURE
High-Temperature Performance	
Dropping point, °F	ASTM D 2265 350 min.
Bearing life, hours at 300°F. 10,000 rpm	 *FTM 331 600 min.
Low-Temperature Properties	
Torque, GCM Start at 0°F. Run at 0°F.	ASTM D 1478 15,000 max. 5,000 max.
Rust Protection and Water Resistance	
Rust test	ASTM D 1743 Pass
Water resistance, %	ASTM D 1264 20 max.
Stability	
Oil separation, % 30 Hours @ 212°F.	 *FTM 321 5 max.

Penetration

Worked	ASTM D 217
	250-300
Bomb Test, PSI Drop	ASTM D 942
100 Hours	10 max.
500 Hours	25 max.
Copper, Corrosion	*FTM 5309
	Pass
Dirt Count, Particles/cc	*FTM 3005
25 Microns +	5,000 max.
75 Microns +	1,000 max.
125 Microns +	None
Rubber Swell	*FTM 3606
	10 max.

* Federal Test Method Std. No. 791a

CAUTION

Do not mix brands of grease as damage to bearings may result. Excessive lubrication is as harmful as inadequate lubrication. After lubricating fan hub, replace both pipe plugs. Use of fittings will allow lubricant to be thrown out, due to rotative speed.

Fuel Oil Recommendations

Cummins Diesel Engines have been developed to take the advantage of high energy content and generally lower cost of No. 2 Diesel Fuels. Experience has shown that a Cummins Diesel Engine will also operate satisfactorily on No. 1 fuels or other fuels within the following specifications.

TABLE 10-2: REQUIREMENTS FOR HIGH SPEED DIESEL FUEL AS PER IS 1460 : 2005

Sr. No.	Characteristics	Requirement		Method of test Ref. to [P;] of IS 1448/ISo/ASTMD/ IP/EN/Annex of this Standard
		Bharat Stage II	Bharat Stage III	
1	2	3	4	5
1	Acidity, Inorganic	Nil	Nil	[P : 2]
2	Acidity, total mg. of KOH/g *Max.*	To report	To report	[P : 2]
3	Ash, percent by mass *Max.*	0.01	0.01	[P : 4]/ISo 6245
4	Carbon residue (Ramsbottom) on 10 percent residue[1)], percent by mass, *Max*	0.30	0.30	[P : 8]/ISo 10370
5	Cetane Number[2)], *Min.*	48[3)]	51[3)]	[P : 9]/ISO 5165
6	Cetane index[2)], *Min.*	*46[3)]*	*46[3)]*	D 4737/ISo 4264
7.	Pour point[4)], *Max.*			[P : 10]/D 5949 or D 5950 or D 5985
	a) Winter	3°C	3°C	
	b) Summer	15°C	15°C	
8	Copper strip corrosion for 3 hours at 100°C	Not worse than No. 1	Not worse than No. 1	[P : 15]/ISO 2160
9	Distillation percent *v/v,* recovered			[P : 18]/ISO 3405
	a) at 350°C, *Min.*	85	—	
	b) at 360°C, *Min.*	—	95	
	c) at 370°C, *Min.*	95	—	
10	Flash point : (a) Abel, °C *Min.*	35	35	[P : 20]
	b) Pensky Martens closed cup[5)], °C, *Min.*	66	66	[P : 21]
11	Kinematic viscosity cSt at 40°C	2.0 to 5.0	2.0 to 4.5	[P : 25]ISO 3104
12	Sediment, percent by mass *Max*	0.05	—	[P : 30]
13	Total contamination, mg / kg	—	24	EN 12662
14	Density at 15°C[6)],kg/m^3	820-860	820-845	[P : 16]or [P:32][7)]/D 4052 ISO 3675 or ISO 12185
15	Total sulphur[8)], mg / kg, *Max*	500	350	IP : 336 or D 4294[9)] ISO 14596orISO 8754/P :83/D 2785/D 5433/D2622/D3120
16	Water content, percent (v/v)	0.05	—	[P : 40]/ISo 3733/ISO6296
	Water content mg / kg, *Max*	—	200	ISO 12937
17.	Cold Filter Plugging Point (CFPP)[4)], *Max.*			[P : 110]/D6371
	a) Winter	6°C	6°C	
	b) Summer	18°C	18°C	
18	Total sediments[10)], mg. per 100 ml. *Max.*	1.5	—	Annex A/ISO 11205/D2274[10)]
19	Oxidation stability, g/m^3, *Max*	—	25	ISO 12205 or D 2274
20	Polycyclic aromatic hydrocarbon (PAH), precent by mass, *Max*	—	11	IP 391 or EN 12916
21	Lubricity corrected wear scar diameter (wsd 1.4) at 60^{0C}, microns, *Max*	460	460	ISO 12156-1
22	Oxygen content[11)] percent by mass, *Max*	0.6	0.6	Annex B

Table 10-3 : Recommended Fuel Oil Properties :

Property	Recommended Specifications
Viscosity (ASTM D445)	1.3 to 5.8 centistokes (1.3 to 5.8 mm per second) at (40°C[104°F])
Cetane Number (ASTM D-613)	40 Minimum above 32°F. 45 Minimum below 32°F.
Sulfur Content (ASTM D-129 or 1552)	Not to exceed 0.25 % mass percent.
Active Sulfur (ASTM D130)	Copper Strip Corrosion not to exceed No. 2 rating after three hours at (50°C[122°F]).
Water and Sediment (ASTM D1796)	Not to exceed 0.1 volume percent.
Carbon Residue (Rams bottom, ASTM D524 or Conradson, ASTM D189)	Not to exceed 0.35 mass percent on 10 volume percent residuum.
Density (ASTM D287)	42 to 30° API gravity at 15°C (0.816 to 0.876 g/cc at 60°F).
Cloud Point (ASTM D97)	(6°C [10°F]) below lowest ambient temperature at which the fuel is expected to operate
Ash (ASTM D482)	Not to exceed 0.02 mass percent (0.05 mass percent with lubricating oil blending).
Distillation (ASTM D86)	The distillation curve must be smooth and continuous.
Acid Number (ASTM D664)	Not to exceed 0.1 Mg KOA per 100 ML.

Coolant Specifications

Cooling System

Cummins engines are provided with fleetcool XB Coolant Additive Concentrate - (CAC) and premix coolant. To ensure adequate corrosion protection, checking coolant at every B Check is essential. The checking procedures and the details of the Coolant Checking Kit are given below :

Salient Features of CAC

- Safe / environmental & user friendly
- Easy operation, time saving at 'B' check.
- To be filled in through make up (auxiliary) tank Cap
- Cost benefit to the customer at 'B' check.
- Easy checking process.

CAC Availability form and Checking

CAC is available in two forms,

a) Coolant Additive Concentrate, which can be mixed with water of **1:16** proportion and,

b) Pre-mixed coolant, which can be directly added in cooling system. To check the coolant concentration Test Strip and a Test Kit are available.

Make Up Coolant Specifications

Where possible, it is recommended that a supply of make-up coolant be prepared to the following specifications, using soft water. Chromate treatment of coolant assures constant level of concentration when coolant is added.

2. Coolant Additive Concentrate (CAC)

A. Coolant Additive Concentrate

It is supplied in plastic red colour containers having different part nos. for different volumes. The colour of the coolant additive concentrate is deep purple.

Part Number	Description	Qty.
3167214	Coolant additive concentrate	0.5 lt.
3167215	Coolant additive concentrate	1 lt.
3167216	Coolant additive concentrate	2 lt.
3167217	Coolant additive concentrate	5 lt.
3167218	Coolant additive concentrate	10 lt.

B. Pre-mixed Coolant

It is supplied in plastic white colour containers having different part nos. for different volumes. The colour of the coolant is pink.

Part Number	Description	Qty. Effective from Aug. 04
3167221	Pre-mixed Coolant	5 lt.
3167222	Pre-mixed Coolant	10 lt.
3167223	Pre-mixed Coolant	20 lt.
3167224	Pre-mixed Coolant	205 lt.

C. Test strip

New Test strip is introduced. Test strip is required to check coolant concentration and are packed individually in a foil pack.

Part Number	Description
4912590	Test strip

D. Test Kit

Test kits are supplied in cardboard boxes.

Part Number	Description
4912590	Test Kit

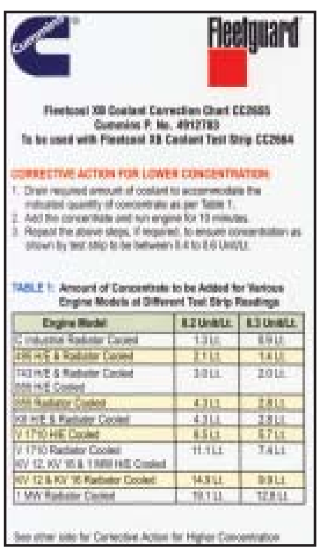
This consists of

a) 2 test strips,

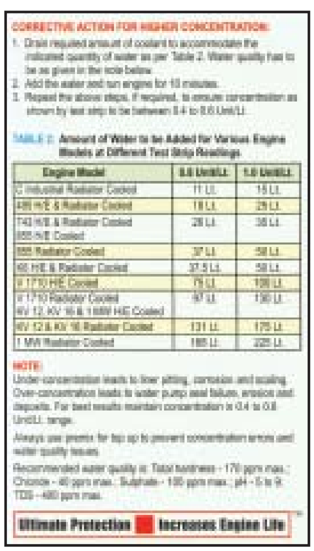
b) a clear plastic beaker

c) a dropper to collect the coolant.

d) Fleetcool XB Concentration correction table part no. 4912783.



Front Page of concentration correction table



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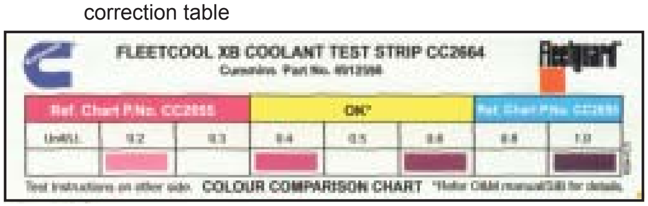


Test Strip Pin 4912590

IMPORTANT NOTE

Shelf life for Coolant Additive Concentrate & Pre-mixed Coolant is 5 years & that of test strip is one year.

It is proven that high concentration of fleetcool XB coolant causes gel effect leading to water pump seal surface damage. Lower concentration of fleetcool XB coolant cause liner pitting. Purpose of this note is to emphasize need to control fleetcool XB coolant concentration within band of 0.4 to 0.6 units per liter. The Coolant Checking Strip Part number 3167225 is superseded by new part number 4912590. The new test strip is supplied with engine effective from August 2004.

For correct coolant concentration adjustment Tabulated card Part no 4912783 is included in each Coolant checking kit Part No. 3167226. This card tabulates amount of coolant to be removed and to be topped up with water for reducing excess concentration.

In case of lower concentration, tabulation gives amount of coolant to be replaced with Coolant concentrate in order to increase concentration.

Tabulation is done for different models and for different measured concentrations. It is advisable to run the engine for few minutes after coolant concentration correction and recheck concentration in order to ensure that it is within 0.4 to 0.6 units per liter.

The tabulation is aimed to attain coolant concentration correction in one go and avoid iteration i.e no repeat adjustment should be required.

Checking is recommended in case of following conditions –

1. At the time of initial commissioning,
2. When coolant is totally replaced / excessive coolant loss occurs
3. When concentration levels are unknown / doubtful.

Special Instructions :

For all old engines using fleetcool XB coolant, it is strongly recommended that coolant concentration should be checked and controlled within 0.4 to 0.6 units per liter. In case it is excess of 0.6, immediate correction as per tabulation Card Part No. 4912783 provided in Coolant test kit Part No. 3167226 is required.

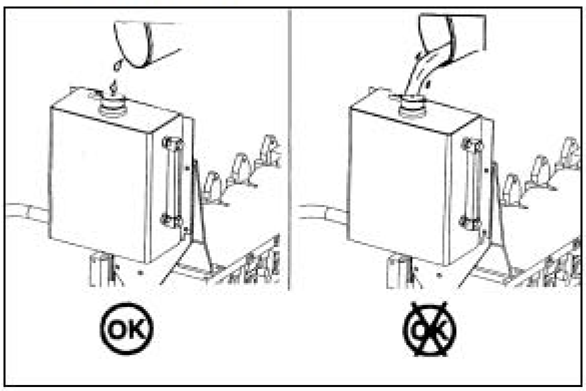
INSTRUCTIONS FOR USE

The Coolant Additive Concentrate and pre-mixed coolant is supplied with each engine as,

- Required quantity of Coolant Additive Concentrate as per engine model.
- Coolant test kit 3167226
- Pre-mixed coolant for top up.

1) First fill at the time of engine commissioning Genset Applications

a) Add Coolant Additive Concentrate supplied in kit in expansion tank (Ref. Picture 1).



Picture 1

b) Fill the remaining system by water till the system is completely filled.

2. Coolant Top Up

If system is topped up by water it leads to dilution of the coolant i.e. coolant concentration becomes lower. In order to maintain the coolant concentration it is must to top up the system by pre-mixed coolant only and not by water.

To facilitate top uppre-mixed coolantis made available. This Pre-mixed coolant is to be used as supplied. Do not dilute.

If pre-mixed coolant is not available, mix 15 parts of water : 1 part of Coolant Additive Concentrate and use this coolant for top up.

Improper cooling system top-up is the primary reason for low concentration levels in the coolants which in term causes corrosion and liner pitting.

3. Coolant Checking

In normal operating condition with system maintained as per above, the coolant will be maintained to the required specifications and no checking is required. However coolant checking is suggested as audit check, at every 1500 hours/6 months during operation. Checking is also suggested in case of following :

— At the time of commissioning the engine,

— When coolant is totally replaced / excessive coolant loss occurs

— When concentration levels are unknown / doubtful. Coolant checking is very easy with the use of Test Strip.

During coolant checking two coolant properties namely coolant concentration and pH value of coolant are to be checked as follows :

Concentration

This can be checked by Test Kit, using following method:

i. Remove the top tank cap of heat exchanger, use dropper or open vent cocks in the cooling system & collect coolant sample in the beaker.

ii. Allow the coolant temperature to reach room temperature.

iii. Remove ‘Test Strip’ from the pack. Dip the strip in coolant for 3 seconds.

iv. Remove strip and shake briskly to remove excess coolant.

v. Wait for 45 seconds. Compare the colour of the strip with the colour chart within next 30 seconds.

vi. Take action as shown in the colour chart.

pH of coolant

No special checking kit is required for this property. This is only visual check. Special colour indicator has been added in the new CAC whose colour changes with pH. When colour of the coolant is pink the pH is within limit. (8.5 to 10.0 pH)

If coolant becomes colourless, then it indicates very low level of concentration. Hence add CAC as required to maintained the concentration level.

4. Coolant Replacement

At 6000 hours of operation or after two years, it is necessary to replace the coolant.

Important Note :

Use of good quality water along with CAC is important for optimum cooling system performance. Water used in cooling system must meet following specifications.

Hardness	(as $CaCO_3$)	-	170 ppm max
Chlorides	(as Cl)	-	40 ppm max
Sulfate	(as SO_4)	-	100 ppm max

pH	- 5 to 9
TDS (Total Dissolved Solids)	- Less than 400 ppm.

It is suggested to get Water quality checked from authorised laboratories if water quality is doubtful.

Coolant

Water coolant is important for cooling system performance. Excessive levels of calcium and magnesium contributes to scaling problems and excessive levels of chlorides and sulphates cause cooling system corrosion. The quality of water must meet the requirements listed below :

Water maximum levels

- Calcium Magnesium (Hardness) 170 ppm as ($CaCO_3$ + $MgCO_3$)
- Chloride 40 ppm as (Cl)
- Sulphur (Sulphates) 100 ppm as (SO_4)

To ensure adequate corrosion protection check engine coolant per procedure under Check Engine Coolant in section 3.

Check magnesium plate for pitting or being eaten away, change if more than 50% of area is lost, where Corrosion Resistor is used.

Section 11 -
Capscrew Markings and Torque Values

Section 11 - Capscrew Markings and Torque Values

Section Contents

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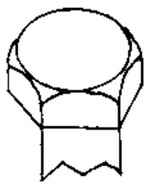
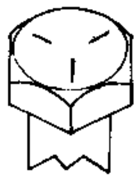
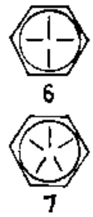
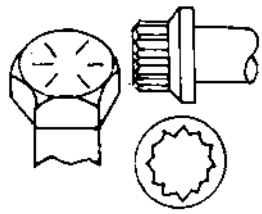
Capscrew Markings and Torque Values

Current Usage	**Much Used**	**Much Used**	**Used at Time**	**Used at Time**
Minimum Tensile Strength PSI MPa	To 1/2—69.000 (476) To 3/4—64,000 (421) To 1-55,000 (379)	To 3/4—120,000 (827) To 1—115,000 (793)	To 5/8—140,000 (965) To 3/4—133,000(917)	150,000 (1034)
Quality of Material	**Indeterminate**	**Minimum Commercial**	**Medium Commercial**	**Best Commercial**
SAE Grade Number	1 or 2	5	6 or 7	8
Capscrew Head-Markings Manufacturer's marks may vary These are all SAE Grade 5 (3 line) 				

Capscrew Body Size (Inches)—(Thread)	**Torque Ft-Lbs (N.M)**	**Torque Ft-Lbs (N.m)**	**Torque Ft-Lbs (N.m)**	**Torque Ft.Lbs (N.m)**
1/4 — 20	5 (7)	8 (11)	10 (14)	12 (16)
— 28	6 (8)	10 (14)		14 (19)
5/16 — 18	11 (15)	17 (23)	19 (26)	24 (33)
— 24	13 (18)	19 (26)		27 (37)
3/8 — 16	18 (24)	31 (42)	34 (46)	44 (60)
— 24	20 (27)	35 (47)		49 (66)
7/16 — 14	28 (38)	49 (66)	55 (75)	70 (95)
— 20	30 (41)	55 (75)		78 (106)
1/2 — 13	39 (53)	75 (102)	85 (115)	105 (142)
— 20	41 (56)	85 (115)		120 (163)
9/16 — 12	51 (69)	110 (149)	120 (163)	155 (210)
— 18	55 (75)	120 (163)		170 (231)
5/8 — 11	83 (113)	150 (203)	167 (226)	210 (285)
— 18	95 (129)	170 (231)		240 (325)
3/4 — 10	105 (142)	270 (366)	280 (380)	375 (508)
— 16	115 (156)	295 (400)		420 (569)
7/8 — 9	160 (217)	395 (536)	440 (597)	605 (820)
— 14	175 (237)	435 (590)		675 (915)
1 — 8	235 (319)	590 (800)	660 (895)	910 (1234)
— 14	250 (339)	660 (895)		990 (1342)

Notes :

1. **Always use the torque values listed above when specific torque values are not available.**
2. **Do not use above values in place of those specified in other sections of this manual; special attention should be observed when using SAE Grade 6. 7 and 8 capscrews.**
3. **The above is based on use of clean dry threads.**
4. **Reduce torque by 10 % when engine oil is used as a lubricant.**
5. **Reduce torque by 20 % if new plated capscrews are used.**
6. **Capscrews threaded into aluminium may require reductions in torque of 30% or more of Grade 5 capscrews torque and must attain two times capscrew diameters of thread engagement.**

Caution : If replacement capscrews are of a higher grade than originally supplied, adhere to torque specifications for that placement.

Capscrew Markings and Torque Values - Metric

Commercial Steel Class

			
Thread Diameter mm	Torque N•m (ft-lb)	Torque N•m (ft-lb)	Torque N•m (ft-lb)
5	6 (5)	8 (6)	8 (6)
6	9 (7)	14 (10)	15 (11)
8	24 (18)	34 (25)	38 (28)
10	43 (32)	64 (47)	77 (57)
12	77 (57)	112 (83)	137 (101)
14	127 (94)	180 (133)	216 (159)
16	195 (144)	266 (196)	319 (235)

Notes :

1. **Do not use these values when the torque values are specified in another section of the manual.**

2. **These values are based on clean, dry threads. Reduce the value by 10% when a lubricant is used. Reduce the value by 20% if new plated capscrews are used.**

Torque Specification

Always use caution to be sure that capscrews from the engine are put back in their proper locations.

When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Incorrect capscrews can result in engine damage.

Metric Capscrew Nomenclature

M8 X 1.25 – 25

- 25 — Length in millimeters
- 1.25 — Distance between threads in millimeters
- M8 — Major thread diameter in millimeters

Section 12 - Troubleshooting

Section 12 - Troubleshooting

Section Contents

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Troubleshooting

Troubleshooting is an organized study of the problem and a planned method of procedure for investigation and correction of the difficulty. The chart on the following page includes some of the problems that an operator may encounter during the service life of a Cummins diesel engine.

Cummins Diesel Engines

The chart does not give all the answers for correction of the problems listed, but it is meant to stimulate a train of thought and indicate a work procedure directed toward the source of trouble. To use the troubleshooting chart, find the complaint at the top of the chart; then follow down that column until you come to a black dot. Refer to the left of the dot for the possible cause.

Think Before Acting

Study the problem thoroughly. Ask these questions :

1. What were the warning signs preceding the trouble?
2. What previous repair and maintenance work has been done ?
3. Has similar trouble occurred before ?
4. If the engine still runs, is it safe to continue running it to make further checks ?

Do Easiest Things First

Most troubles are simple and easily corrected; examples are "low-power" complaints caused by loose throttle linkage or dirty fuel filters, "excessive lube oil consumption" caused by leaking gaskets or connections, etc.

Always check the easiest and obvious things first. Following this simple rule will save time and trouble .

Double-Check Before Beginning Disassembly Operations

The source of most engine troubles can be traced not to one part alone but to the relationship of one part with another. For instance, excessive fuel consumption may not be due to an incorrectly adjusted fuel pump, but instead to a clogged air cleaner or possibly a restricted exhaust passage, causing excessive back pressure. Too often, engines are completely disassembled in search of the cause of a certain complaint and all evidence is destroyed during diassembly operations. Check again to be sure an easy solution to the problem has not been overlooked.

Find And Correct Basic Cause of Trouble

After a mechanical failure has been corrected, be sure to locate and correct the cause of the trouble so the same failure will not be repeated. A complaint of "sticking injector plungers" is corrected by replacing the faulty injectors, but something caused the plungers to stick. The cause may be improper injector adjustment or more often, water in the fuel.

Tools and Procedures To Correct A Complaint

Tools and procedures to correct the complaints found in this Troubleshooting section are available from Cummins dealers. This list includes all engine model, shop and engine repair and rebuild manuals.

AFC Fuel Pump Adjustments

All AFC fuel pump adjustments are specified for calibration on a fuel pump test stand and not to be made on the engine. Contact your nearest authorized Cummins dealers to perform maintenance, if required.

Electronic Governor Controller (EFC) :

On Gen drive engines EFC Governor option is provided for better performance. For Operation, maintenance and trouble shooting refer to Electric Fuel Control (EFC) Governor User's Manual, Bulletin No. 3243775.

Trouble Shooting

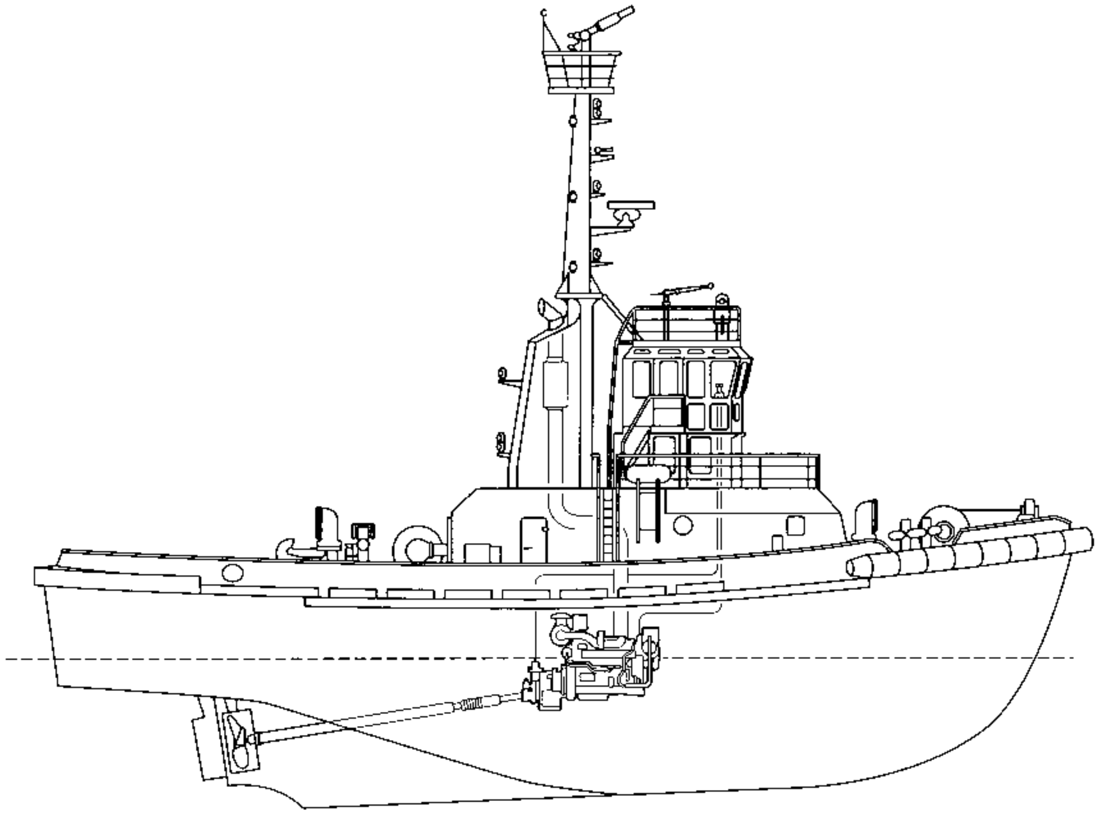
Cummins Engines

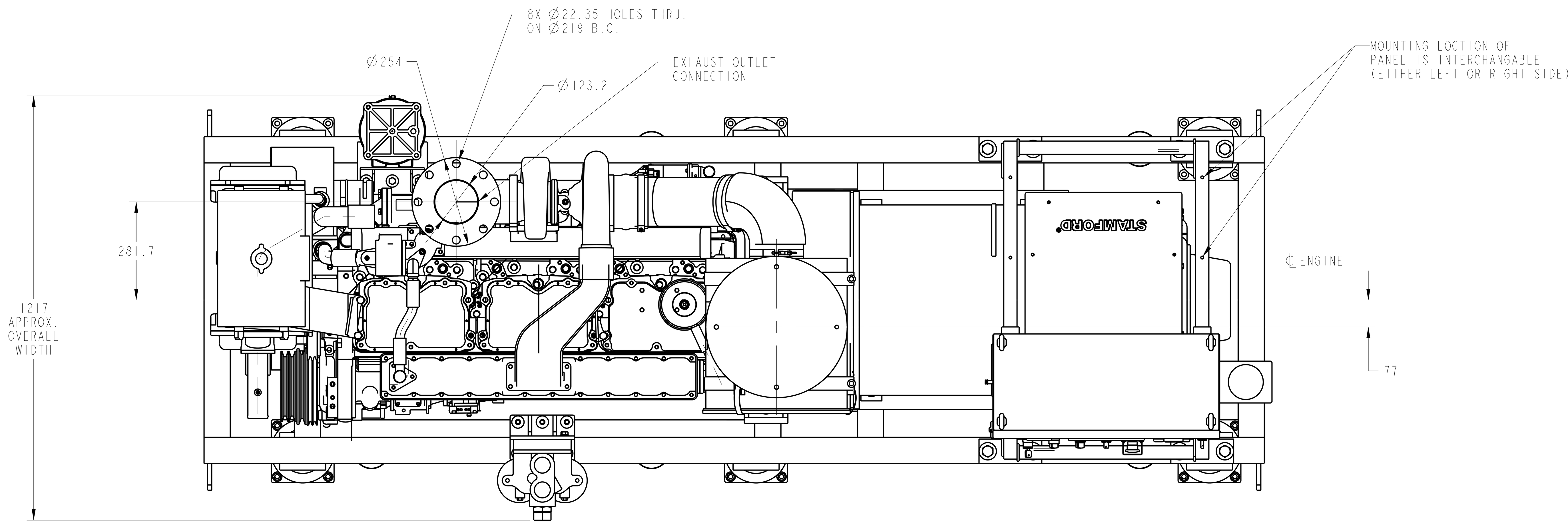
CAUSES	COMPLAINTS	Hard Starting or Failure to Start	Engine Misses	Excessive Black Smoke at Idle	Excessive White Smoke at Idle	Excessive Smoke Under Load	Excessive Acceleration Smoke	Low Power or Loss of Power	Cannot Reach Covered RPM	Low Air Output	Sluggish Engine Acceleration	Excessive Fuel Consumption	Poor Deceleration	Erratic Idle Speed	Engine Dies	Surging at Governed RPM	Excessive Oil Consumption	Crankcase Studge	Dilution	Low Oil Pressure	Coolant Temperature too Low	Coolant Temperature too High	Oil Temperature too High	Piston Liner and Ring Wear	Wear of Bearings and Journals	Worn Valves and Guides	Fuel Knocks (Combustion Noise)	Mechanical Knocks	Gear Train Whine	Excessive Engine Vibration	Excessive Noise	Excessive Crankcase Pressure
Air System	Restricted Air Intake					●	●	●		●		●																				
	High Exhaust Back Pressure					●	●	●				●																				
	Thin Air in Hot Weather or High Altitude					●	●	●		●																						
	Air Leaks Between Cleaner and Engine						●	●		●														●	●	●						
	Dirty Turbocharger Compressor					●	●	●			●	●																				
	Improper Use of Starter AID/Air Temp.	●			●																			●	●		●					
Fuel System	Stuck Drain Valve			●		●	●					●	●																		●	
	Out of Fuel or Fuel Shut Off Closed	●													●																	
	Poor Quality Fuel/Grade Fuel	●	●		●	●		●				●		●	●			●									●					
	Air Leaks in Suction Lines	●	●					●		●	●		●	●	●	●											●					
	Restricted Fuel Lines	●	●	●		●	●	●			●	●	●																			
	External or Internal fuel Leaks							●	●			●			●				●													
	Plugged Injector Spray Holes		●	●		●	●	●				●																				
	Broken Fuel Pump Drive Shaft	●													●																	
	Scored Gear Pump or Worn Gears	●						●																								
	Wrong Injector Cups			●	●	●	●	●				●																				
	Cracked injector Body or Cup	●	●	●	●	●	●	●				●								●							●					
	Damaged Injector O-Ring		●					●				●	●							●												
	Excessive Injector Check Ball Leakage												●																			
	Throttle Linkage or Adjustment							●	●				●	●	●	●																
	Incorrectly Assembled Idle Springs												●	●	●																	
	incorectly Assembled Governor Weights													●	●	●																
	High-Speed Governor Set Too Low							●	●																							
	Water in Fuel and/or Waxing	●	●								●			●	●																	
	AFC Calibration Incorrect	●					●	●			●																				●	
	Damaged/Worn AFC Pluger Seal/Barrel										●																					
	Fuel Pump Calibration Incorrect					●	●	●	●		●	●	●	●	●																●	
	Injector Flow incorrect		●			●	●	●	●		●	●																				
	AFC Air Leak, Belows							●			●																					
Lubricating System	External and Internal Oil Leaks																●			●												
	Dirty Oil Filter																	●		●					●	●						
	Faulty Cylinder oil Control			●													●		●					●								
	Clogged Oil Drillings																			●				●	●	●						
	Oil Suction Line Restriction																			●				●	●	●						
	Faulty Oil Pressure Regulator																			●												
	Crankcase Low or Out of Oil																			●		●	●	●	●	●						
	Wrong Grade Oil for Weather Conditions																●			●				●	●							
	Oil Level Too High							●				●					●						●									
Cooling System	Insufficient Coolant/Worn Pump																			●		●	●									
	Faulty Thermostats																	●		●	●	●	●									
	Damaged Hose/Loose Belts																			●		●	●									
	Internal Water Leaks																	●	●													
	Clogged oil Cooler or Water Passages																		●				●									
	Exterior Leaks/Air in System																		●			●	●									
	Low Coolant Capacity/Dirty Radiator																		●			●	●									
	Coolant Temperature Low				●													●	●		●						●					
Operation and Maintenance practices	Dirty Filters/Screens/Breather							●	●										●					●	●	●						
	Long Idle periods	●	●	●	●	●		●										●	●		●											
	Engine Overloaded							●	●			●												●	●		●					
	Oil Needs Changing																	●						●	●	●						
	Engine Exterior Dirty																					●	●									
Mechanical Adjustments or Repair	Gasket Blow-By or Leakage	●	●	●		●	●	●	●		●	●	●	●	●	●	●		●	●												
	Faulty Damper/Flywheel Balance																											●		●	●	
	Valve Leakage/Adjustment Bad	●	●			●	●	●																		●					●	
	Broken or Worn Piston Rings	●	●	●		●		●									●							●				●				●
	Incorrect bearing Clearances							●				●								●					●			●	●			
	Excessive Crankshaft End Clearance																								●			●	●			
	Broken Cam Lobes						●																									
	Main Bearing Bore Out of Alignment																								●			●		●		
	Engine Due for Overhaul	●		●		●		●				●					●		●					●	●	●		●	●	●		●
	Damaged Main or Rod Bearings																		●						●			●				
	Geartain Backlash/Broken Tooth																											●	●		●	
	Misalignment-Engine to Driven Unit											●													●				●	●		
	Loose Mounting Bolts/Head Capscrew																											●		●		
	Incorrect Valve and Injection Timing	●			●	●	●	●				●															●				●	
	Worn or Scored Liners or Pistons			●			●	●									●							●				●			●	●
	Injectors Need Adjustment		●	●	●	●	●	●	●		●	●															●					
	Broken/Bent Push Rod or Cam Box						●																					●			●	

Section 13 -

Installation , Wiring and Schematic Diagrams

Commercial Marine Installation Directions





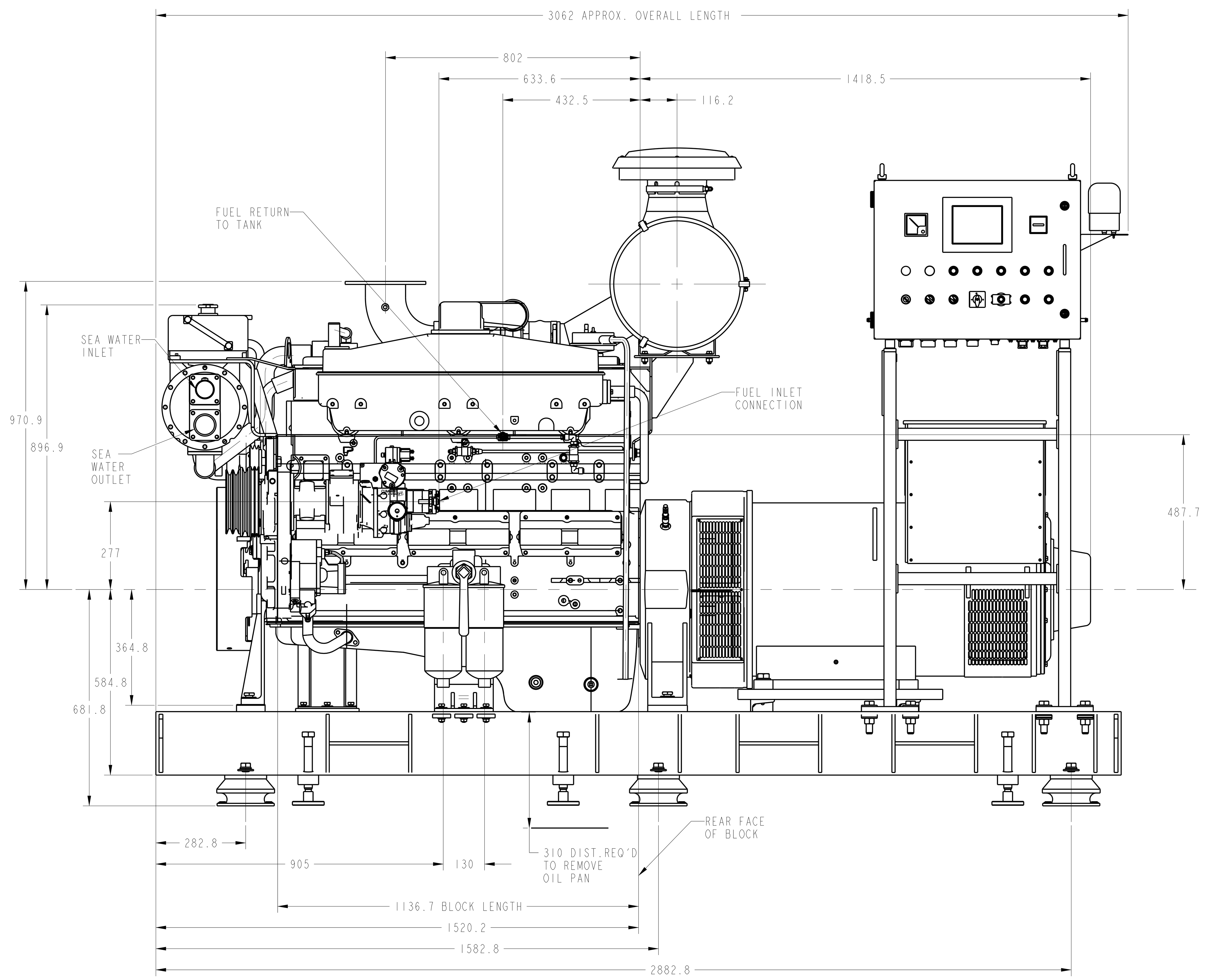
ENGINE SERVICE CONNECTIONS

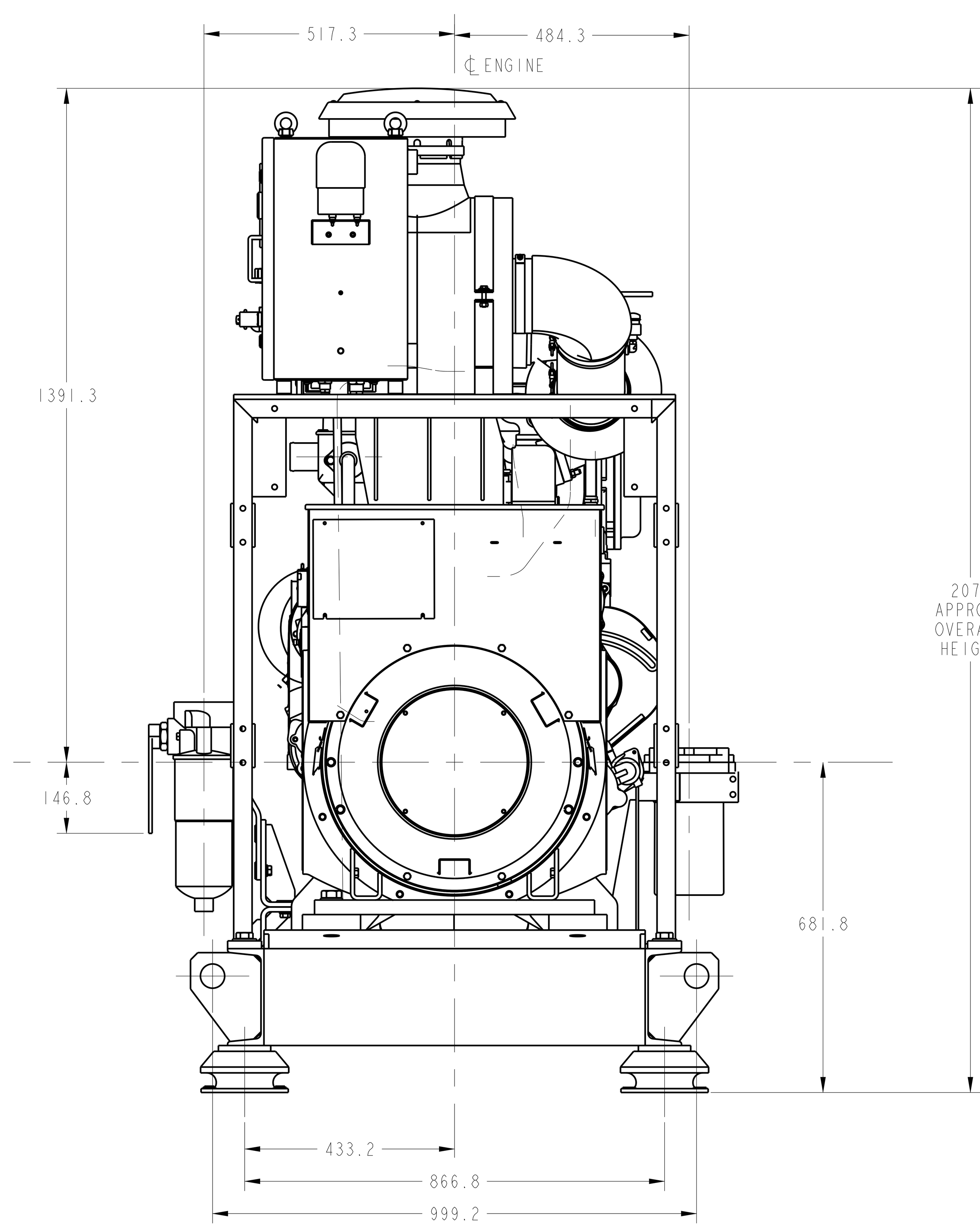
1. FUEL INLET- [7/8-14] UNF-2A
2. FUEL RETURN TO TANK- [3/4-16] UNF-2A
3. EXHAUST OUTLET CONNCTION - Ø123.2 ID
4. SEA WATER INLET- Ø57.1
5. SEA WATER OUTLET-Ø69.85

NOTE: MOUNTING DETAILS PROVIDED ON SHEET 3.

OVERALL DIEMENSIONS IN MM (LXWXH)-3062X1217X2073

1. WEIGHT OF SUBBASE = 360 Kg. APPROX.
2. WEIGHT OF ALTERNATOR = 1160 Kg. APPROX.
3. WET WEIGHT OF ENGINE = 1341 Kg. APPROX.
4. WEIGHT OF OTHER ACCESSORY = 150 Kg. APPROX.
5. WEIGHT OF COMPLETE D.G. SET = 3011 Kg.±5%





PRELIMINARY

NOTE: THIS DRAWING HAS NOT COMPLETED ALL REQUIRED PRODUCT RELEASE CHECK PROCESSES.

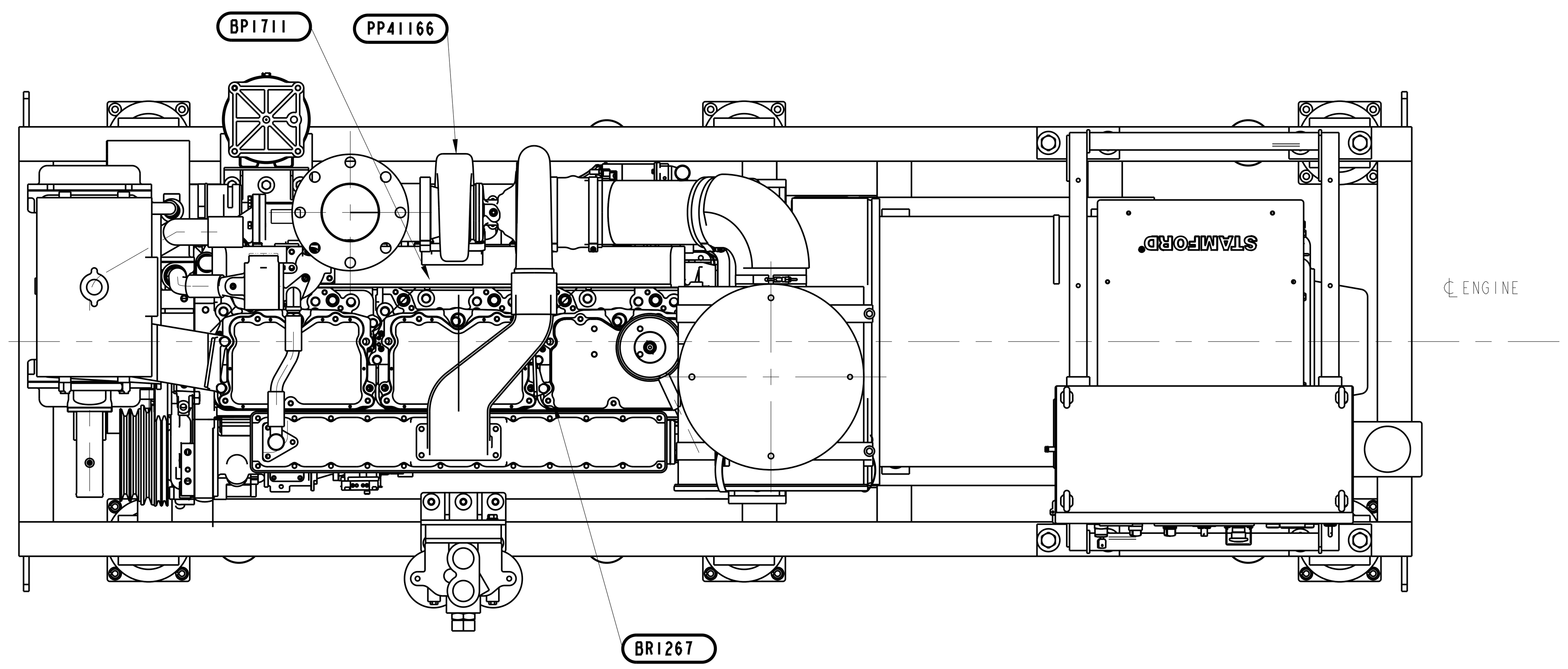
ENGINE MODEL-NTA-855-D(M)

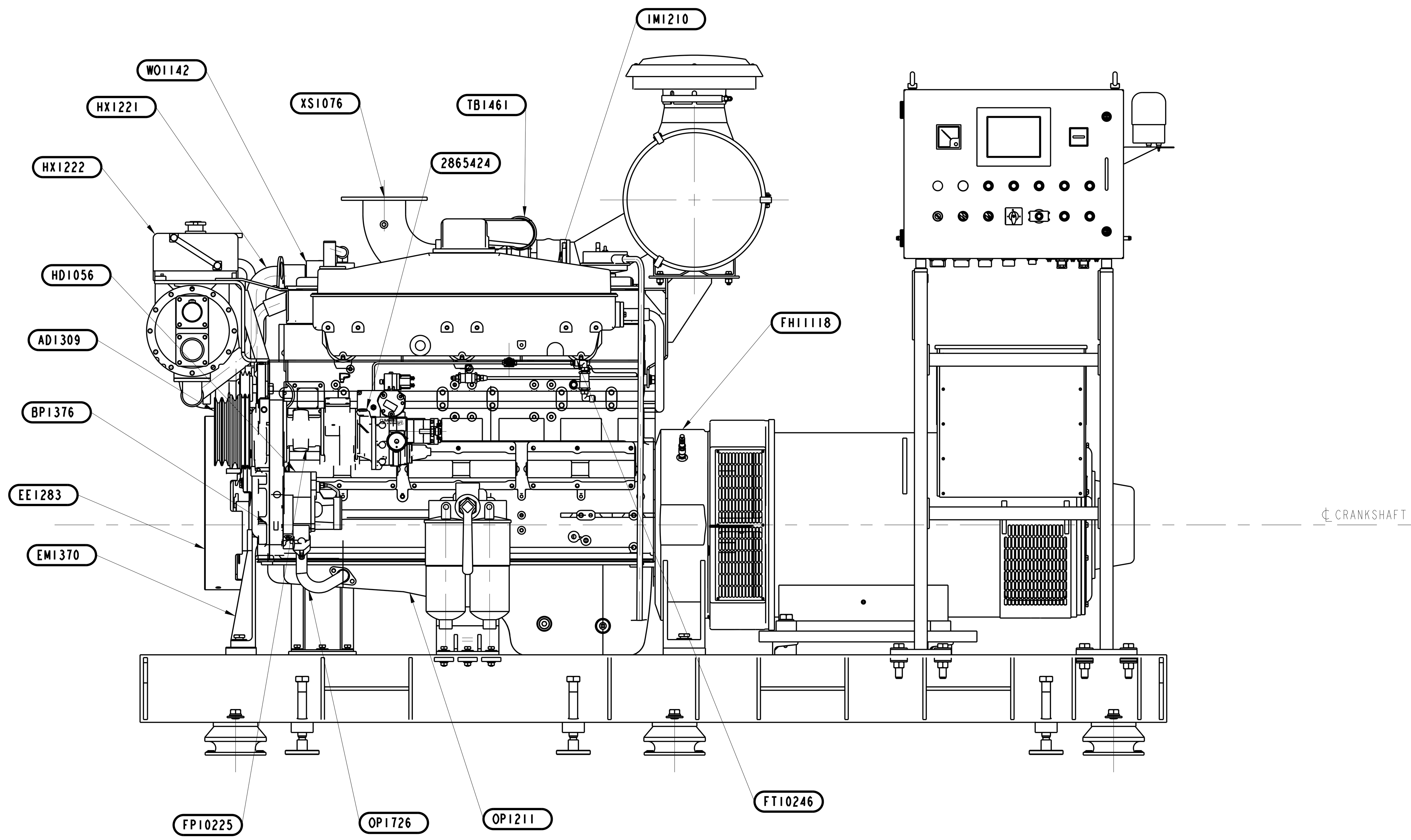
APPLICATION- 8000 DWT 200KW MAIN D.G.

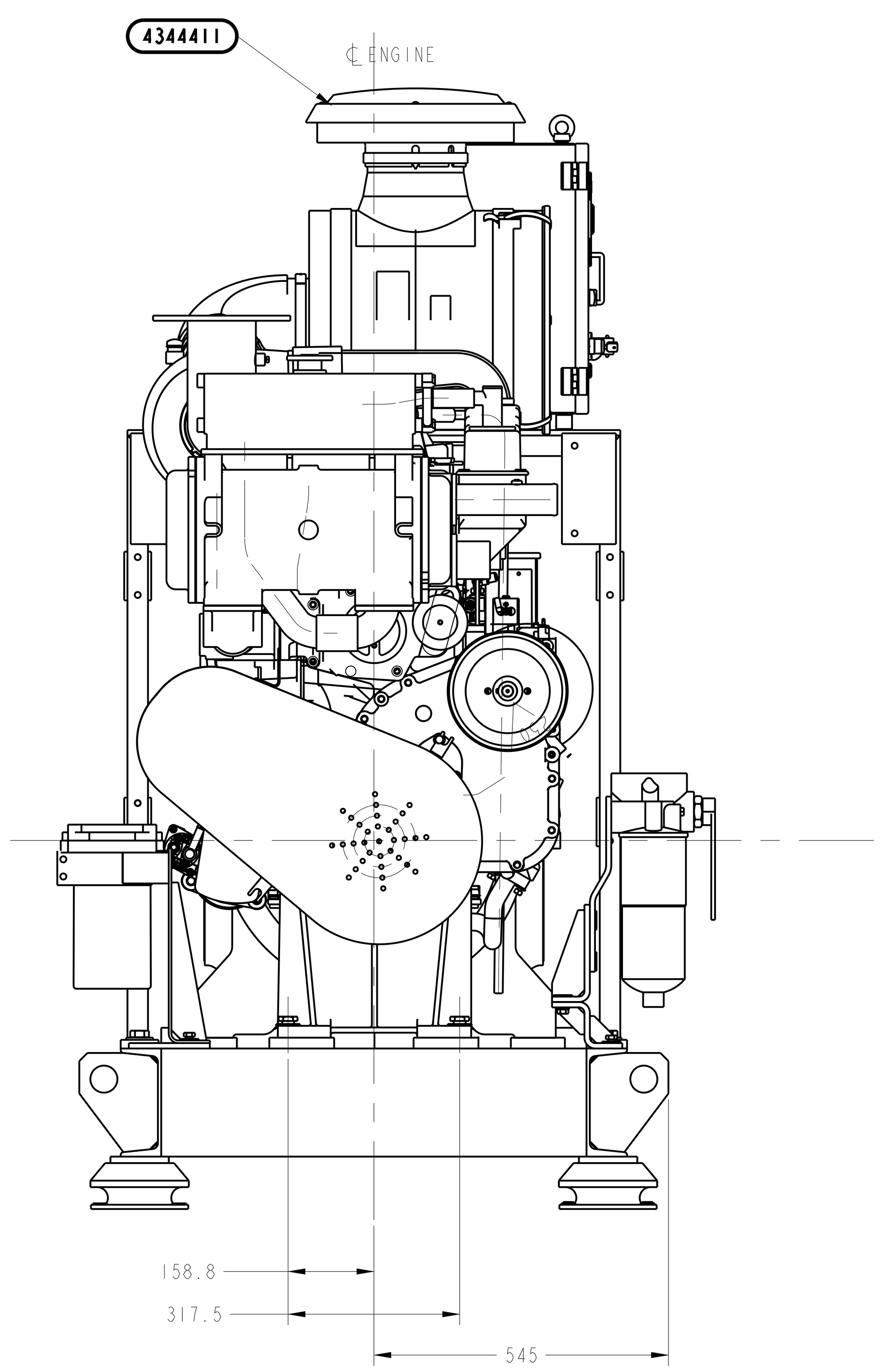
ALTERNATOR MAKE & MODEL-STAMFORD HC4

CUSTOMER-COCHIN SHIPYARD LIMITED

Cummins Inc.	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994	
REF. ITEM NO.: 5278801	ENGR. STD.: 10903
THIRD ANGLE PROJECTION — SIZE J	THIS DOCUMENT (AND THE INFORMATION SHOWN THEREON) IS **CONFIDENTIAL AND PROPRIETARY** AND SHALL NOT BE DISCLOSED TO OTHERS IN HARD COPY OR ELECTRONIC FORM, REPRODUCED BY ANY MEANS, OR USED FOR ANY PURPOSE WITHOUT WRITTEN CONSENT OF CUMMINS INC.
ITEM NAME: NTA-855-D(M)	
IDENTIFIER: INSTALLATION DRAWING	ITEM NUMBER: 5611039
SCALE 0.15	CODE IDENT NO. — SHEET 1 OF 5







REF. NO.	ITEM NO.	QTY.	ITEM NAME
1	169195	8	SCREW,HEXAGON HEAD CAP
2	502469	1	PLATE,BLANKING
3	2865424	1	PUMP,FUEL TLN
4	2889934	1	PANEL,INSTRUMENT
5	3055769	1	GASKET,SEA WATER PUMP
6	3059972	2	WASHER ,PLAIN
7	3226033	1	WASHER,BEVEL
8	3637643	1	SCREW,HEXAGON HEAD CAP
9	3873282	2	WASHER,BEVEL
10	4344411	1	CLEANER,AIR
11	4398201	1	CONNECTION,HET EXC INLET
12	5276349	1	GUARD,COUPLING
13	A062D001	1	CHASSIS,BASE
14	A062D007	1	INSTALLTION,VIABRATION MOUNTS
15	AD1309	1	PULLEY,ACCESSORY DRIVE
16	BP1376	1	PARTS,BASE
17	BP1711	1	COVER,COMPONENT
18	BR1267	1	ARRANGEMENT,CRCBREATHER
19	DA1291	1	DAMPER,VIBRATION
20	EE1283	1	MOUNTING,ALTERNATOR
21	EM1370	1	SUPPORT,FRONT ENGINE
22	EP1282	1	ALTERNATOR
23	ES8029	1	ACCESSORIES,ELESTARTING
24	FH11118	1	HOUSING,FLYWHEEL
25	FH1724	1	DEVICE,SIGNAL GENERATING
26	FO1046	1	COVER,HANDHOLE
27	FP10225	1	PUMP,FUEL
28	FP1365	1	GOVERNOR,ELECTRONIC
29	FT10246	1	PLUMBING,FUEL
30	FW1056	1	FLYWHEEL
31	HD1056	1	PUMP, AUXILIARY
32	HX1221	1	EXCHANGER,HEAT
33	HX1222	1	TANK,EXPANSION
34	IM1210	1	MANIFOLD,AIR INTAKE
35	LF1243	1	FILTER,LUBRICATINGOIL
36	OB1256	1	GAUGE,OIL LEVEL
37	OP1211	1	PAN,OIL
38	OP1726	1	MOUNTING,OILPAN
39	PP41166	1	PARTS,PERFORMANCE
40	S-608	8	WASHER,LOCK
41	ST1403	1	MOTOR,STARTING
42	TB10095	1	ARRANGEMENT,TURBOCHARGER
43	TB1461	1	MANIFOLD,EXHAUST
44	WI1030	1	CONNECTION,WATER INLET
45	WM1161	1	MANIFOLD,WATER
46	WM1719	1	COVER,WATER HEADER
47	WO1142	1	CONNECTION,WATER OUTLET
48	XS1076	1	CONNECTION,EXHAUST OUTLET

PRELIMINARY

NOTE: THIS DRAWING HAS NOT COMPLETED ALL REQUIRED PRODUCT RELEASE CHECK PROCESSES.

Cummins Inc.

DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994

REF. ITEM NO.: 5278801 | ENGR. STD.: 10903

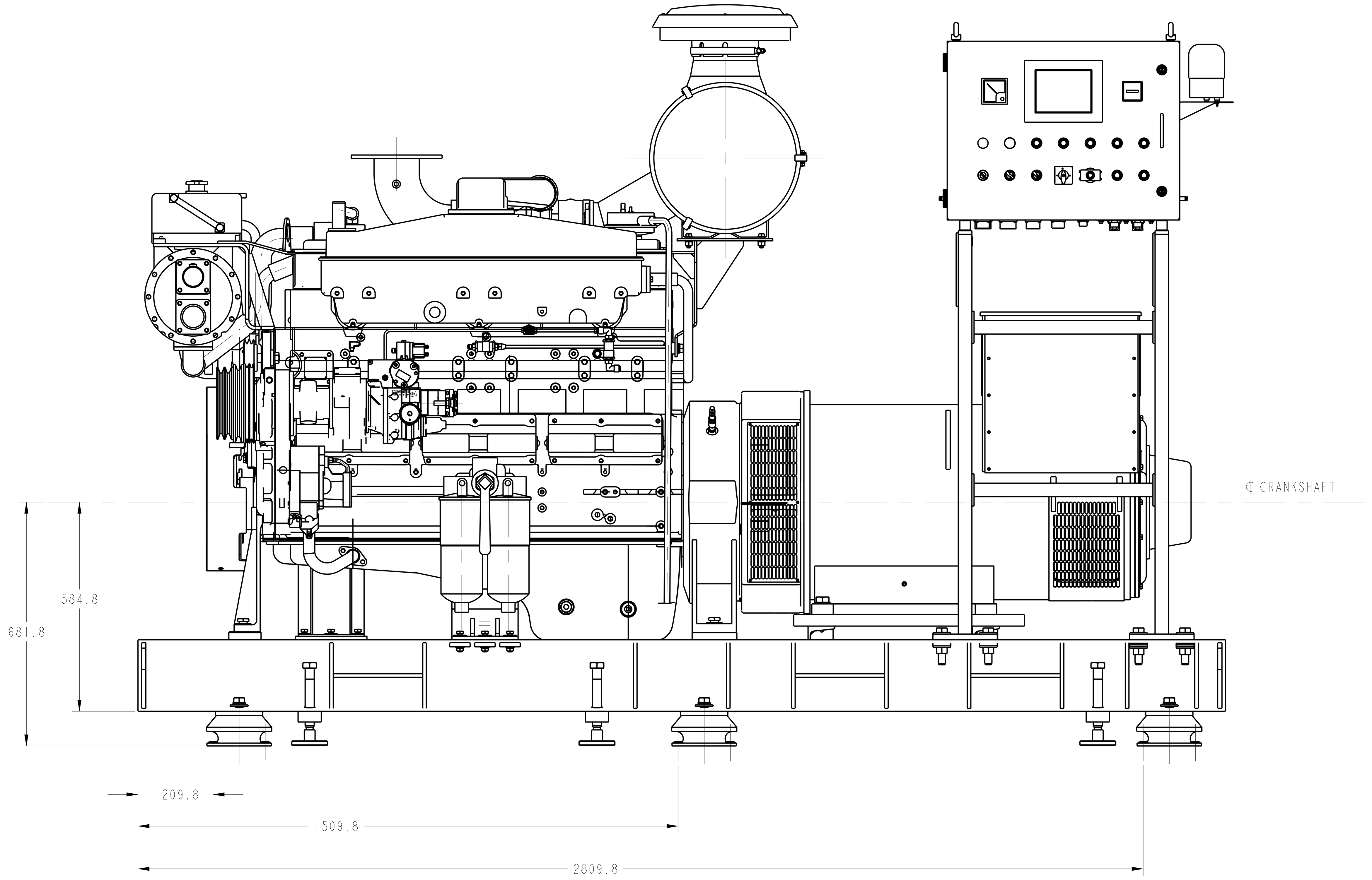
THIRD ANGLE PROJECTION | SIZE J

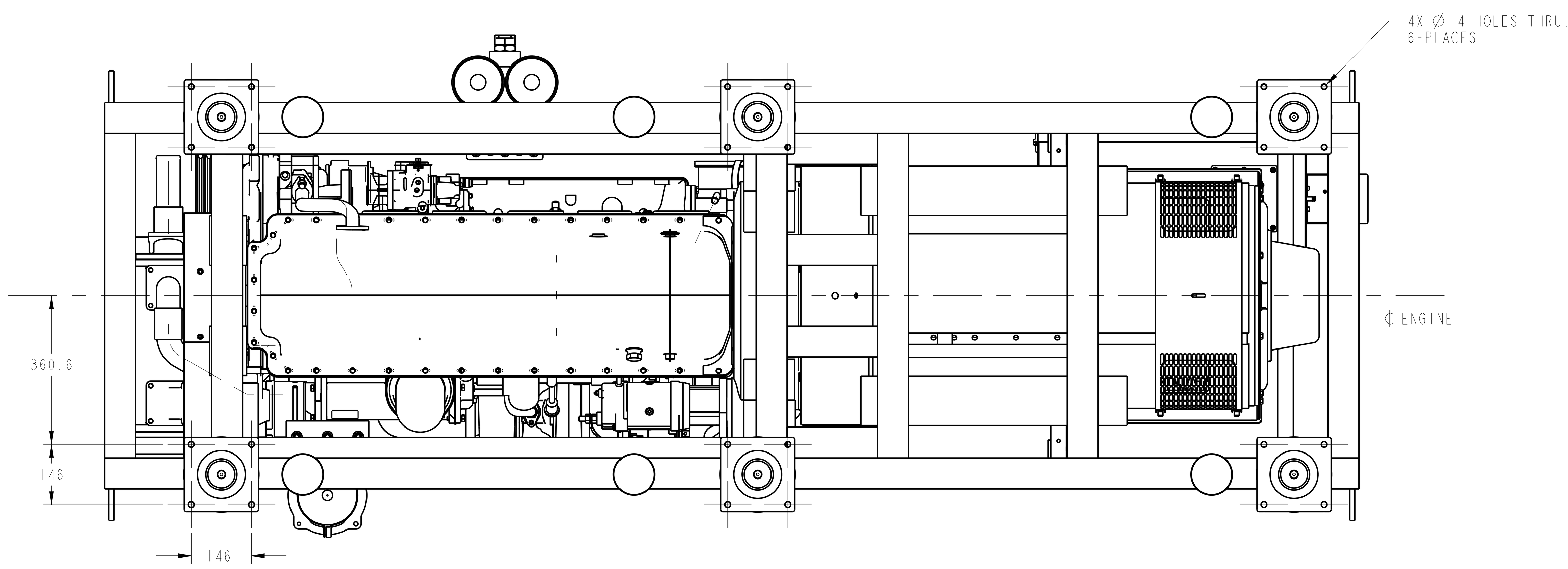
ITEM NAME: NTA-855-D(M)

IDENTIFIER: INSTALLATION DRAWING

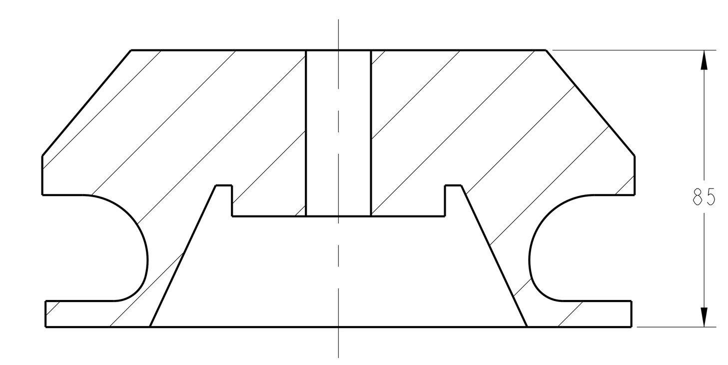
ITEM NUMBER: 5611039

SCALE 0.15 | CODE IDENT NO. | SHEET 2 OF 5

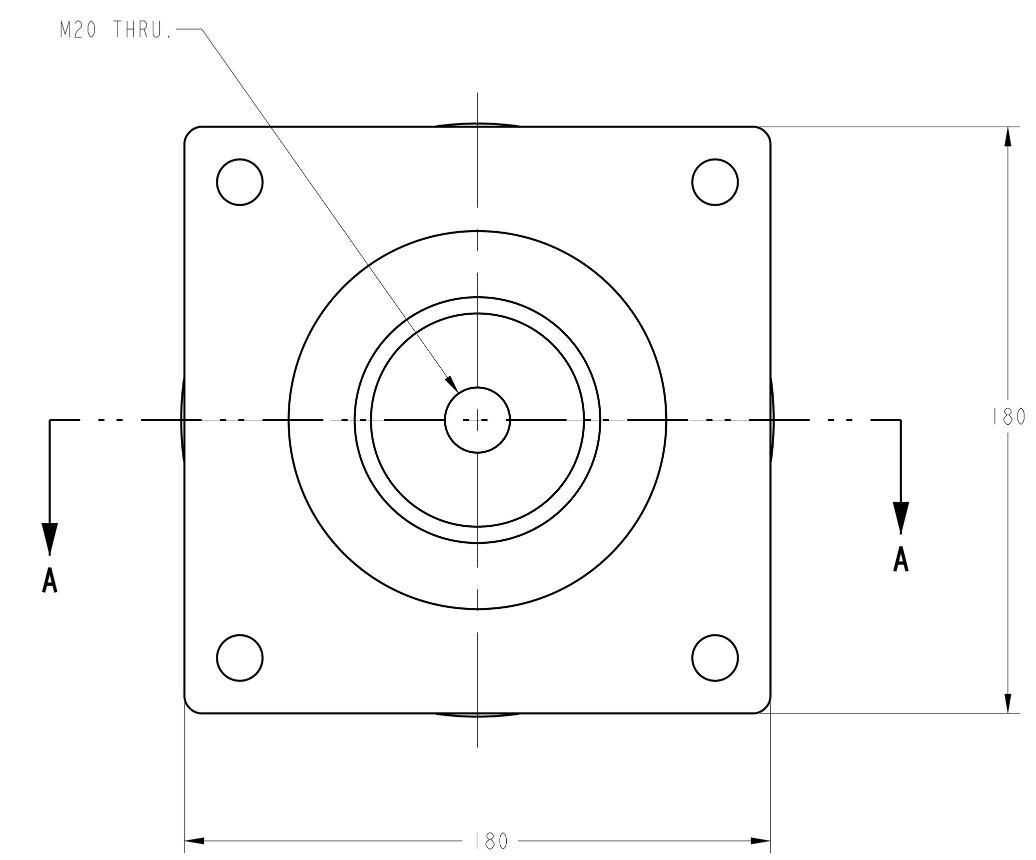




BOTTOM VIEW FOR AVM MOUNTING



SECTION **A-A**
SCALE 0.8



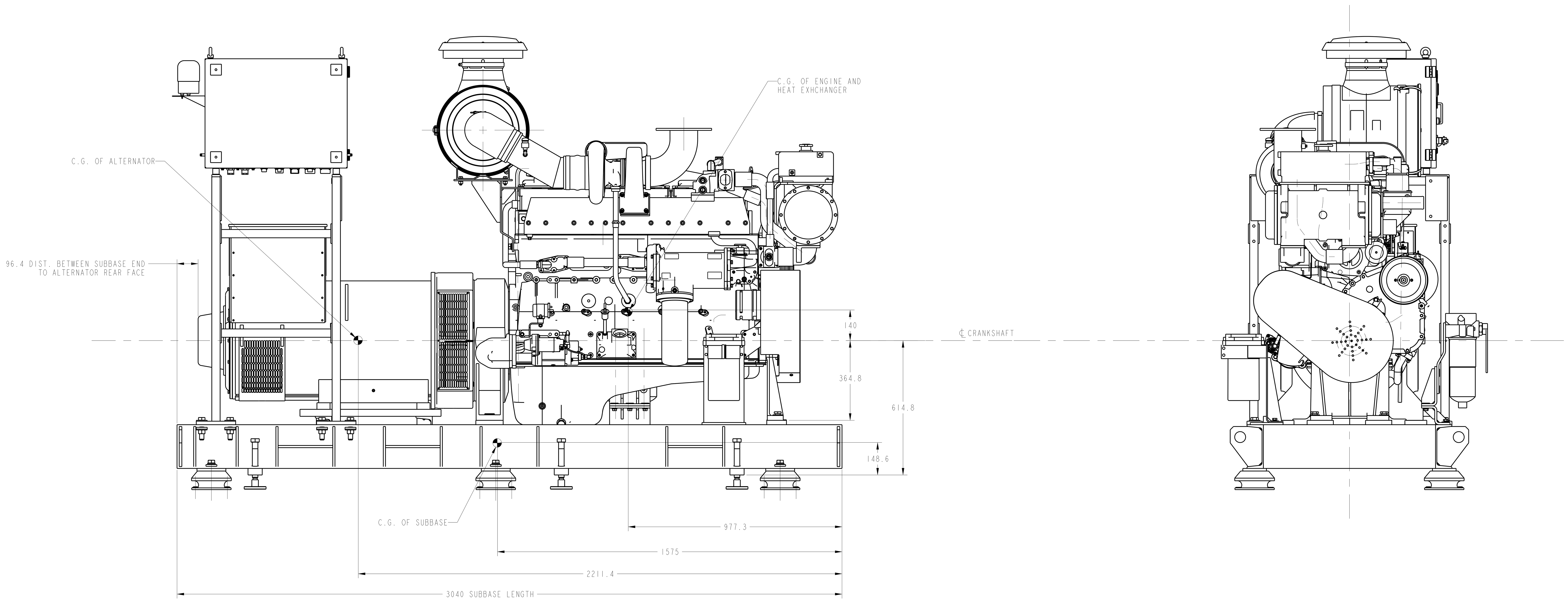
AVM NO. 4398448

PRELIMINARY

NOTE: THIS DRAWING HAS NOT COMPLETED ALL REQUIRED PRODUCT RELEASE CHECK PROCESSES.

DWN

Cummins Inc.	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994	
REF. ITEM NO.: 5278801	ENGR. STD.: 10903
THIRD ANGLE PROJECTION — SIZE J	THIS DOCUMENT (AND THE INFORMATION SHOWN THEREON) IS **CONFIDENTIAL AND PROPRIETARY** AND SHALL NOT BE DISCLOSED TO OTHERS IN HARD COPY OR ELECTRONIC FORM, REPRODUCED BY ANY MEANS, OR USED FOR ANY PURPOSE WITHOUT WRITTEN CONSENT OF CUMMINS INC.
ITEM NAME: NTA-855-D(M)	
IDENTIFIER: INSTALLATION DRAWING	ITEM NUMBER: 5611039
SCALE 0.15	CODE IDENT NO. — SHEET 3 OF 5



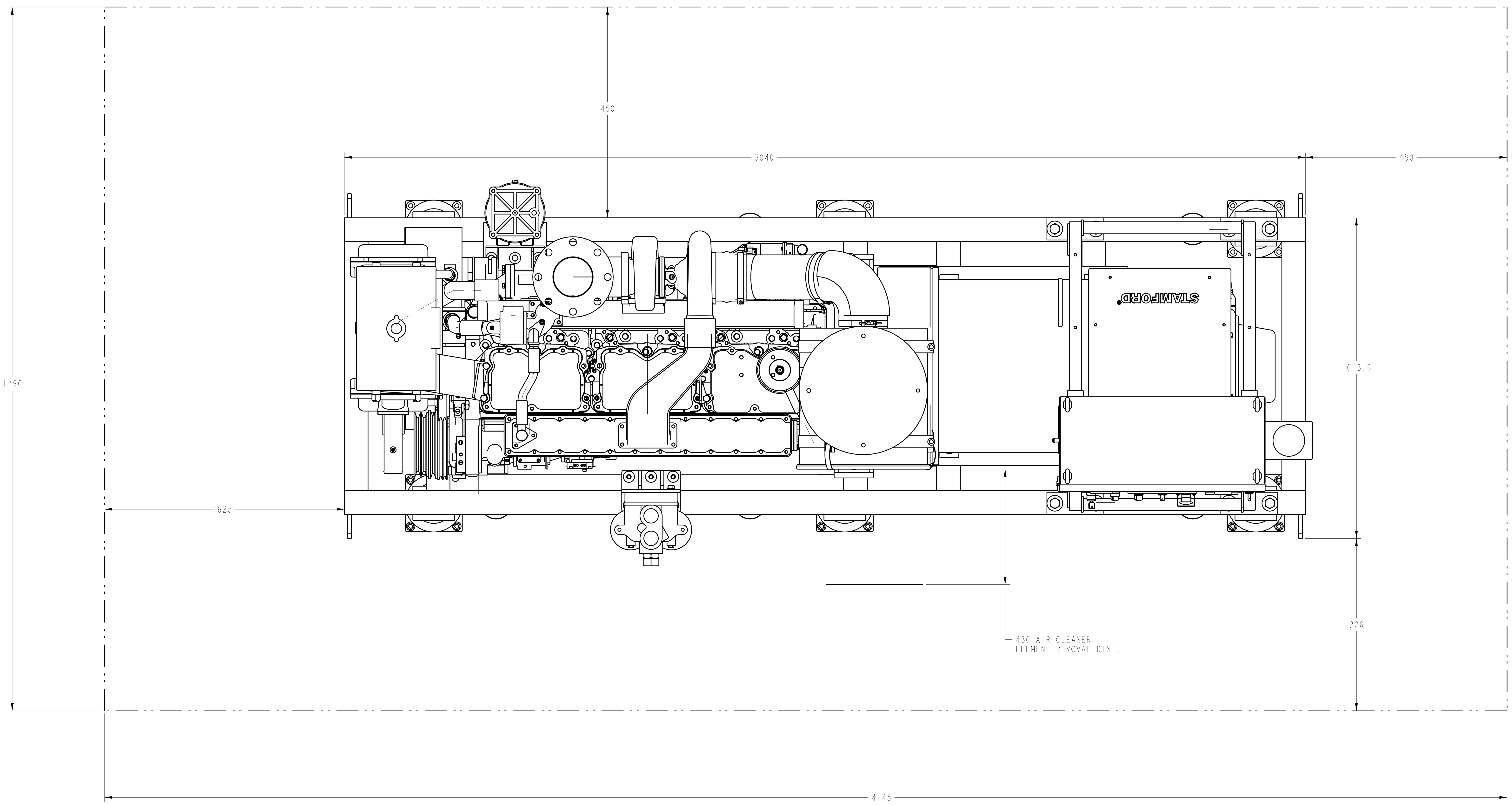
PRELIMINARY

NOTE: THIS DRAWING HAS NOT COMPLETED ALL REQUIRED PRODUCT RELEASE CHECK PROCESSES.

DWN

Cummins Inc.	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994	
REF. ITEM NO.: 5278801	ENGR. STD.: 10903
THIRD ANGLE PROJECTION — SIZE J	THIS DOCUMENT (AND THE INFORMATION SHOWN THEREON) IS **CONFIDENTIAL AND PROPRIETARY** AND SHALL NOT BE DISCLOSED TO OTHERS IN HARD COPY OR ELECTRONIC FORM, REPRODUCED BY ANY MEANS, OR USED FOR ANY PURPOSE WITHOUT WRITTEN CONSENT OF CUMMINS INC.
ITEM NAME: NTA-855-D(M)	
IDENTIFIER: INSTALLATION DRAWING	ITEM NUMBER: 5611039
SCALE 0.15	CODE IDENT NO. — SHEET 4 OF 5

OVERALL MAINTAINANCE ENVELOP REQ'D. 4145 (L) X 1790 (W)



PRELIMINARY

NOTE: THIS DRAWING HAS NOT COMPLETED ALL REQUIRED PRODUCT RELEASE CHECK PROCESSES.

DWN

Cummins Inc.

DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994

REF. ITEM NO.: 5278801 | ENGR. STD.: 10903

THIRD ANGLE PROJECTION

SIZE J

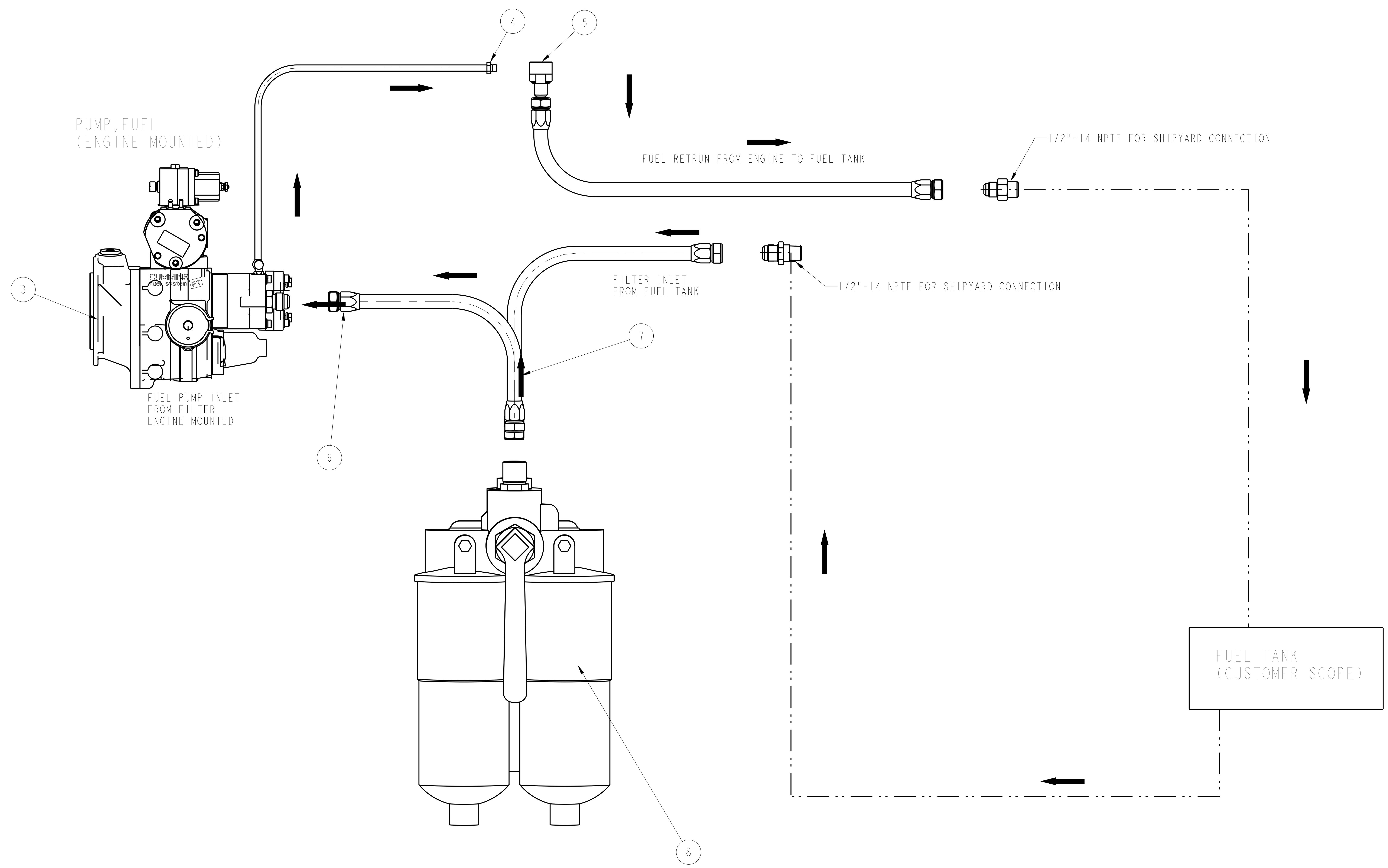
ITEM NAME
NTA-855-D(M)

IDENTIFIER
INSTALLATION DRAWING

ITEM NUMBER
5611039

SCALE 0.15 | CODE IDENT NO. | SHEET 5 OF 5

REF. NO.	ITEM NO.	QTY.	ITEM NAME
1	2865424	1	PUMP,FUEL TLN
2	3225109	1	TUBE,FUEL DRAIN
3	3874427	1	TEE MALE
4	AM10040SS	1	HOSE,FLEXIBLE
5	AM8044SS	1	HOSE,FLEXIBLE
6	FF4093	1	FILTER,FUEL
7	NEW	1	HOSE,FLEXIBLE



SYSTEM :- FUEL

APPLICATION :- 8000DWT 200 KW MARINE GENSET

CUSTOMER :- COCHIN SHIPYARD LIMITED

ENGINE MODEL -NTA-855-D(M)

Cummins Inc.

DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994

REF. ITEM NO.: 5277997 | ENGR. STD.: 10903

THIRD ANGLE PROJECTION | SIZE E

ITEM NAME
NTA-855-D(M)

IDENTIFIER
SCHEMATIC DRAWING

ITEM NUMBER
5611048

SCALE 0.5 | CODE IDENT NO. | SHEET 1 OF 1

SYSTEM :- FUEL
APPLICATION :- 8000DWT 200 KW MARINE GENSET
CUSTOMER :- COCHIN SHIPYARD LIMITED

CUMMINS INC.

DIMENSIONING AND TOLERANCING PER ASME Y 14.5 M ISO R1101

REF. ITEM NO.:4360983 | ENGR. STD.: 10903

THIRD ANGLE PROJECTION | SIZE J

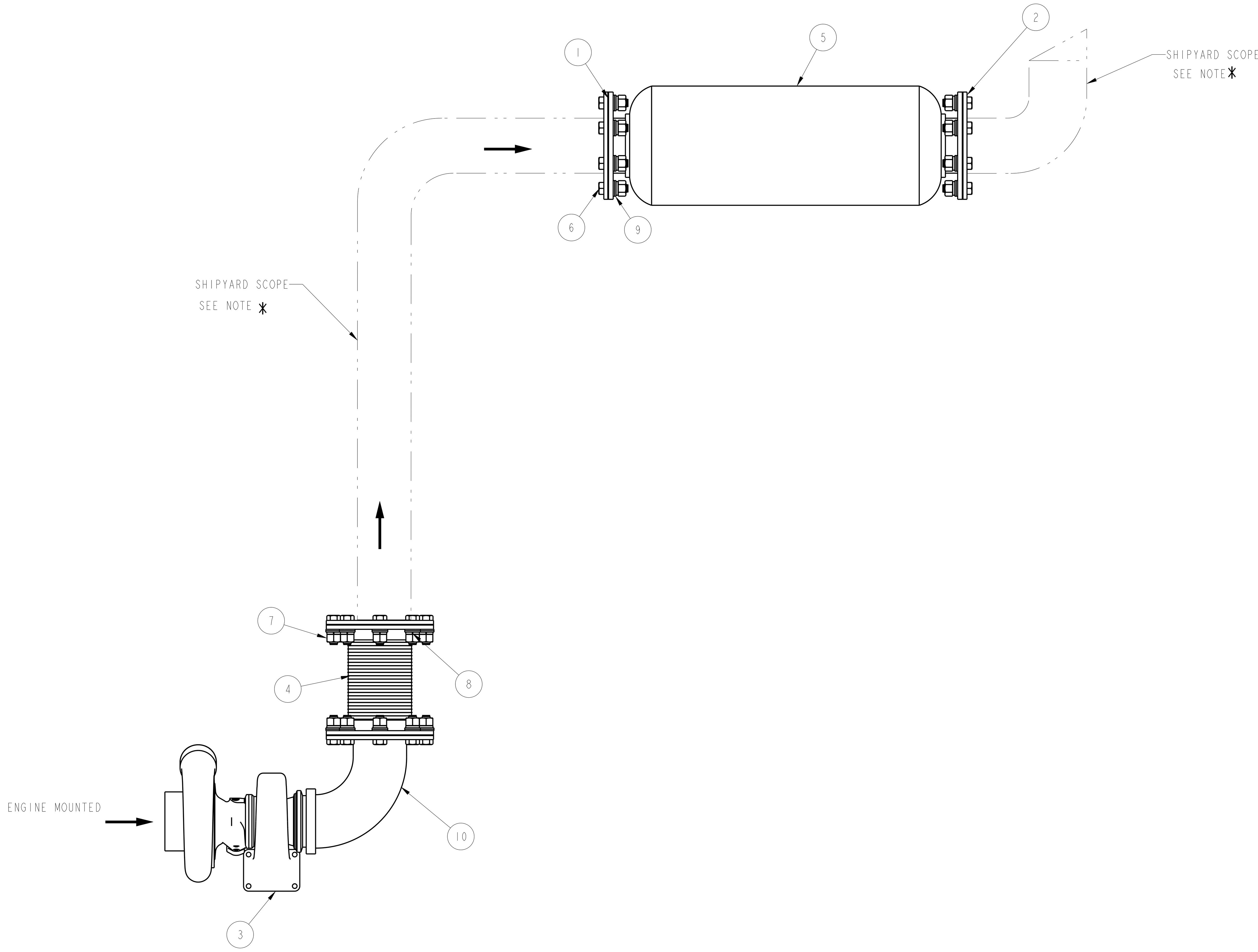
ITEM NAME: FUEL SYSTEM

IDENTIFIER: P&ID LAYOUT | ITEM NUMBER: 5611159

SCALE: DRAWING SCALE | CODE IDENT NO. | SHEET 7 OF 9

REF. NO.	ITEM NO.	QTY.	ITEM NAME
1	2880039	4	GASKET,EXH.OUT CONNECTION
2	3226087	3	FLANGE,WELD
3	3529032	1	TURBOCHARGER
4	3877642	1	CONNECTION,EXHAUST OUTLET
5	NEW	1	MUFFLER
6	S-112-C	32	SCREW,HEXAGON HEAD CAP
7	S-204	32	NUT,HEAVY HEXAGON
8	S611	32	WASHER,LOCK
9	S640	64	WASHER,PLAIN
10	XS1076	1	CONNECTION,EXHAUST

* EXHAUST PIPING IS IN CUSTOMER SCOPE (NOT CIL SUPPLY)



SYSTEM :- EXHAUST

APPLICATION :- 8000DWT 200 KW MARINE GENSET

CUSTOMER :- COCHIN SHIPYARD LIMITED

ENGINE MODEL :- NTA-855-D(M)

Cummins Inc.

DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994

REF. ITEM NO.: 5277998 | ENGR. STD.: .

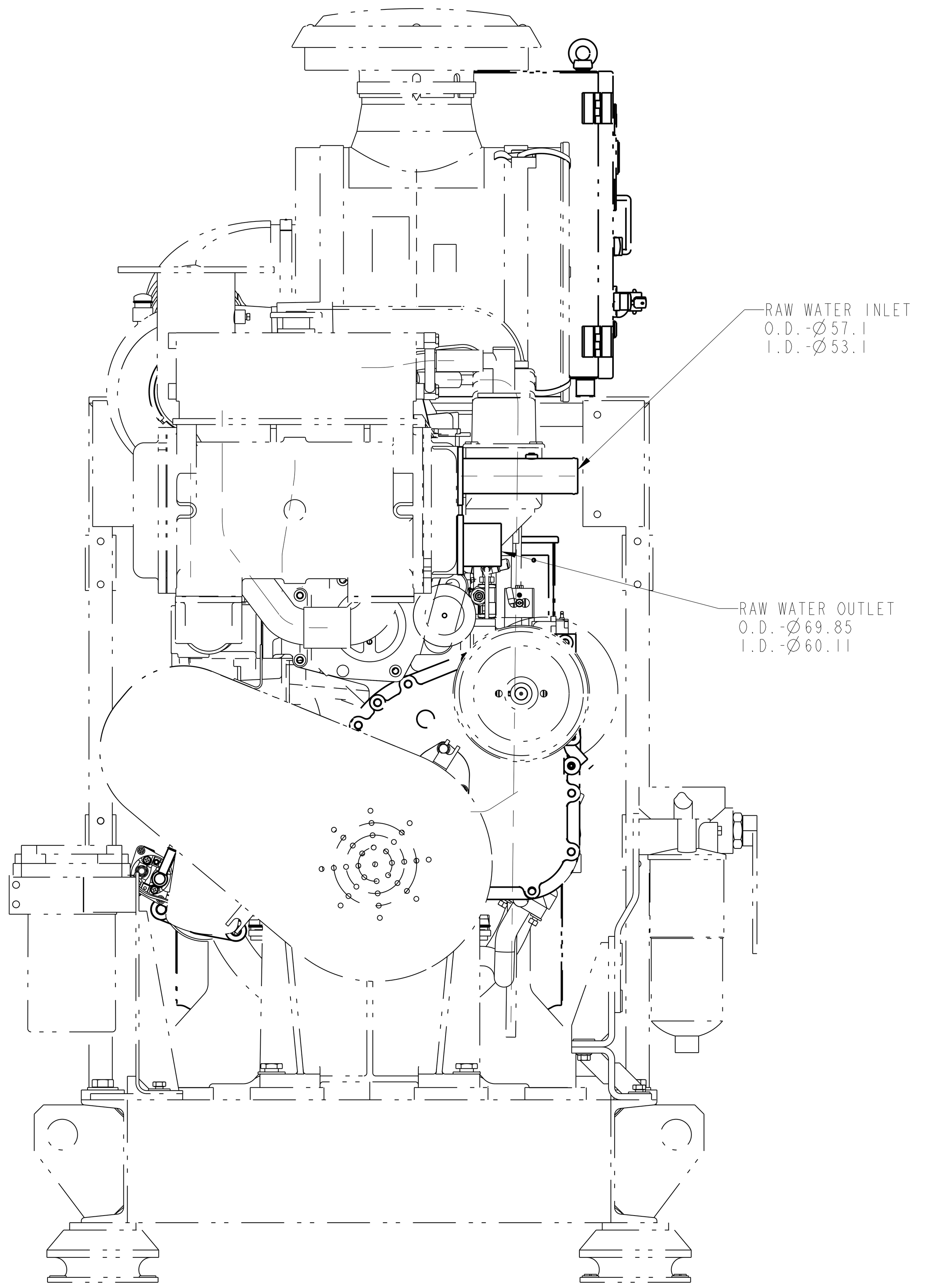
THIRD ANGLE PROJECTION | SIZE J

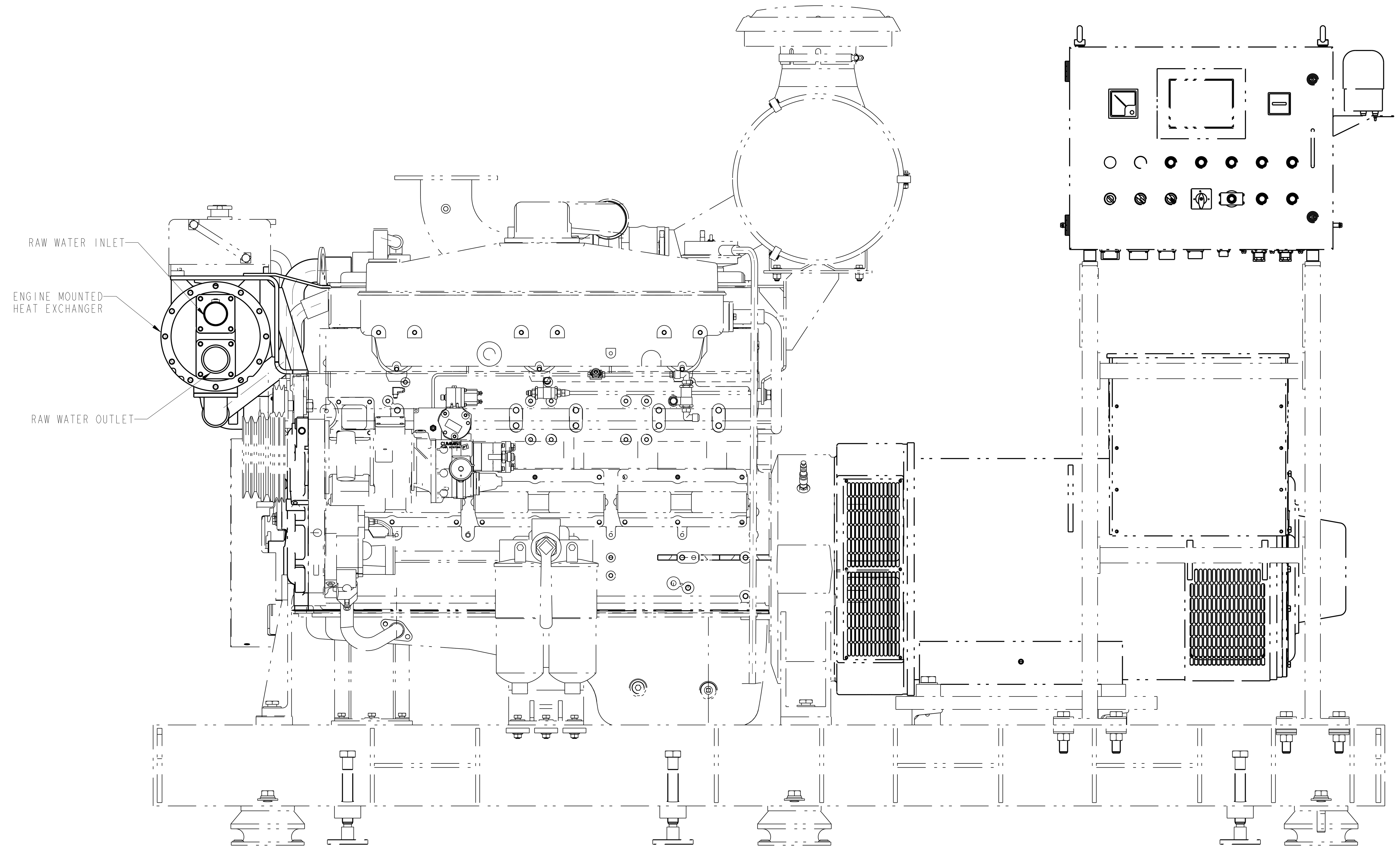
ITEM NAME
NTA-855-D(M)

IDENTIFIER
SCHEMATIC DRAWING

ITEM NUMBER
5611049

SCALE 0.2 | CODE IDENT NO. | SHEET 1 OF 1





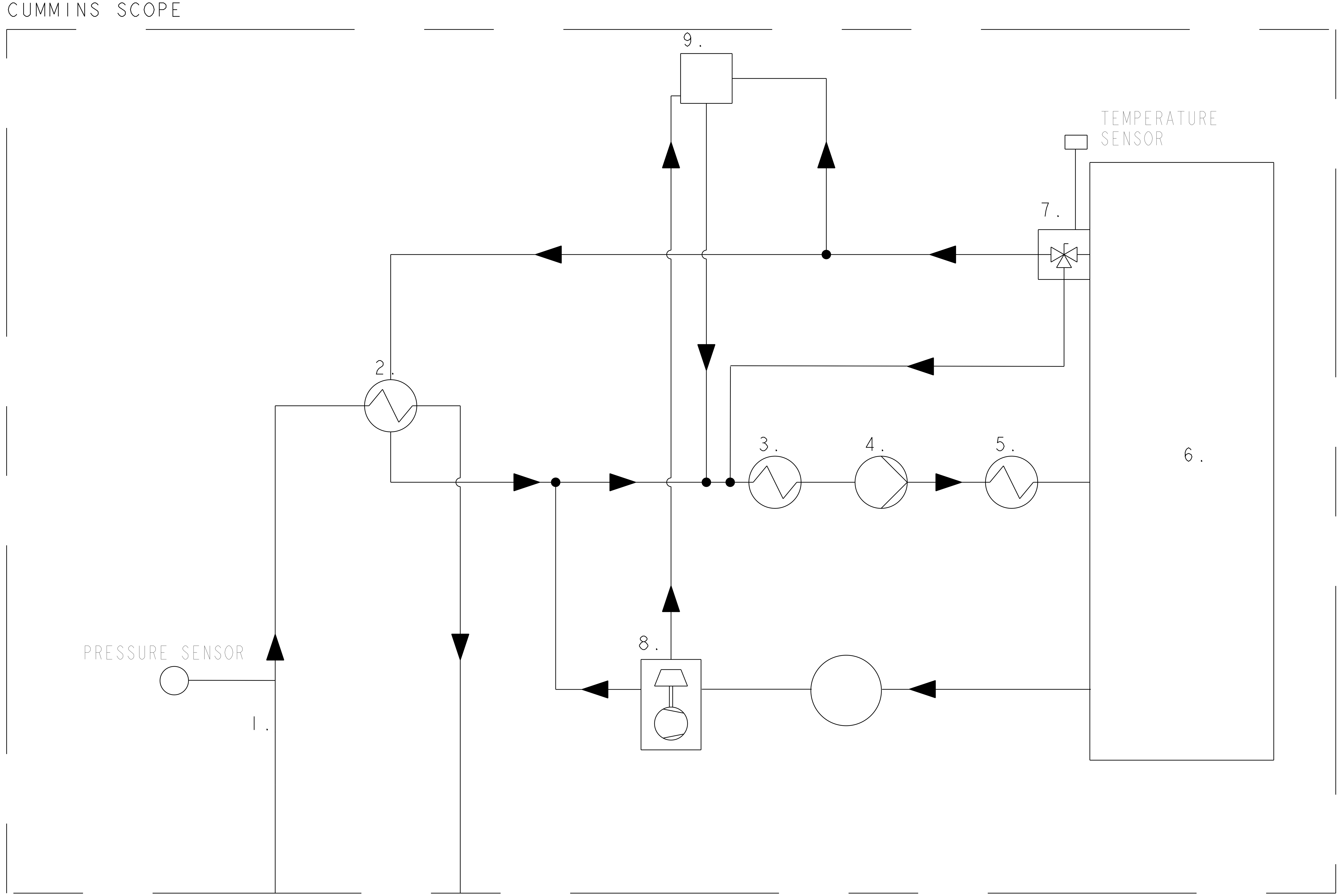
SYSTEM :- COOLING

APPLICATION :- 8000DWT 200 KW MARINE GENSET

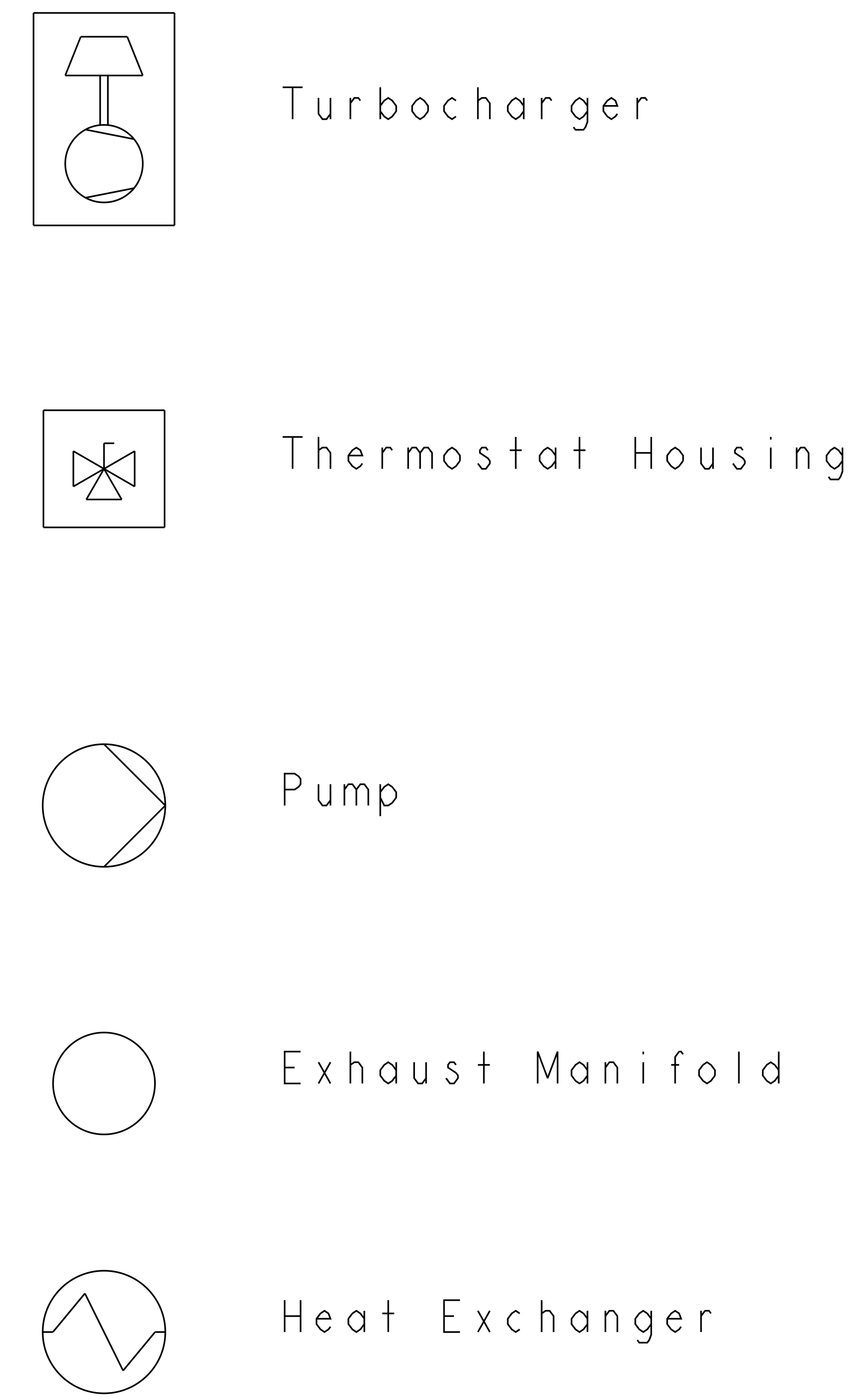
CUSTOMER :- COCHIN SHIPYARD LIMITED

ENGINE MODEL :-NTA-855-D(M)

Cummins Inc.		
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994		
REF. ITEM NO.: 5278801		ENGR. STD.: 10903
THIRD ANGLE PROJECTION	SIZE J	THIS DOCUMENT (AND THE INFORMATION SHOWN THEREON) IS **CONFIDENTIAL AND PROPRIETARY** AND SHALL NOT BE DISCLOSED TO OTHERS IN HARD COPY OR ELECTRONIC FORM, REPRODUCED BY ANY MEANS, OR USED FOR ANY PURPOSE WITHOUT WRITTEN CONSENT OF CUMMINS INC.
ITEM NAME NTA-855-D(M)		
IDENTIFIER INSTALLATION DRAWING		ITEM NUMBER 5611051
SCALE 0.2	CODE IDENT NO.	SHEET 1 OF 1



1. Pressure Sensor
2. Heat Exchanger
3. Aftercooler
4. Coolant Pump
5. Oil Cooler
6. Engine Cylinders
7. Thermostat Housing
8. Turbocharger
9. Expansion Tank
10. Exhaust Manifold



SYSTEM :-COOLING
APPLICATION :- 8000DWT 200 KW MARINE GENSET
CUSTOMER :- COCHIN SHIPYARD LIMITED

Cummins Inc.

DIMENSIONING AND TOLERANCING PER ASME Y 14.5 M ISO R 1101

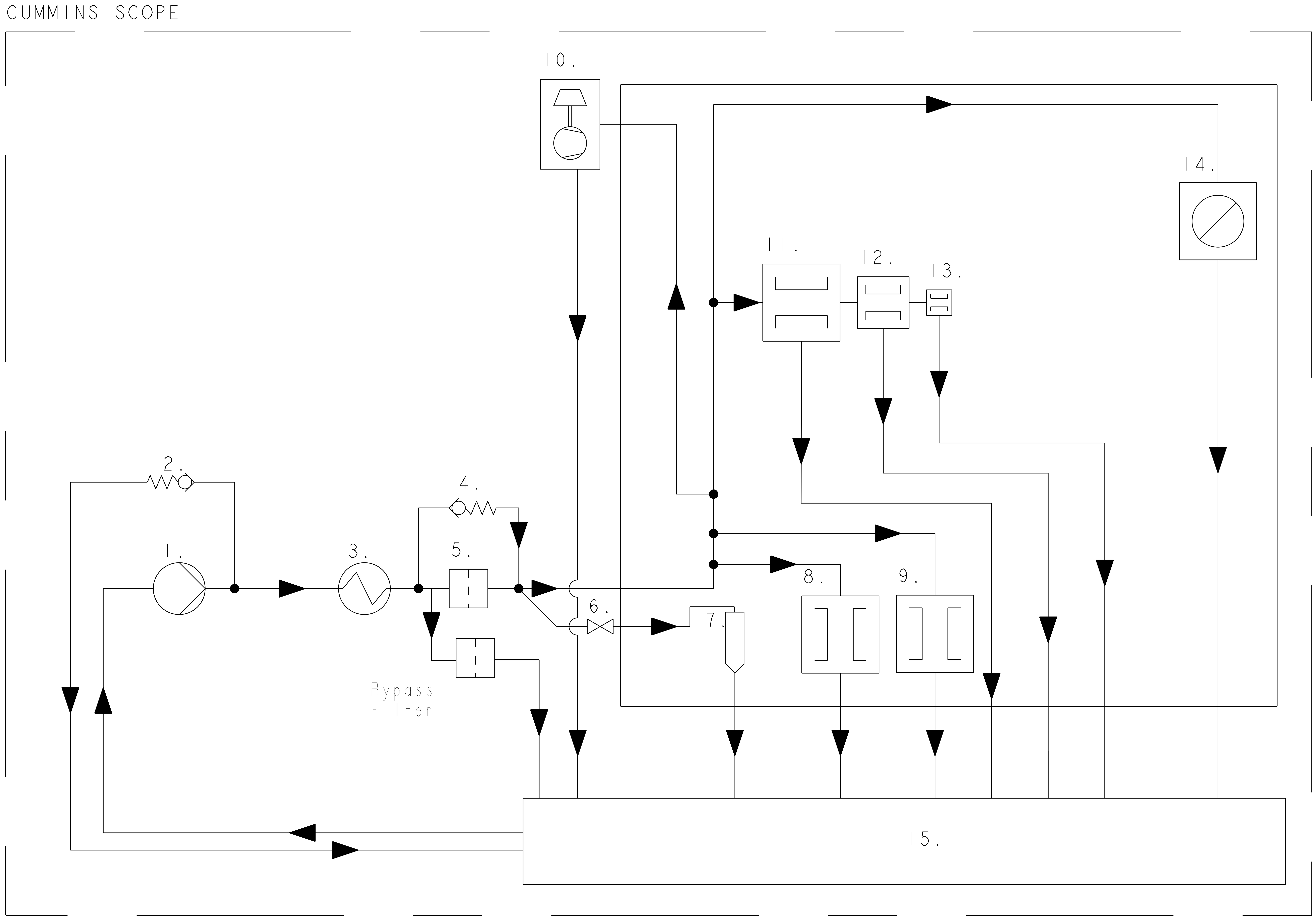
REF. ITEM NO.: 4360982 ENGR. STD.: 10903

THIRD ANGLE PROJECTION SIZE J

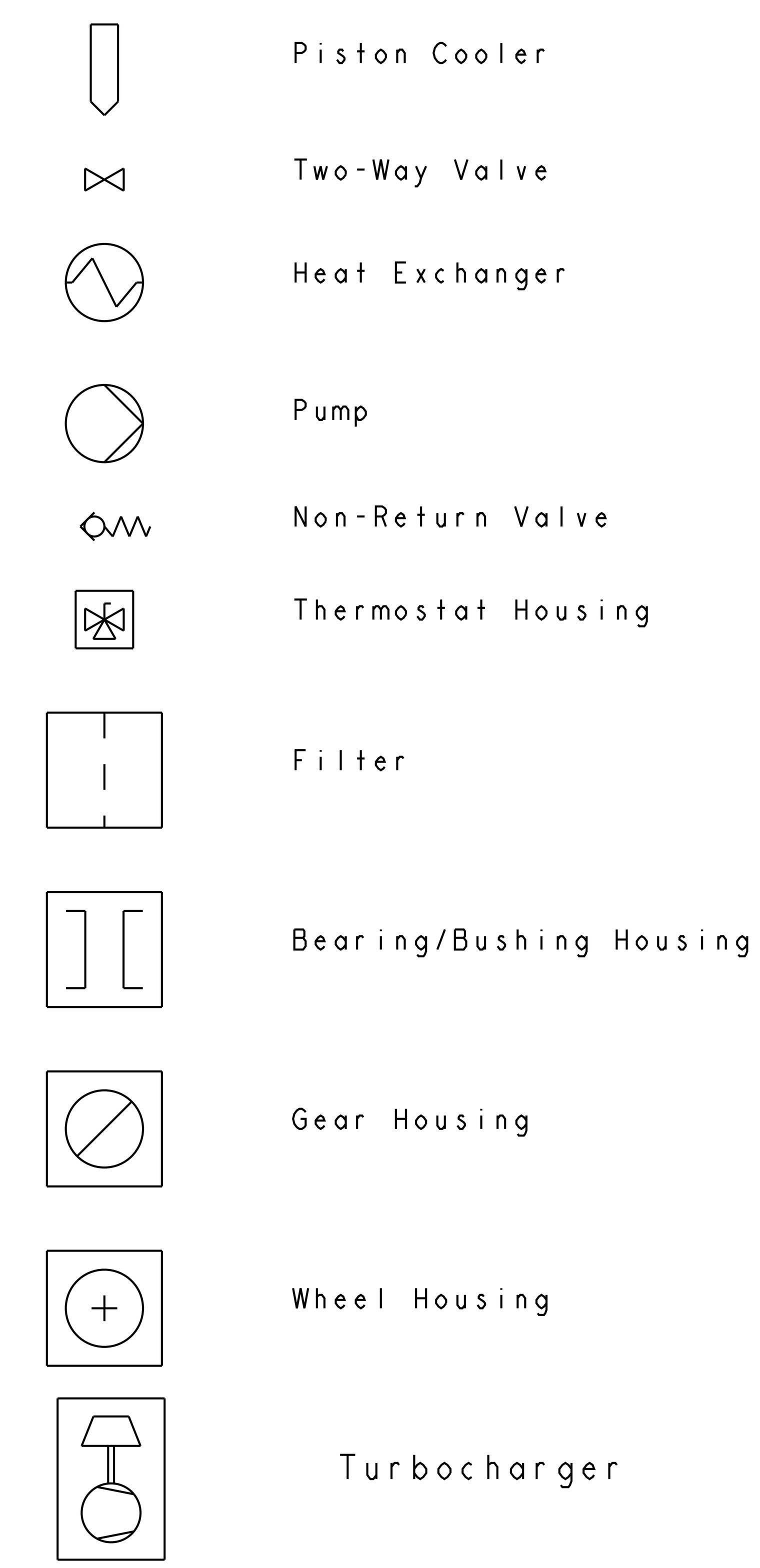
ITEM NAME: COOLING SYSTEM

IDENTIFIER: P&ID DIAGRAM ITEM NUMBER: 5611160

SCALE: DRAWING SCALE CODE IDENT NO.



1. Oil Pump
2. Pressure Regulator
3. Oil Coolers
4. Bypass Valve
5. Filter
6. Piston Cooling Nozzle Control Valve
7. Piston Cooling Nozzles
8. Cam Bearing
9. Rocker Bushings
10. Turbochargers
11. Main Bearing
12. Rod Bearing
13. Wrist Pin Bushing
14. Front Gear Assembly
15. Oil Pan
16. Bypass Filter



SYSTEM :-LUBE OIL SYSTEM
APPLICATION :- 8000DWT 200 KW MARINE GENSET
CUSTOMER :- COCHIN SHIPYARD LIMITED

CUMMINS INC.

DIMENSIONING AND TOLERANCING PER ASME Y 14.5 M-2009

REF. ITEM NO.: A

ENGR. STD.: 10903

THIRD ANGLE PROJECTION

SIZE J

ITEM NAME: LUBE OIL SYSTEM

IDENTIFIER: P & ID DIAGRAM

ITEM NUMBER: 5611166

SCALE: DRAWING SCALE

CODE IDENT NO.

SHEET 6 OF 9

FUNCTIONAL REQUIREMENTS

DESCRIPTION	REQUIREMENT	CHECK METHOD
FINISH	POWDER COATING SHEET	-
APPROX. WEIGHT	40±5 KG	-
COLOUR SHADE OF PANEL	COLOR RAL7032 PEBBLE GREY	-
ENCLOSURE	WATER FROM HEAVY SEAS OR WATER PROJECTED FROM JETS SHALL NOT ENTER THE MACHINE IN ANY HARMFUL QUANTITY IP55	-
OPERATING VOLTAGE	24 V DC POWER SUPPLY	-
CABLE ENTRY	MULTIPINS (ALLIED SERIES OR EQUIVALENT) SHOULD ENTER FROM THE BOTTOM CENTER SIDE OF PANEL	-
EARTHING	EARTHING BOLTS OR STUDS SHOULD BE PROVIDED ON BOTH SIDE OF PANEL	-
PUSH BUTTONS	ACKNOWLEDGE/RESET LAMP CHECK ENGINE START ENGINE STOP (WITH INDICATION) EMERGENCY STOP WITH PROTECTIVE COVER SPEED RAISE SPEED LOWER	-
MAGNETIC PICKUP	AS PER REQUIREMENT	-
SHUTDOWN/ WARNING FAULTS	LUBE OIL PRESSURE ALARM JACKED FUEL OIL LEAKAGE ALARM WATER TEMP. HIGH ALARM LUBE OIL TEMP. HIGH ALARM LUBE OIL PRE. LOW SHUTDOWN WATER TEMP. HIGH SHUTDOWN LUBE OIL TEMPERATURE HIGH SHUTDOWN OVER SPEED SHUTDOWN WINDING TEMPRATURE R/Y/B (ALARM)/LOW COOLANT LEVEL ALARM	-
VOLTMETER & AMMETER	TO DISPLAY BATTERY VOLTAGE, RANGE 0-30 V DC FROM ENGINE BATTERY. AMMETER TO SHOW BATTERY CHARGING CURRENT.	-
ON/OFF SWITCH 16 A	TO ON/OFF THE CONTROL PANEL POWER SUPPLY	-
CIRCUIT BREAKER (GOVERNOR)	TRIPPING SHOULD BE PROVIDED FOR CURRENT ABOVE 6 A	-
CIRCUIT BREAKER (PANEL)	TRIPPING SHOULD BE PROVIDED FOR CURRENT ABOVE 10 A	-
DISPLAY	MAINS ON/OFF SWITCH CONTROL ON (HMI) LOCAL CONTROL (HMI) REMOTE CONTROL (HMI) LUBE OIL PRESS. LOW ALARM (HMI) WATER TEMP. HIGH ALARM (HMI) LUBE OIL TEMP. HIGH ALARM (HMI) LUBE OIL PRESS. LOW TRIP (HMI) WATER TEMP. HIGH TRIP (HMI) LUBE OIL TEMPERATURE HIGH TRIP (HMI) JACKED FUEL OIL LEAKED ALARM (HMI) OVERSPEED TRIP (HMI) ENGINE RUNNING (HMI) EMERGENCY SHUTDOWN (HMI) BATTERY CHARGING FAILURE (HMI) WINDING TEMPRATURE R-PHASE (HMI) WINDING TEMPRATURE Y-PHASE (HMI) WINDING TEMPRATURE B-PHASE (HMI) ENGINE RUNNING (HMI), ENGINE READY TO START	-
RELAYS	IT WILL CONVERT LOW POWER SIGNAL & DRIVE THE HIGH POWER DEVICES SUCH AS LAMPS, HOOTER ETC.	-
PLC	INPUT MODULE WILL SENSE ANALOG INPUT THAT HAS A CONTINUOUS SIGNAL. TYPICAL ANALOG INPUTS MAY VARY FROM 0 TO 20 MA, 4 TO 20 MA	-
POTENTIAL FREE CONTACTS	LUBE OIL PRESS. WATER TEMP. EMERGENCY SHUTDOWN LOW COOLANT LEVEL LUBE OIL PRESS. WATER TEMP. ENGINE RUNNING OVERSPEED HOOTER CONTROL SUPPLIER ON LOCAL AND REMOTE INDICATION ENGINE READY TO START	ALARM TO OEM USE TRIP TO OEM USE ALARM TO OEM USE ALARM TO OEM USE TRIP TO OEM USE TRIP TO OEM USE TO OEM USE TO OEM USE TO OEM USE TO OEM USE TO OEM USE TO OEM USE
INPUT CHANNELS	LUBE OIL PRESS. SENSOR WATER TEMP. SENSOR LUBE OIL TEMP. SENSOR MAGNETIC PICKUP EXHAUST TEMP. SEA WATER PRESS. ENGINE COOLANT LEVEL	-
4-20 MA SIGNALS REQUIRED FOR OEM USE	LUBE OIL PRESSURE WATER TEMPERATURE LUBE OIL TEMPERATURE ENGINE SPEED EXHAUST TEMPERATURE	-
SELECTOR SWITCH	IDLE/RUN MAINS ON/OFF LOCAL/REMOTE SAFETY OVERRIDE SWITCH	-
SERVICIABILITY, MAINTAINANCE INTERVAL MANAGEMENT	DISPLAY TO SHOW ENGINE HOURS FOR TRACKING HOURS MAINTANCE INTERVAL	-
MOUNTING PROVISION	BULKHEAD/BASE RAIL	-
NAME PLATES/ LEGEND PLATES	STAINLESS STEEL	-
COMPONENT GRAPHICAL USER INTERFACE	STICKER OR SS NAME PLATE ON PANEL ON LEFT SIDE IDENTIFIES CUMMINS PART NUMBER WITH NAME AS 24V LOWER SERIES HMLD MARINE PANEL	-
BRANDING	SHALL BE BRANDED WITH CUMMINS DEMARCATION PANEL SHOULD HAVE CUMMINS LOGO ON HMI & DESCRIPTION AS "MARINE"	-
PROVISION FOR REMOTE HMI OR DISPLAY	PANEL SHALL BE RS 485 ETHERNET.	-
DISPLAY	1. COLOR DISPLAY 7" TFT WIDESCREEN WITH FULLY DIMMABLE LED BACKLIGHT WITH ADVANCED TOUCHSCREEN 2. DISPLAY MUST HAVE A CUMMINS LOGO SPLASH SCREEN INTEGRATED TO DISPLAY AT START UP 3. ANTI GLARE COATING ON SCREEN 4. DISPLAY SHOULD HAVE BACKLIGHT CONTROL 5. PART NUMBER OF PANEL SHOULD APPEAR ON SCREEN	-
SWITCH	MARINE GRADED IP55	-
PANEL CONFIGURATION (CONFIGURABLE ANALOG INPUT & OUTPUT)	1. ANALOG INPUTS CAPABILITY SHALL BE 16 AS RESISTANCE OR VOLTAGE SENDERS 2. DIGITAL INPUTS CAPABILITY SHALL BE 16 3. DIGITAL OUTPUT CAPABILITY SHALL BE 16 NOTE : PANEL SHOULD BE RECONFIGURABLE FOR TRANSCEIVERS	-

1. MATERIAL:
   A) FABRICATION MATERIAL: 14 SWG MILD STEEL CRCA SHEET.
   B) HARDWARE: STAINLESS STEEL.
2. METRIC SCREW THREADS SHALL CONFORM TO ASME B1.13M OR ISO 724 UNLESS OTHERWISE SPECIFIED.

Cummins Inc.

UNLESS OTHERWISE SPECIFIED THE INFORMATION WITHIN THIS TITLE BLOCK SHALL APPLY

DIMENSIONS ARE IN: MILLIMETERS [ ] ARE: .

DIMENSIONING AND TOLERANCING PER ASME Y14.5-2009	LAST DATUM LETTER USED: .	LAST REF. LETTER USED: •
FINISH STOCK: .	REF. ITEM NO.: .	MADE FROM NO.: .
WALL THICKNESS: .	MFG. METHOD: 18111	
DRAFT ANGLES: .	INSP. STD.: 16061;16663	
EDGE RADII: .	ENGR. STD.: 10059;10903	
FILLET RADII: .	PERF. STD.: .	
SURFACE FINISH PER: .	PROCESS: .	
SURFACE FIN.:Ramax .	MATERIAL: SEE NOTES	

THIRD ANGLE PROJECTION

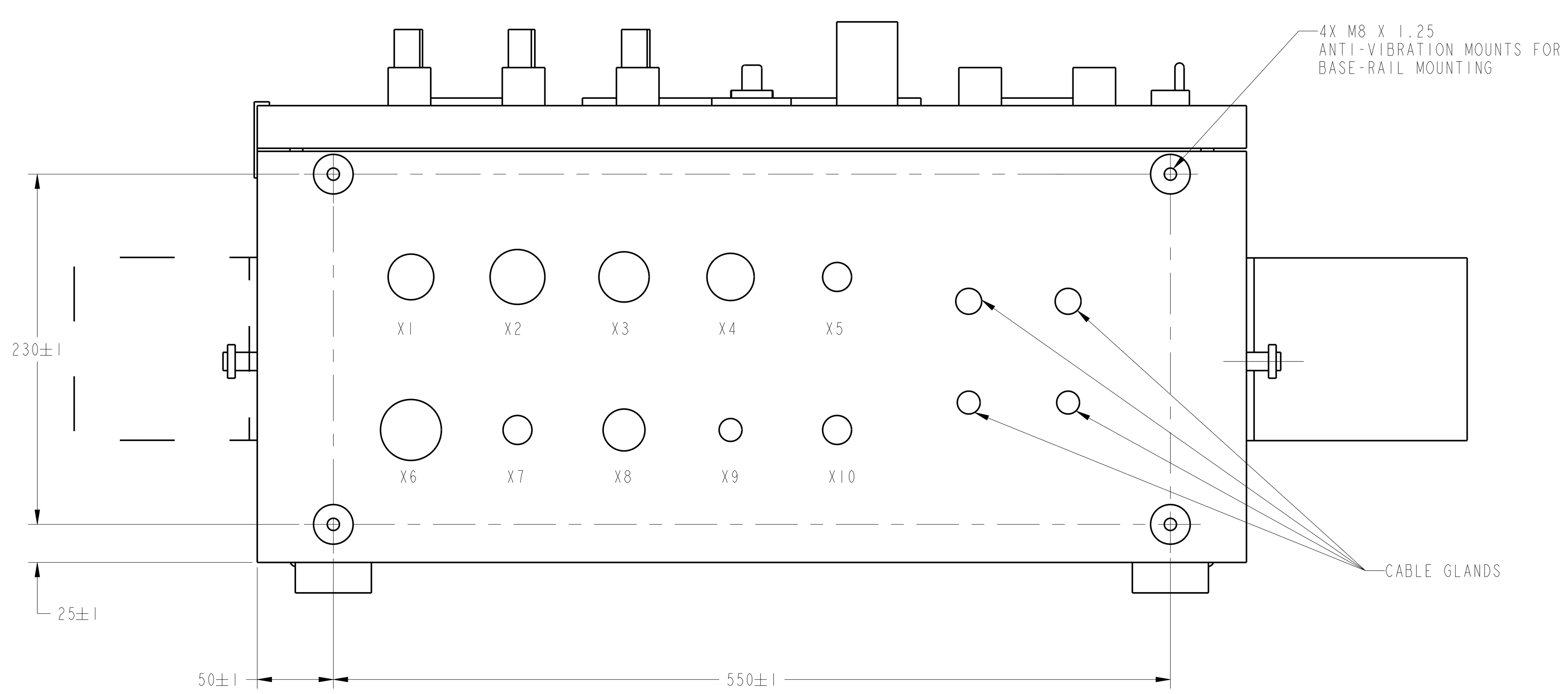
SIZE J

ITEM NAME: PANEL,CONTROL

IDENTIFIER: NON-CUMMINS

ITEM NUMBER: 5563832

SCALE 0.5 | CODE IDENT NO. |



LEGEND :

G1	:	AMMETER
HMI	:	HUMAN MACHINE INTERFACE
HM	:	HOUR METER
H1	:	CONTROL ON
H2	:	CHARGING FAILURE
H6	:	REVOLVING LAMP
B1	:	ACKNOWLEDGE/RESET
B6	:	LAMP CHECK
B3/H3	:	STOP
B4/H4	:	START/READY TO START
B5	:	EMERGENCY STOP
B7	:	SPEED RAISE
B8	:	SPEED LOWER
H7	:	ENGINE RUNNING
SL1/H5	:	LOCAL/REMOTE
SL2	:	IDLE/RUN
SL3	:	SAFETY OVERRIDE
SW1	:	MAINS ON/OFF SWITCH
X1 TO X10	:	MULTIPIN CONNECTORS

PRELIMINARY

NOTE: THIS DRAWING HAS NOT COMPLETED ALL REQUIRED PRODUCT RELEASE CHECK PROCESSES.

23/09/2019

Cummins Inc.

UNLESS OTHERWISE SPECIFIED THE INFORMATION WITHIN THIS TITLE BLOCK SHALL APPLY

DIMENSIONS ARE IN: MILLIMETERS [ ] ARE: .

DIMENSIONING AND TOLERANCING PER ASME Y14.5-2009	LAST DATUM LETTER USED: .	LAST REF. LETTER USED: .
FINISH STOCK: .	REF. ITEM NO.: .	MADE FROM NO.: .
WALL THICKNESS: .	MFG. METHOD: 18111	
DRAFT ANGLES: .	INSP. STD.: 16061;16663	
EDGE RADII: .	ENGR. STD.: 10059;10903	
FILLET RADII: .	PERF. STD.: .	
SURFACE FINISH PER: .	PROCESS: .	
SURFACE FIN.:Ramax .	MATERIAL: SEE NOTES	

THIRD ANGLE PROJECTION

SIZE J

ITEM NAME
PANEL,CONTROL

IDENTIFIER
NON-CUMMINS

ITEM NUMBER
5563832

SCALE 0.5 | CODE IDENT NO. | SHEET 2 OF 2

1. USE OF THIS DRAWING IS CONTROLLED BY THE TERMS OF AN AGREEMENT BETWEEN CUMMINS AND POWER CONTROL ENGINEERS. THIS AGREEMENT IS STORED IN ARIBA CONTRACT WORKBENCH UNDER CONTRACT ID CW267075.

2. THIS IS A SUPPLIER GRAPHIC FOR PART NUMBER 5563832.

SUPPLIER DRAWING

SUPPLIER HAS GRANTED UNENCUMBERED RIGHTS TO CUMMINS INC. FOR THIS GRAPHIC

CUMMINS ENGINEERING STANDARD 10084

PRELIMINARY

NOTE: THIS DRAWING HAS NOT COMPLETED ALL REQUIRED PRODUCT RELEASE CHECK PROCESSES.

DWN 16/10/2019

Cummins Inc.

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DIMENSIONS ARE IN: MILLIMETERS	[ ] ARE: .	
DIMENSIONING AND TOLERANCING PER ASME Y14.5-2009	LAST DATUM LETTER USED: .	LAST REF. LETTER USED: .
FINISH STOCK: .	REF. ITEM NO.: .	MADE FROM NO.: .
WALL THICKNESS: .	MFG. METHOD: 18111	
DRAFT ANGLES: .	INSP. STD.: 16061;16663	
EDGE RADII: .	ENGR. STD.: 10059;10903	
FILLET RADII: .	PERF. STD.: .	
SURFACE FINISH PER: .	PROCESS: .	
SURFACE FIN.:Ramax .	MATERIAL: .	
THIRD ANGLE PROJECTION	SIZE C	THIS DOCUMENT (AND THE INFORMATION SHOWN THEREON) IS **CONFIDENTIAL AND PROPRIETARY** AND SHALL NOT BE DISCLOSED TO OTHERS IN HARD COPY OR ELECTRONIC FORM, REPRODUCED BY ANY MEANS, OR USED FOR ANY PURPOSE WITHOUT WRITTEN CONSENT OF CUMMINS INC.
ITEM NAME PANEL,CONTROL		
IDENTIFIER REFERENCE DRAWING		ITEM NUMBER 5563833
SCALE NONE	CODE IDENT NO.	SHEET 1 OF 28

POWER CONTROL ENGINEERS
77/4,Shed No.3 Vishnumalti Industrial Estate,
Shivane,Pune : 411 023
Maharashtra, India
Phone : +91-020-25290771,
Fax : +91-020-25291011,

PROJECT DESCRIPTION : STANDARD HMLD ENGINE MARINE CONTROL PANEL

DRAWING NUMBER : 30066972

REFERENCE NUMBER :

CUSTOMER : CUMMINS INDIA LTD

END USER :

CUSTOMER P.O. NO. :

Rev	Change	Date	Name		
02	EC-1003-452	11-09-2019	ALB	Start Date	30-07-2018
01	EC-1003-380	15-11-2018	ALB	Drawn By	SPJ
				Checked By	ALB
				Approved by	RMP

PROJECT
STANDARD HMLD ENGINE MARINE CONTROL PANEL

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : TITLE PAGE
DRG NO : 30066972
REF NO :

TABLE OF CONTENTS

Rev	Change	Date	Name		
02	EC-1003-452	11-09-2019	ALB	Start Date	30-07-2018
01	EC-1003-380	15-11-2018	ALB	Drawn By	SPJ
				Checked By	ALB
				Approved by	RMP

PROJECT
STANDARD HMLD ENGINE
MARINE CONTROL PANEL

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : TABLE OF CONTENTS
DRG NO : 30066972
REF NO :

NOTES :-

1. ALL DIMENSIONS ARE IN mm ,UNLESS OTHERWISE SPECIFIED.
2. FABRICATION MATERIAL :- MS, 2mm.THICK CRCA SHEET (14 SWG).
3. SURFACE FINISH :- POWDER COATING.
4. COLOUR SHADE :- PEBBLE GRAY (RAL 7032)
5.ENCLOSURE PROTECTION :-IP55 .
6. APPROXIMATE WEIGHT:- 40KG (+/-5KG).
7.EARTHING BOLTS WOULD BE PROVIDED ON BOTH SIDE OF THE PANEL.
8.INTERNAL WIRING :- FRLS WIRE OF SUITABLE SIZE.
9.CABLE ENTRIES FROM BOTTOM.
10.NAME PLATES/LEGEND PLATES :-STAINLESS STEEL,SIZE:15 X 65.
11.HARDWARE :-STAINLESS STEEL.
12.PANEL MOUNTING :-BASERAIL AND BULKHEAD.

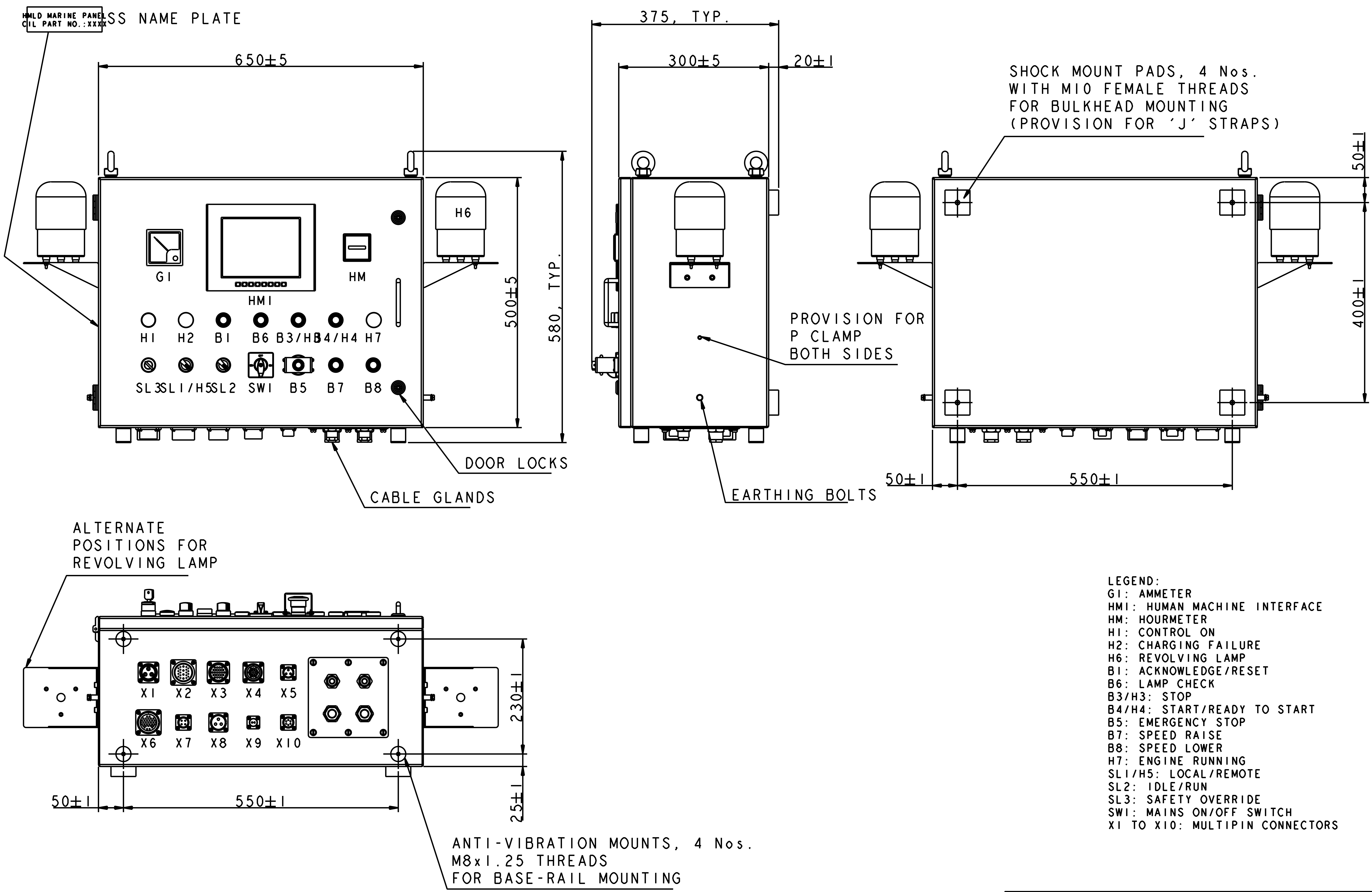
				Start Date	30-07-2018
02	EC-1003-452	11-09-2019	ALB	Drawn By	SPJ
01	EC-1003-380	15-11-2018	ALB	Checked By	ALB
Rev	Change	Date	Name	Approved by	RMP

PROJECT
STANDARD HMLD ENGINE
MARINE CONTROL PANEL

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : GENERAL NOTES
DRG NO : 30066972
REF NO :



LEGEND:
G1: AMMETER
HMI: HUMAN MACHINE INTERFACE
HM: HOURMETER
H1: CONTROL ON
H2: CHARGING FAILURE
H6: REVOLVING LAMP
B1: ACKNOWLEDGE/RESET
B6: LAMP CHECK
B3/H3: STOP
B4/H4: START/READY TO START
B5: EMERGENCY STOP
B7: SPEED RAISE
B8: SPEED LOWER
H7: ENGINE RUNNING
SL1/H5: LOCAL/REMOTE
SL2: IDLE/RUN
SL3: SAFETY OVERRIDE
SW1: MAINS ON/OFF SWITCH
X1 TO X10: MULTIPIN CONNECTORS

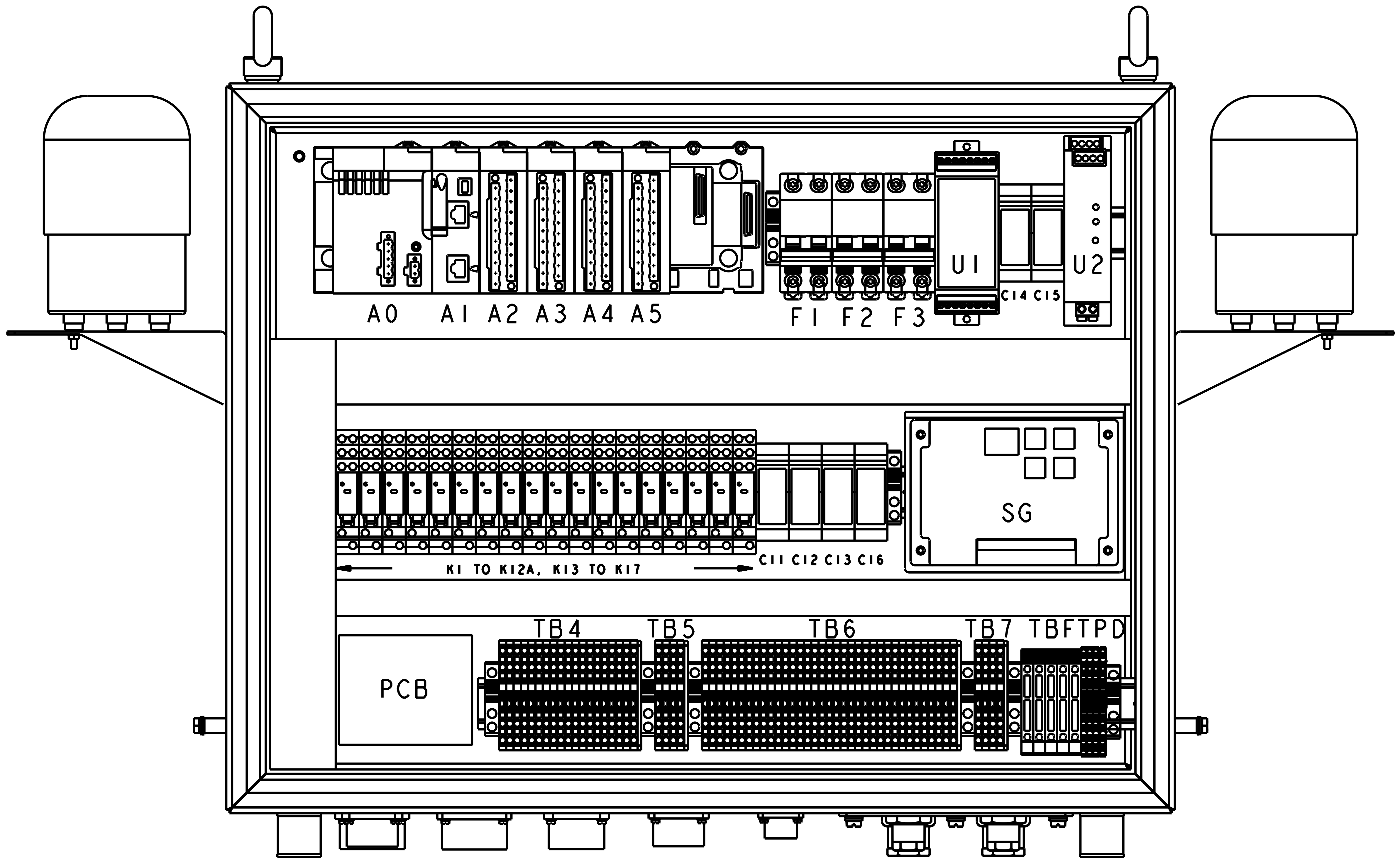
Rev	Change	Date	Name		
				Start Date	30-07-2018
02	EC-1003-452	11-09-2019	ALB	Drawn By	SPJ
01	EC-1003-380	15-11-2018	ALB	Checked By	ALB
Rev	Change	Date	Name	Approved by	RMP

PROJECT
STANDARD HMLD ENGINE
MARINE CONTROL PANEL

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : GENERAL ARRANGEMENT
DRG NO : 30066972
REF NO :



A0: CPU POWER SUPPLY
A1: CPU
A2: DIGITAL INPUT MODULE
A3: DIGITAL OUTPUT MODULE
A4: ANALOG INPUT MODULE
A5: ANALOG INPUT MODULE
F1, F2, F3: MCBs.
U1: F/I CONVERTER
U2: DC-DC CONVETER
C11 TO C16: ISOLATORS
K1 TO K12A, K13 TO K17: RELAYS
SG: ENGINE SPEED GOVERNOR (CIL SCOPE)
PCB: SHORT CIRCUIT PROTECTION PCB
TB4 TO TB7: TERMINALS
TBF: FUSE TERMINALS
TPD: TERMINAL POWER DISTRIBUTION

PAGE TITLE : INTERNAL LAYOUT

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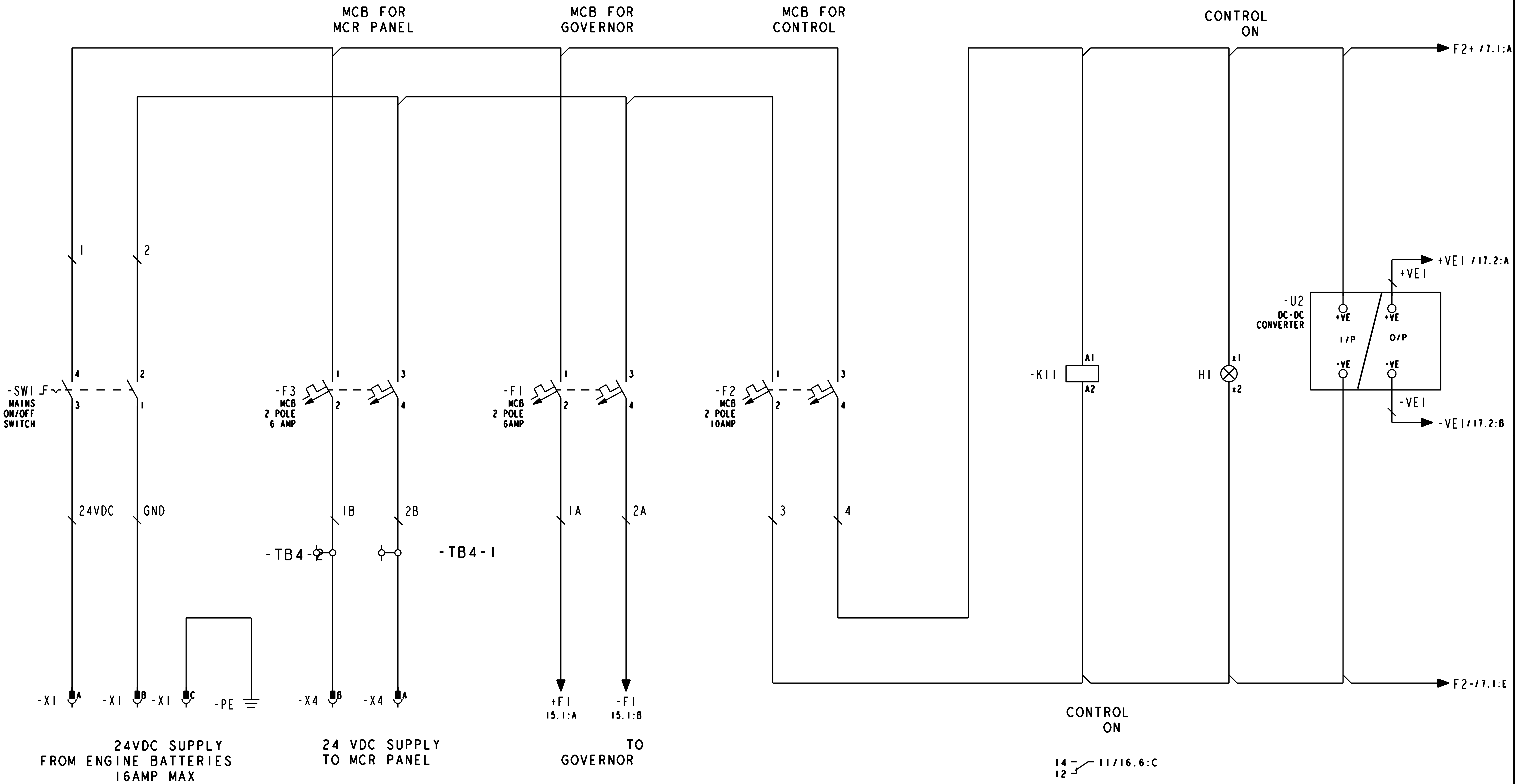

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PAGE TITLE : WIRING DIAGRAM

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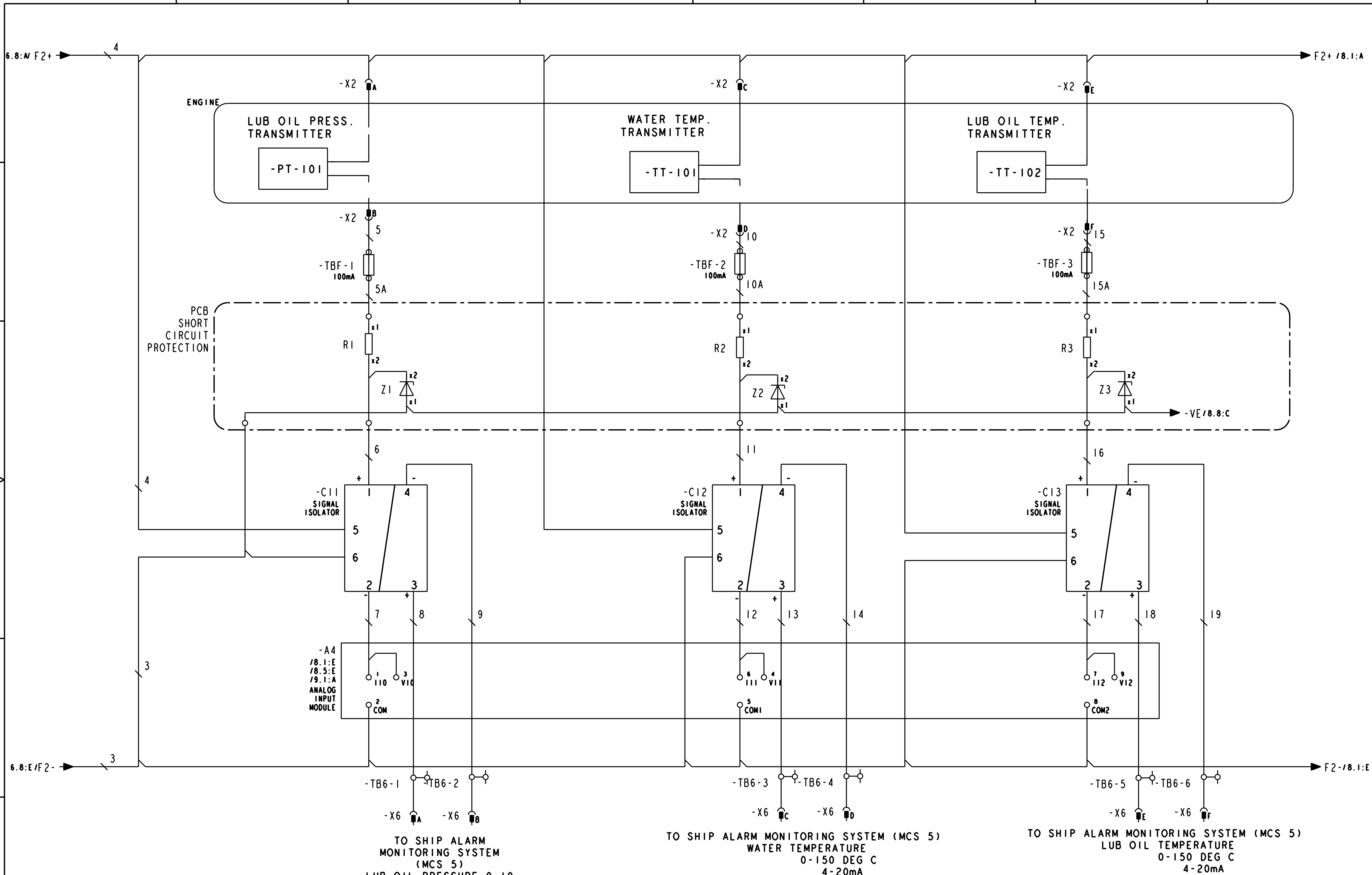

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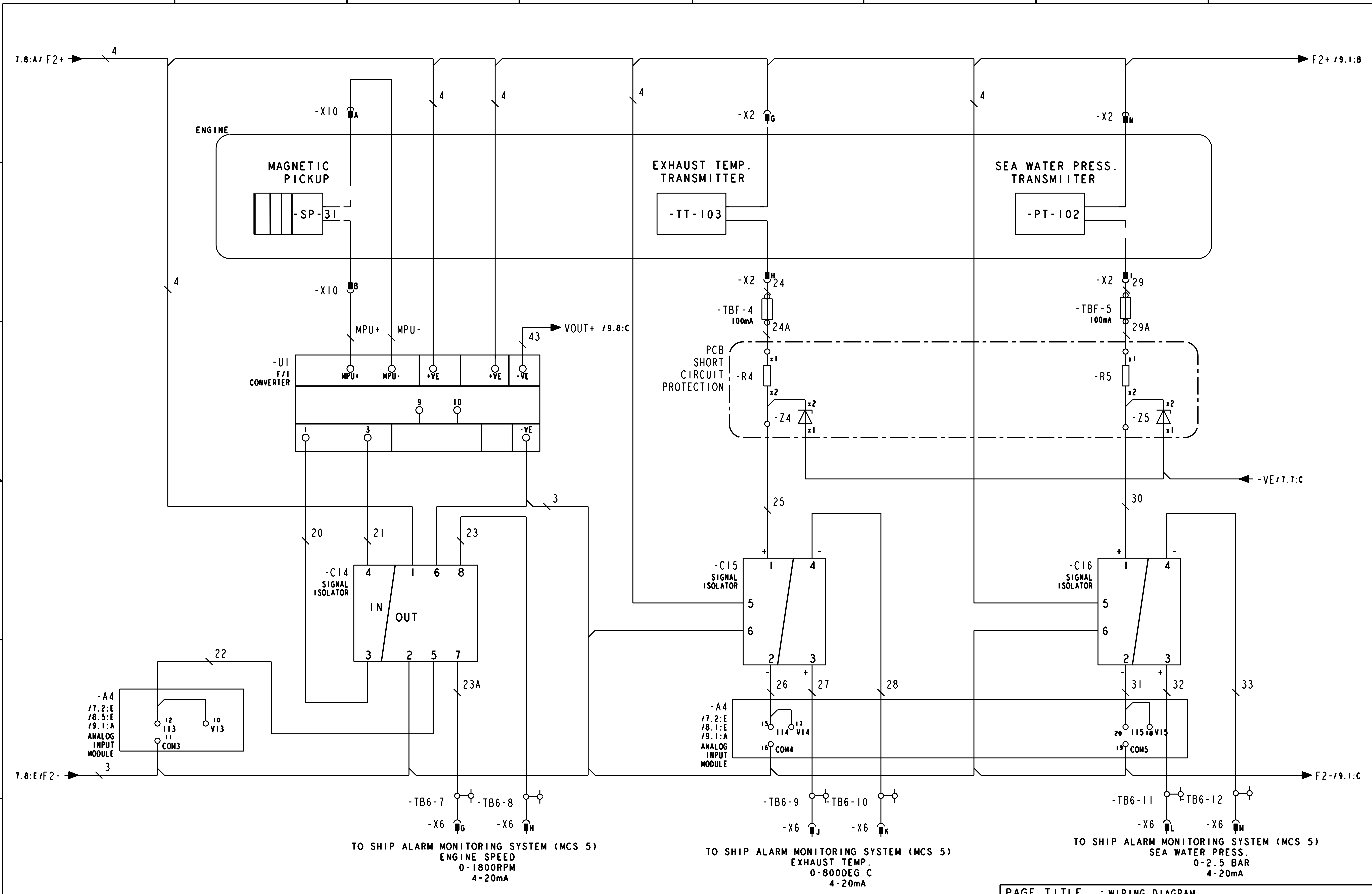

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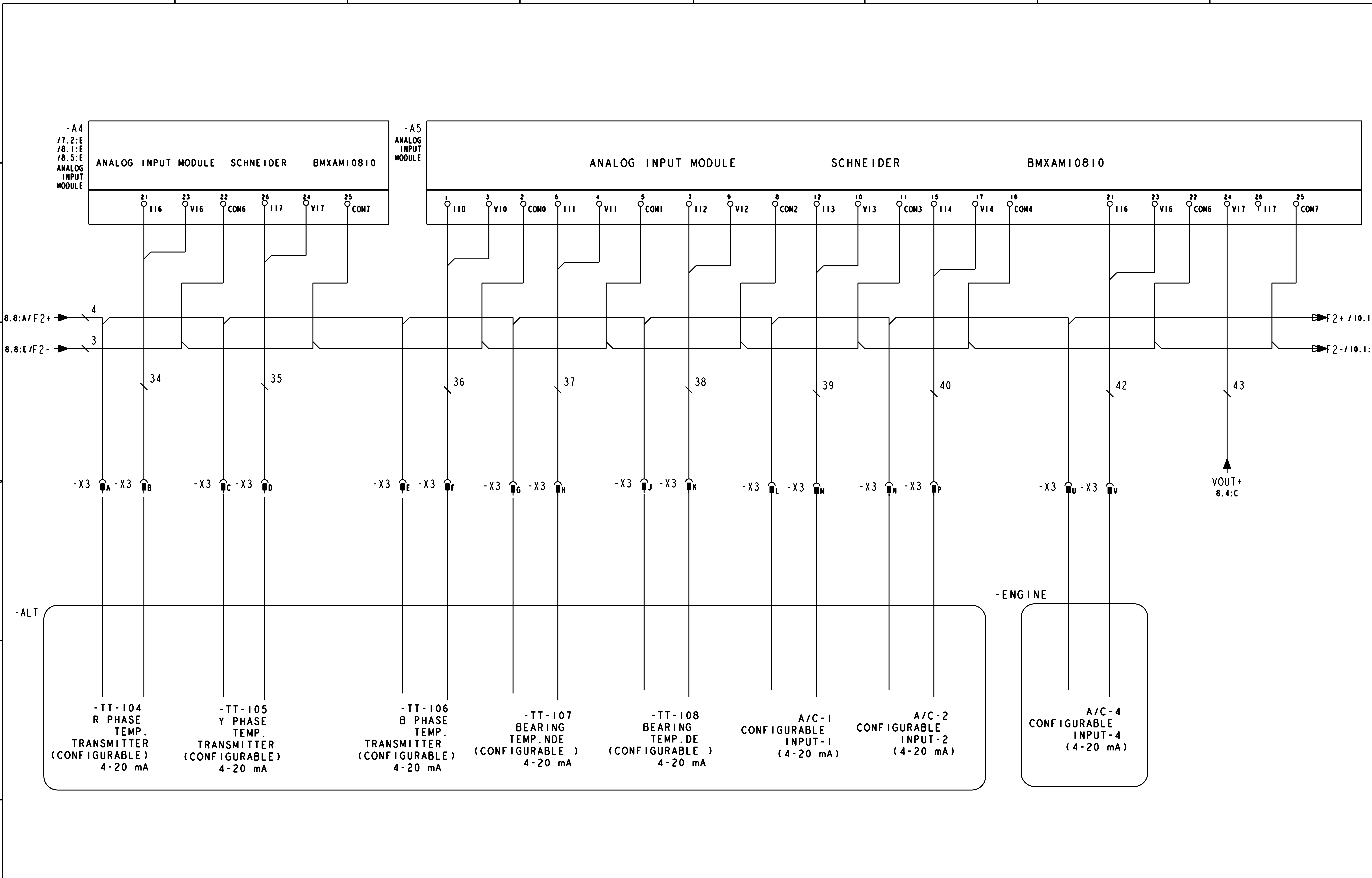

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02	EC-1003-452	11-09-2019	ALB	Drawn By	SPJ	STANDARD HMLD ENGINE MARINE CONTROL PANEL	CUMMINS INDIA LTD.	DRG NO : 30066972
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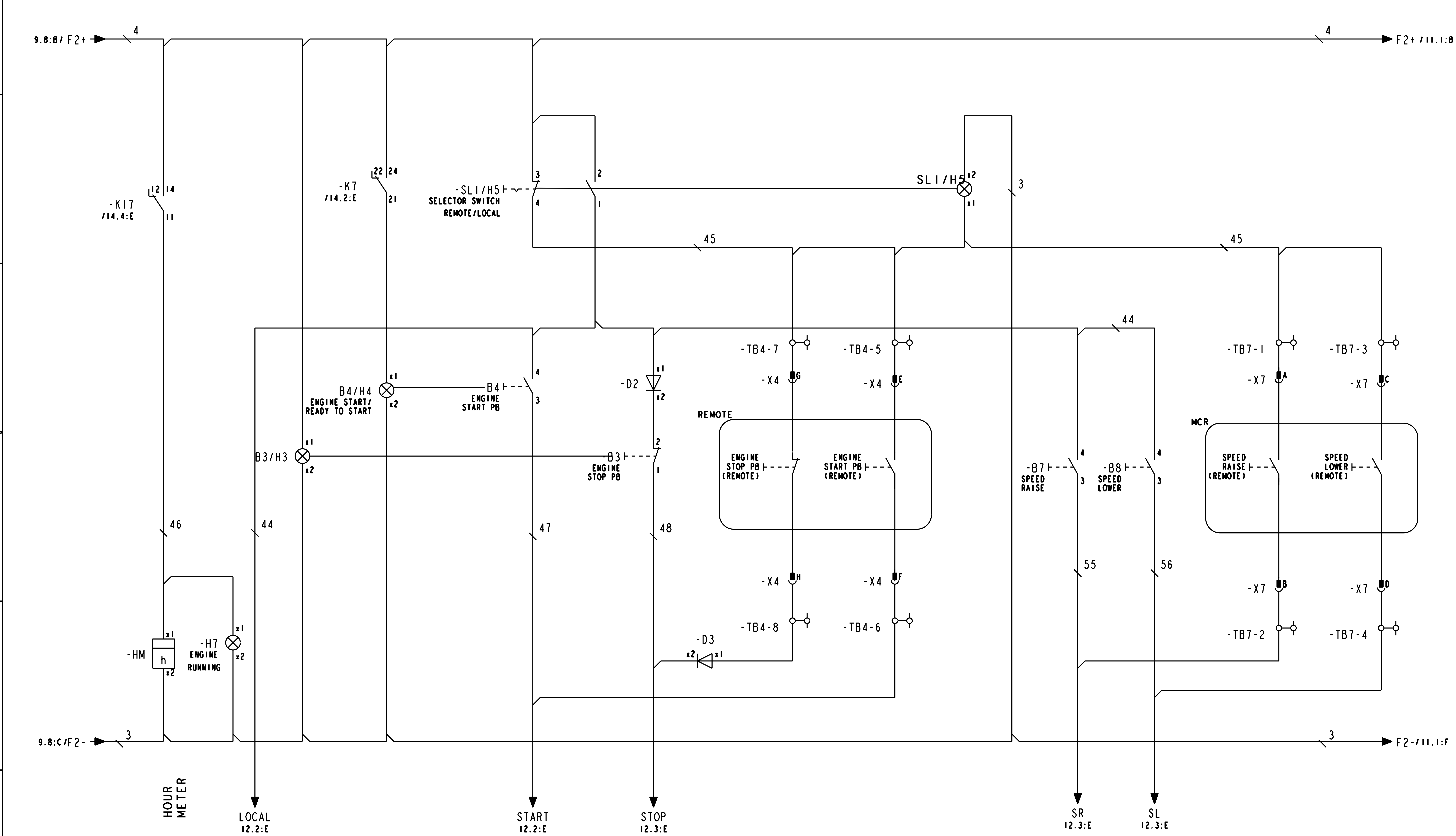

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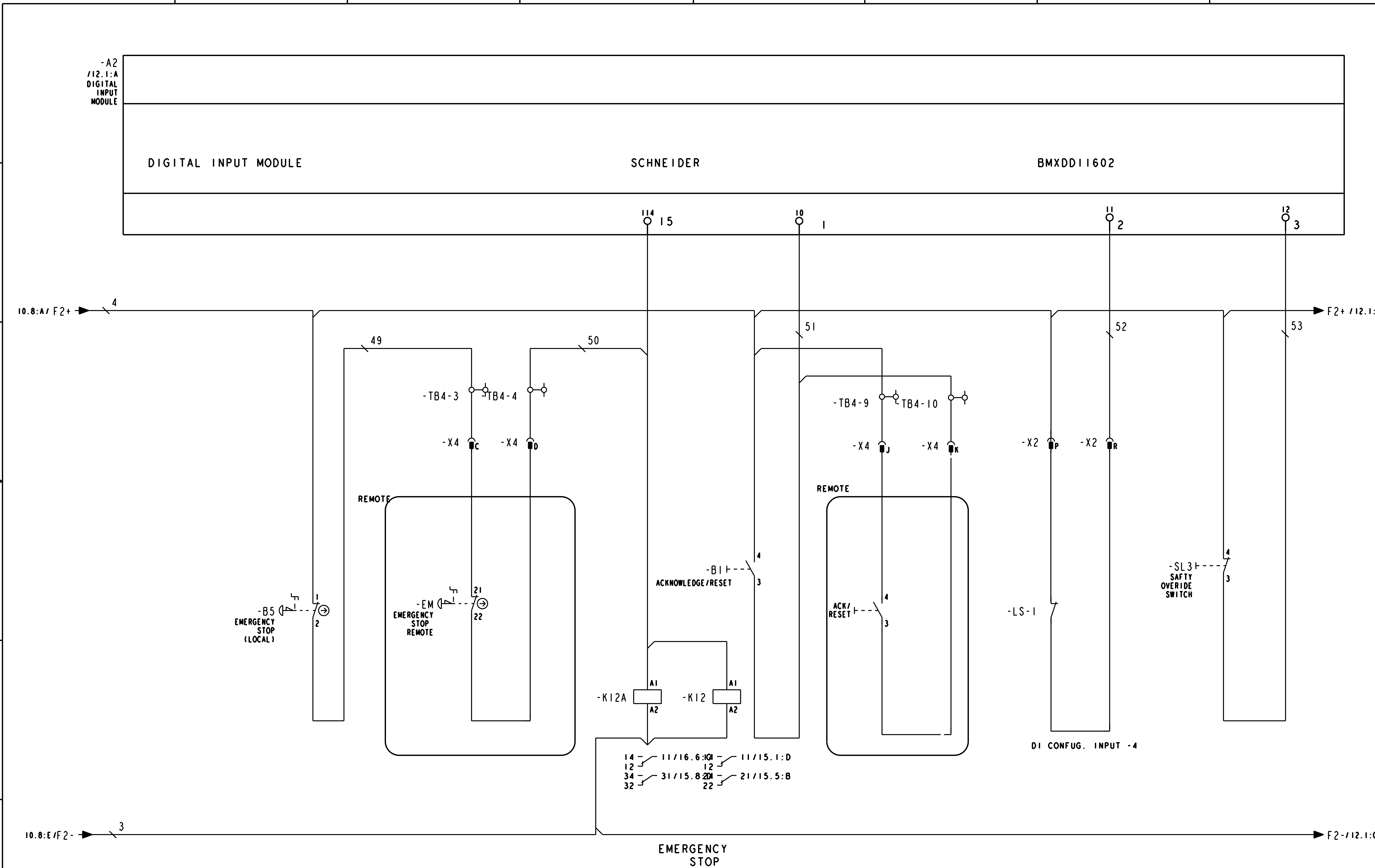

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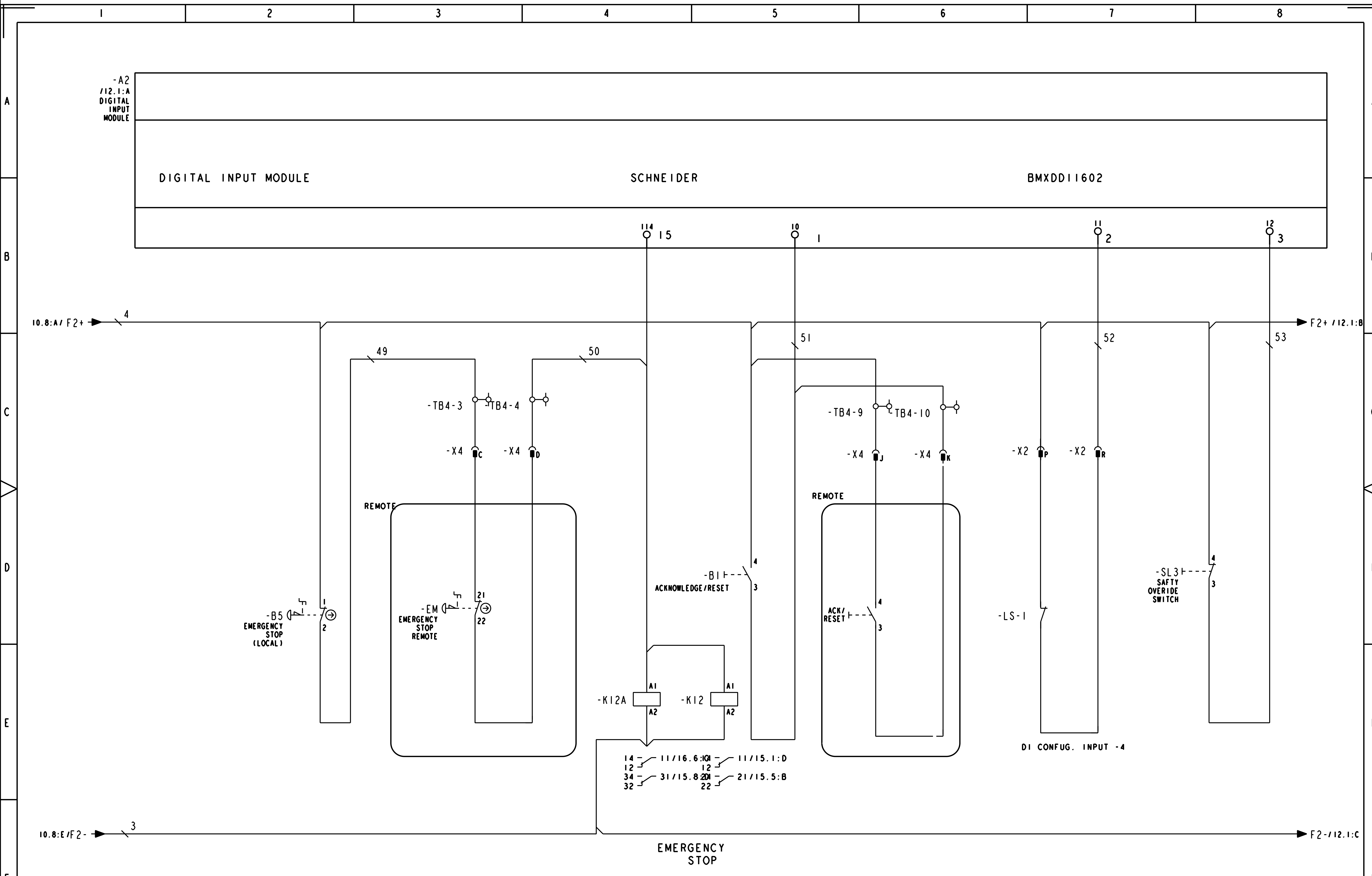

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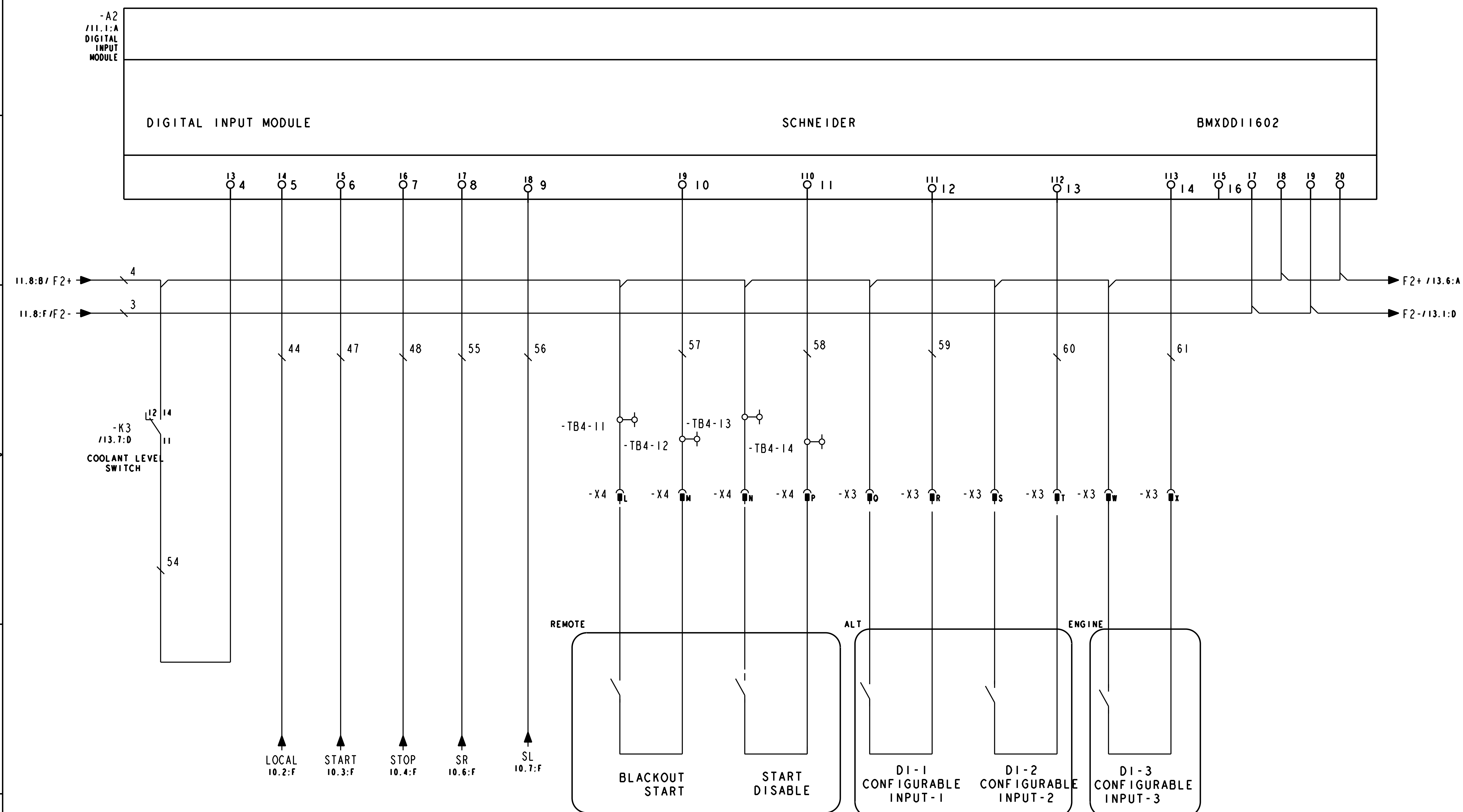

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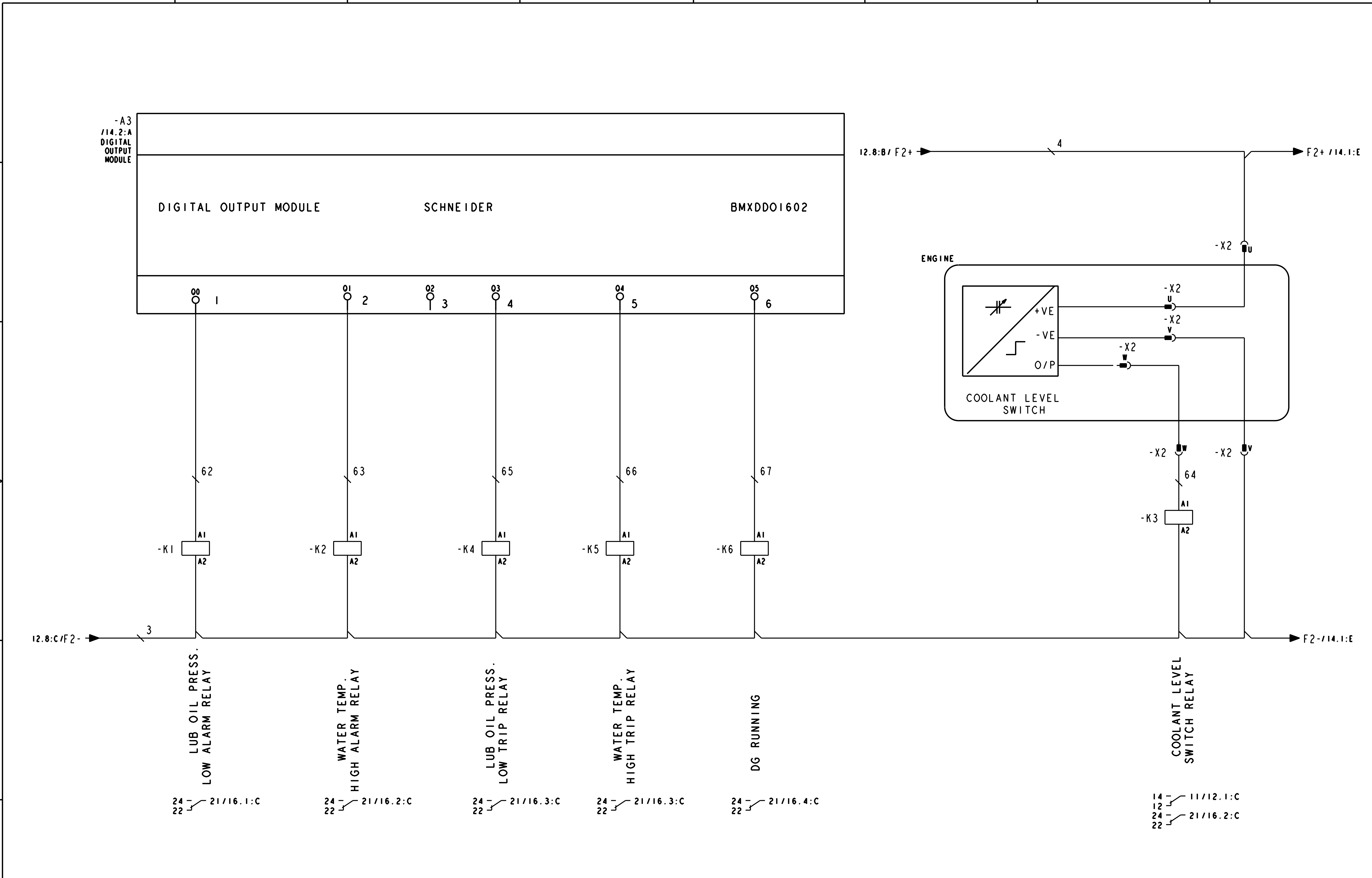

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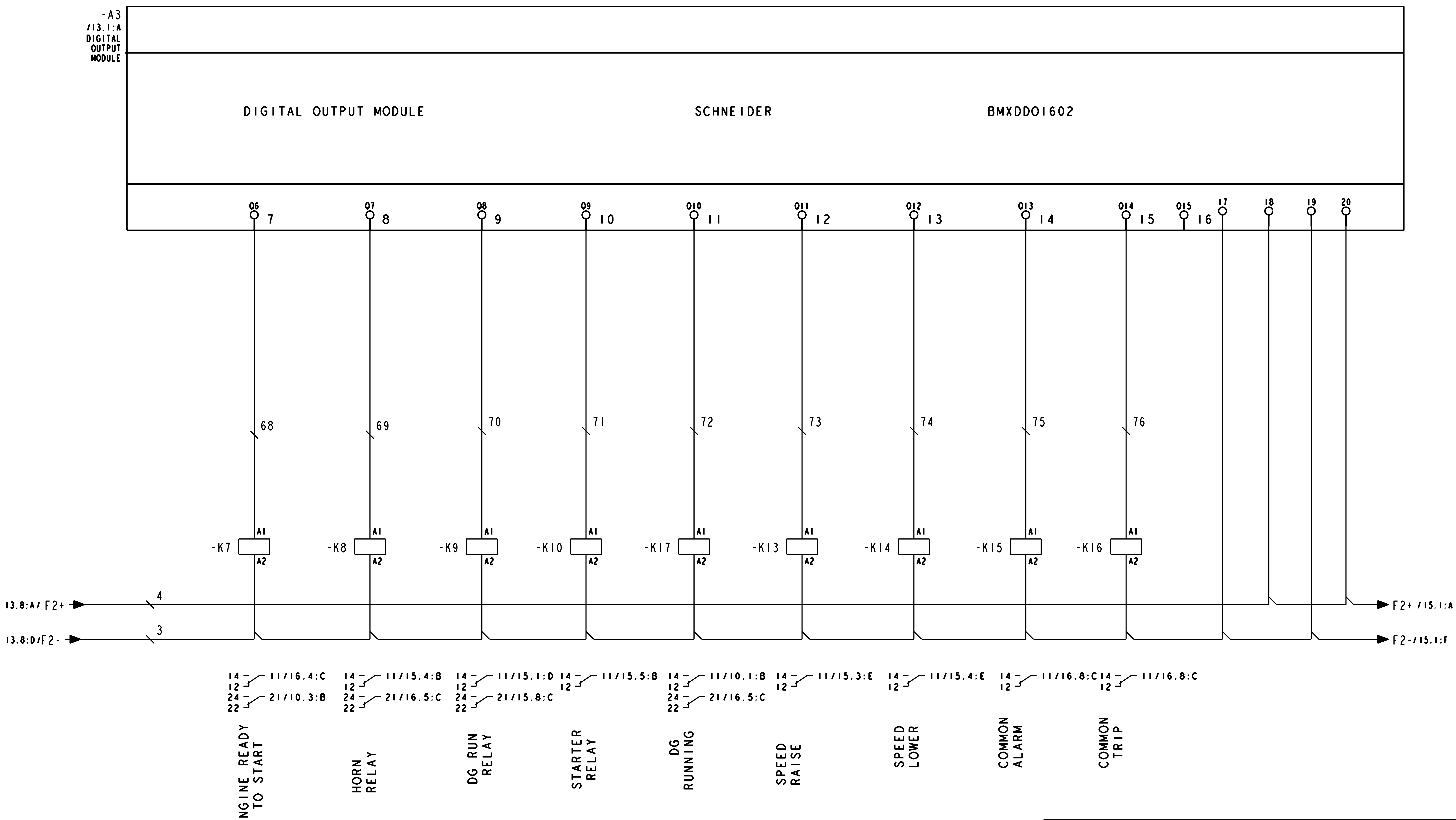

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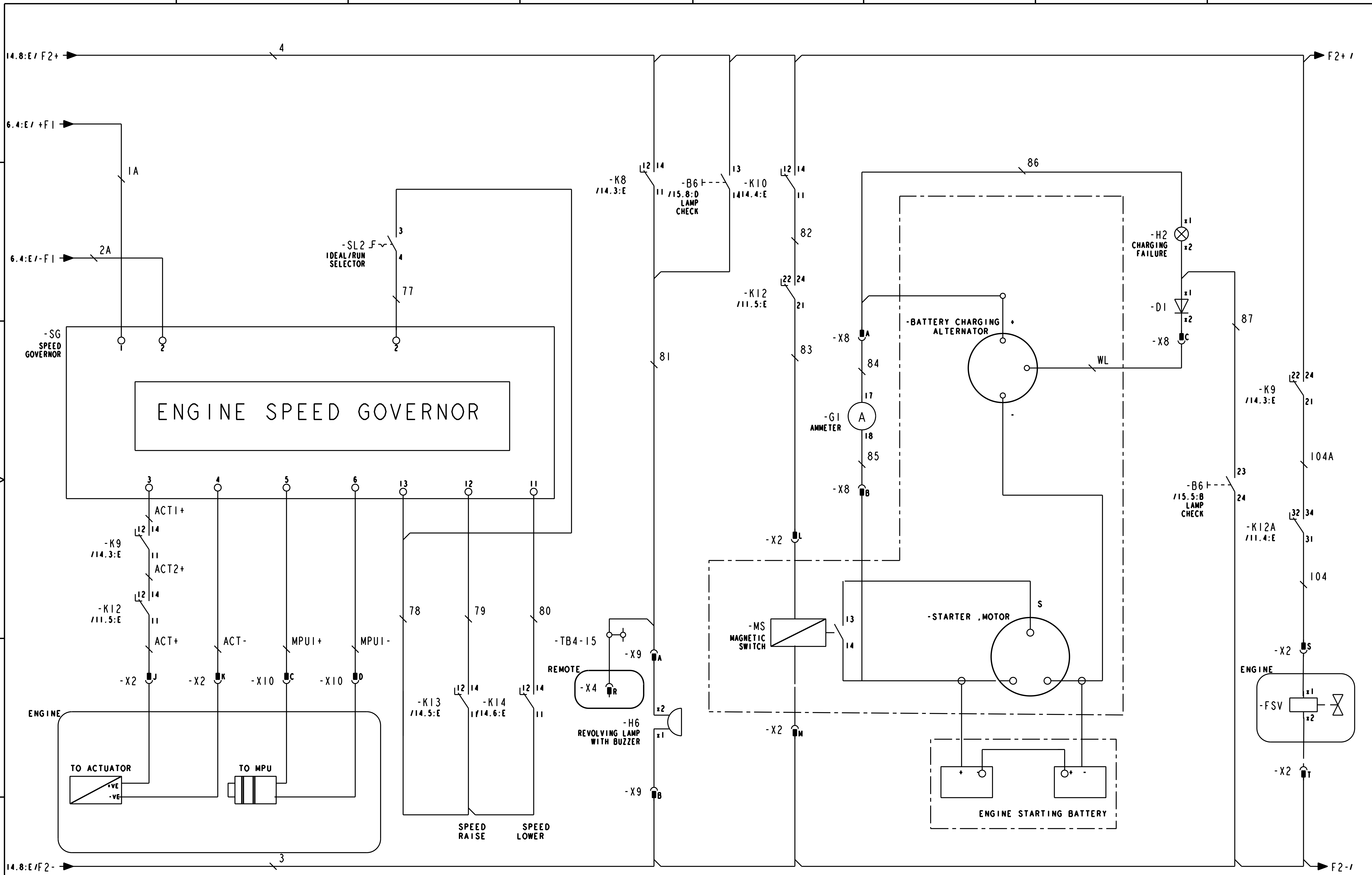

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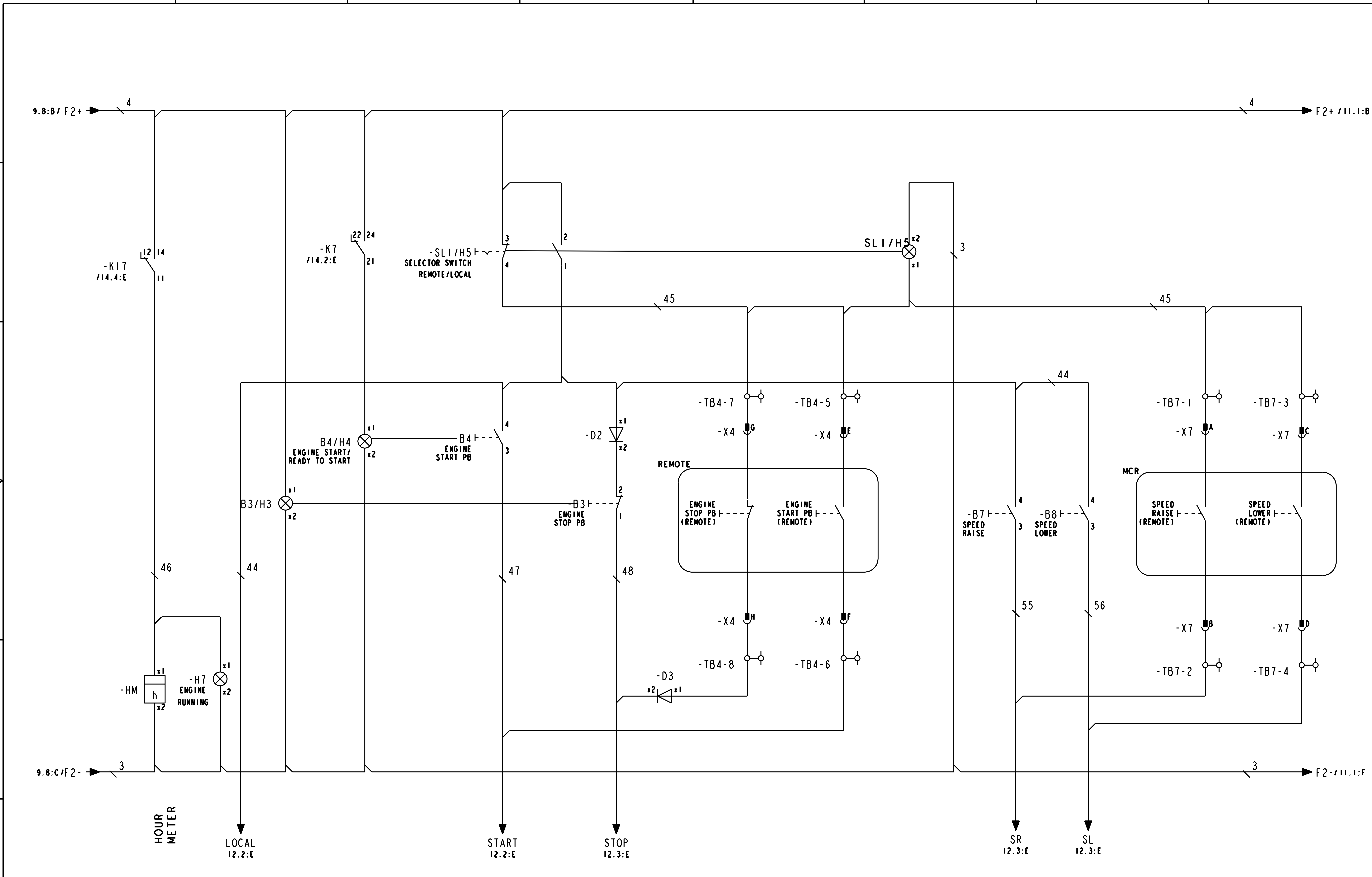

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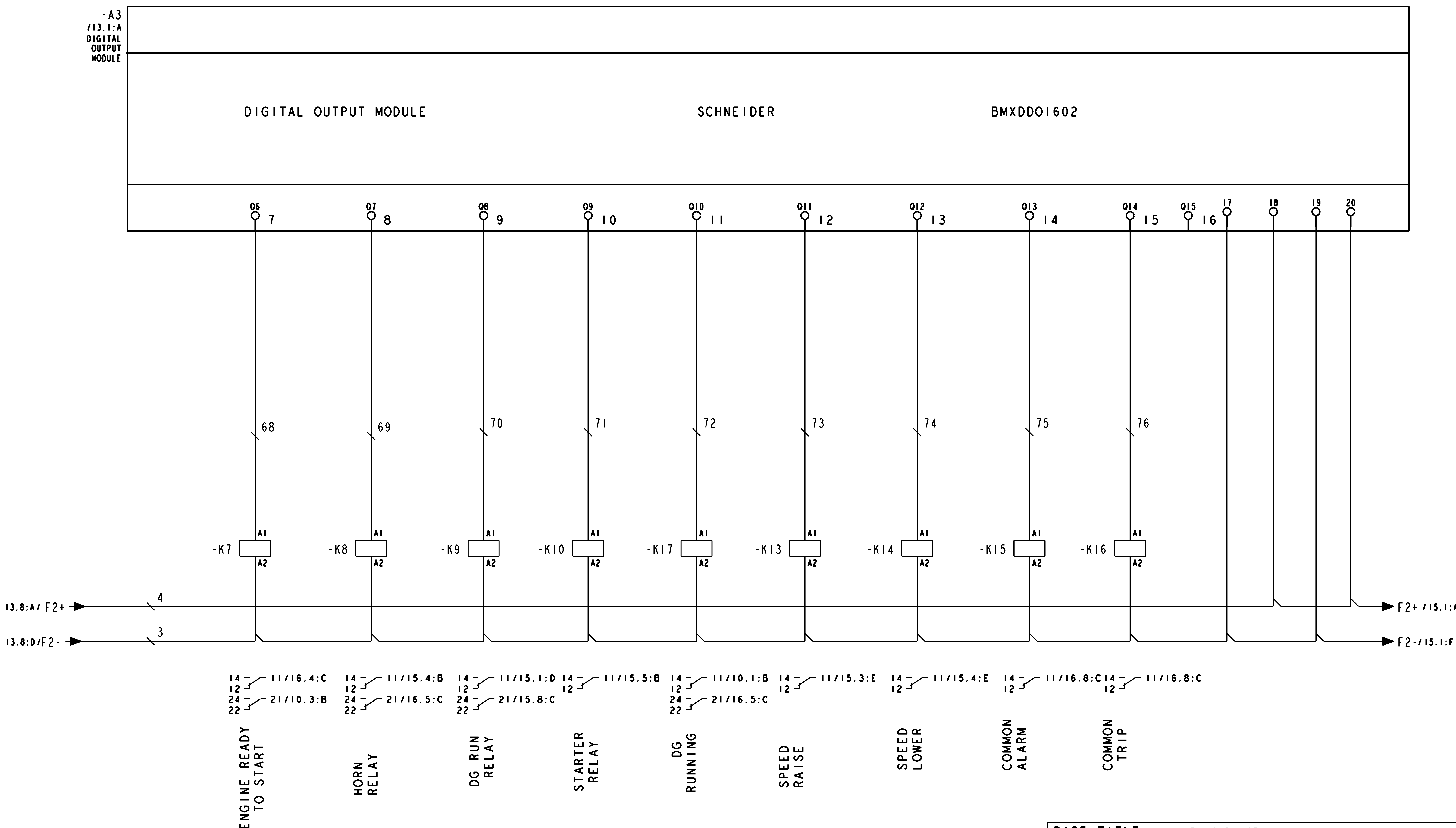

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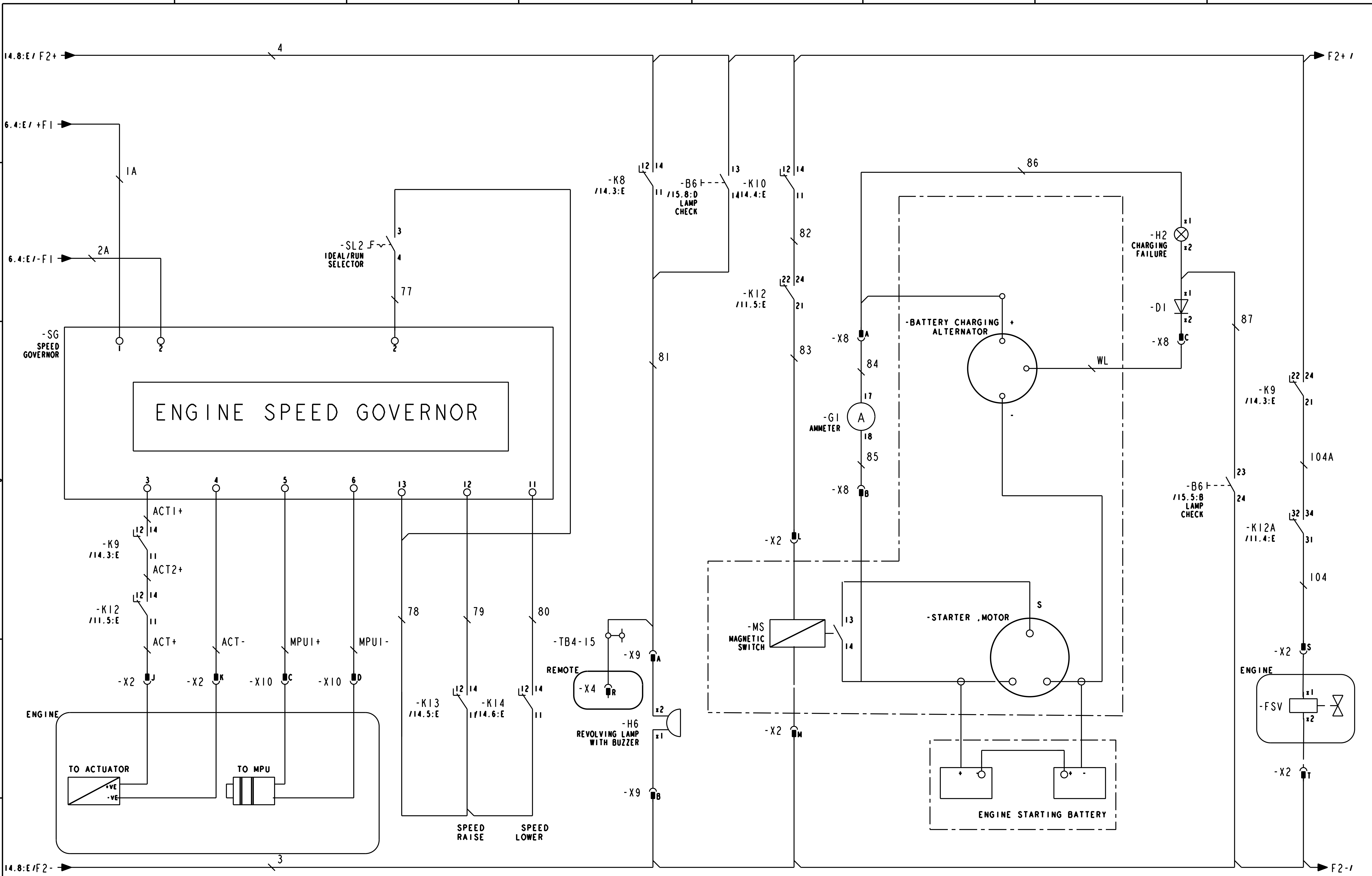

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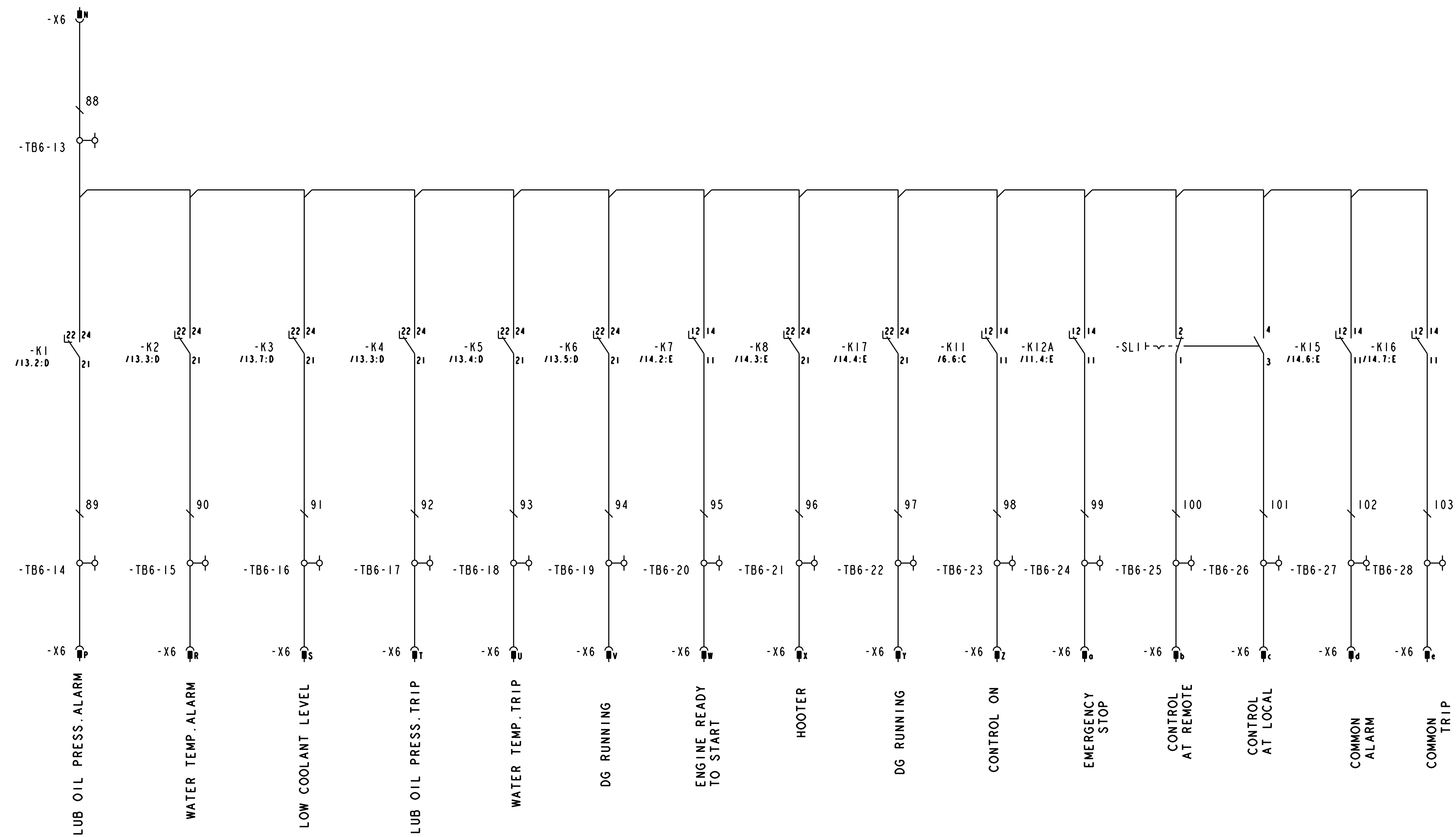

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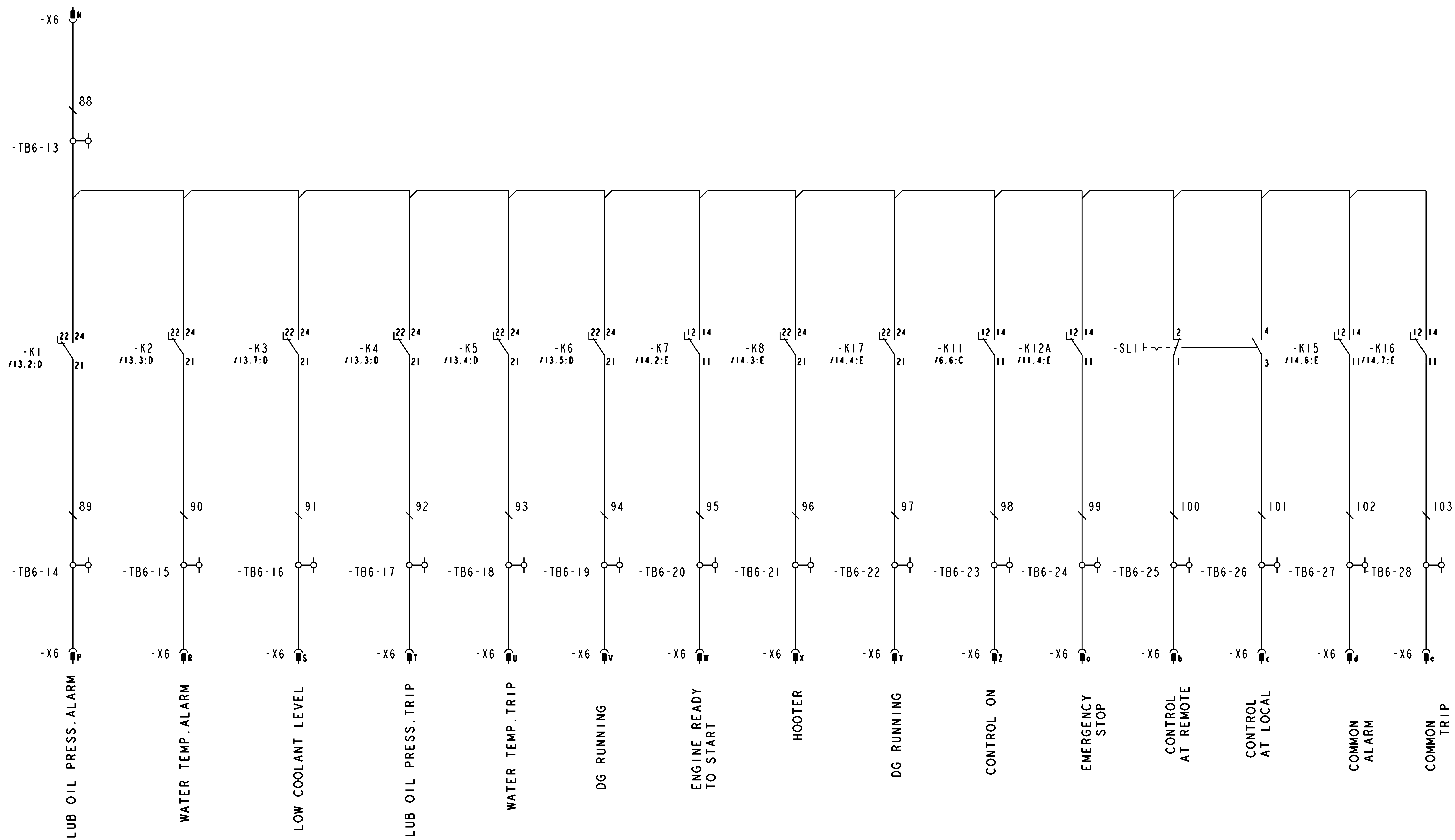

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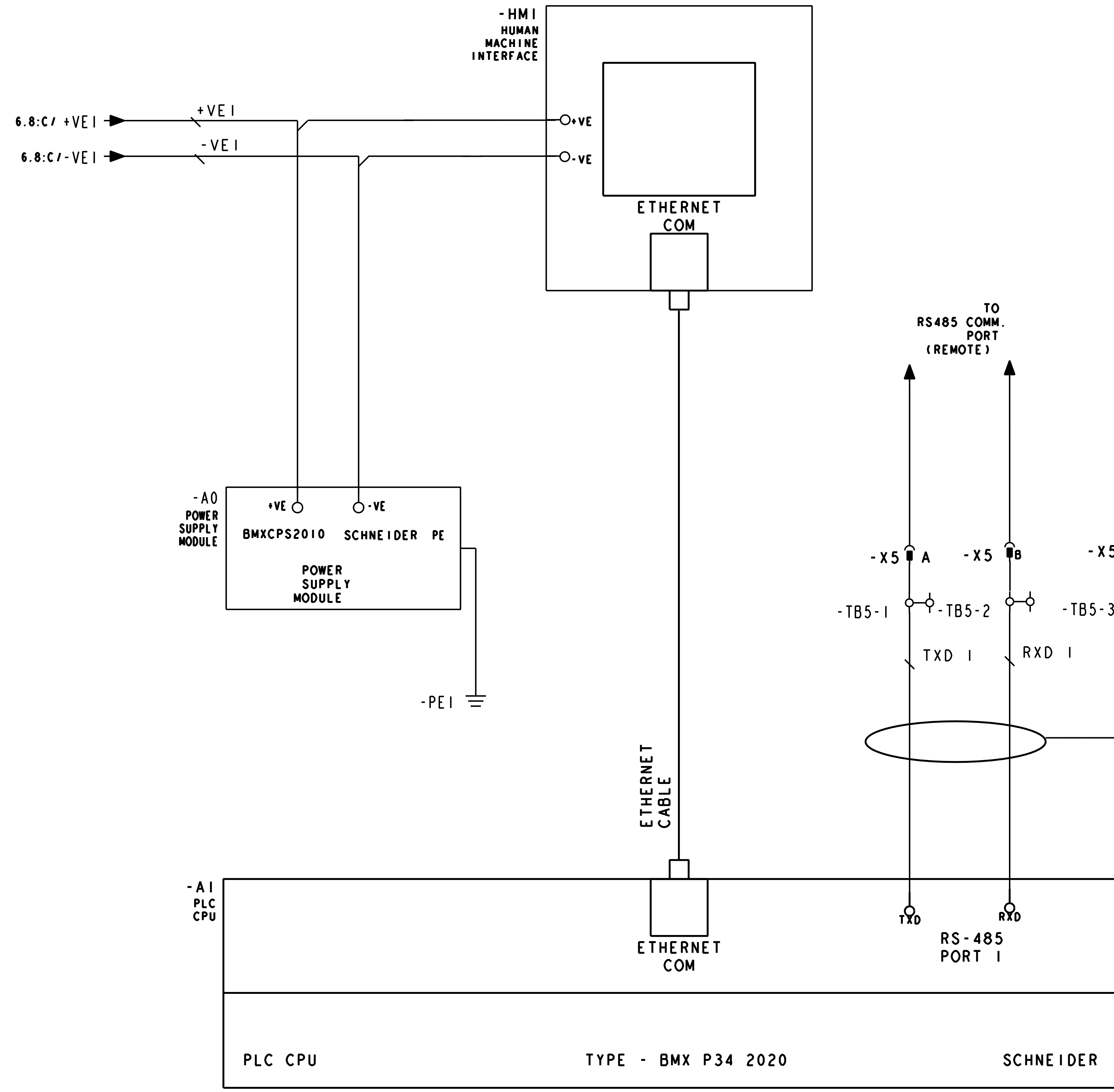

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ANALOG INPUT MODULE (A4)								
SR NO.	PLC ID	INPUT TYPE	SIGNAL TAG NO.	DESCRIPTION	SIGNAL TYPE	SET RANGE	UNIT	SETTING
1.	10	AI(4-20mA)	-PT-101	LUB OIL PRESSURE TRANSMITTER	ANALOG	0-10	BAR	
2.	11	AI(4-20mA)	-TT-101	WATER TEMPERATURE TRANSMITTER	ANALOG	0-150	DEG C	
3.	12	AI(4-20mA)	-TT-102	LUB OIL TEMP. TRANSMITTER	ANALOG	0-150	DEG C	
4.	13	AI(4-20mA)	-SP31	ENGINE SPEED INPUT	ANALOG	0-2400	RPM	
5.	14	AI(4-20mA)	-TT-103	EXHAUST GAS TEMP. TRANSMITTER	ANALOG	0-800	DEG C	
6.	15	AI(4-20mA)	-PT-102	SEA WATER PRESS. TRANSMITTER	ANALOG	0-2.5	BAR	
7.	16	AI(4-20mA)	-TT-104	R PHASE WINDING TEMP. TRANSMITTER (CONFIG. 4-20mA)	ANALOG	0-150	DEG C	
8.	17	AI(4-20mA)	-TT-105	Y PHASE WINDING TEMP. TRANSMITTER (CONFIG. 4-20mA)	ANALOG	0-150	DEG C	
ANALOG INPUT MODULE (A5)								
9.	10	AI(4-20mA)	-TT-106	B PHASE WINDING TEMP. TRANSMITTER (CONFIG. 4-20mA)	ANALOG	0-150	DEG C	
10.	11	AI(4-20mA)	-TT-107	NDE BEARING TEMP. TRANSMITTER (CONFIG. 4-20mA)	ANALOG	0-150	DEG C	
11.	12	AI(4-20mA)	-TT-108	DE BEARING TEMP. TRANSMITTER (CONFIG. 4-20mA)	ANALOG	0-150	DEG C	
12.	13	AI(4-20mA)	-A/C-1	CONFIGURABLE INPUT - 1 (4-20mA)	ANALOG			
13.	14	AI(4-20mA)	-A/C-2	CONFIGURABLE INPUT -2 (4-20mA)	ANALOG			
14.	15	AI(4-20mA)	-A/C-3	SPARE	ANALOG			
15.	16	AI(4-20mA)	-A/C-4	CONFIGURABLE INPUT - 4 (4-20mA)	ANALOG			
16.	17	AI(0-10V)	UI	VOLTAGE TRANSDUCER	ANALOG			

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PAGE TITLE : ANALOG INPUT MODULE REPRESENTATION-A4,A5

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DIGITAL INPUT MODULE (A2)

SR NO.	PLC ID	INPUT TYPE	SIGNAL TAG NO.	DESCRIPTION	SIGNAL TYPE	SET RANGE	UNIT
1.	I0	DI	-B1	ACKNOWLEDGE/RESET	DIGITAL	----	----
2.	I1	DI	-LS-1	DI CONFUG. INPUT -4	DIGITAL	----	----
3.	I2	DI	-SL3	SAFETY OVERIDE SWITCH	DIGITAL	----	----
4.	I3	DI	---	COOLANT LEVEL SWITCH	DIGITAL	----	----
5.	I4	DI	-SL1	CONTROL AT LOCAL	DIGITAL	----	----
6.	I5	DI	-B4	ENGINE START	DIGITAL	----	----
7.	I6	DI	-B3	ENGINE STOP	DIGITAL	----	----
8.	I7	DI	-B7	SPEED RAISE	DIGITAL	----	----
9.	I8	DI	-B8	SPEED LOWER	DIGITAL	----	----
10.	I9	DI	----	BLACKOUT START	DIGITAL	----	----
11.	I10	DI	----	START DISABLE	DIGITAL	----	----
12.	I11	DI	----	DI CONFUG. INPUT -1	DIGITAL	----	----
13.	I12	DI	----	DI CONFUG. INPUT -2	DIGITAL	----	----
14.	I13	DI	----	DI CONFUG. INPUT -3	DIGITAL	----	----
15.	I14	DI	----	SPARE DI-1	DIGITAL	----	----
16.	I15	DI	----	SPARE DI -2	DIGITAL	----	----

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PAGE TITLE : DIGITAL INPUT MODULE REPRESENTATION-A2

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DIGITAL OUTPUT MODULE (A3)

SR NO.	PLC ID	OUTPUT TYPE	SIGNAL TAG NO.	DESCRIPTION	SIGNAL TYPE	SET RANGE	UNIT
1.	Q0	DO	-K1	LUB OIL PRESS. LOW ALARM RELAY	DIGITAL	----	----
2.	Q1	DO	-K2	WATER TEMP. HIGH ALARM RELAY	DIGITAL	----	----
3.	Q2	DO	-K3	SPARE DO	DIGITAL	----	----
4.	Q3	DO	-K4	LUB OIL PRESS. TRIP RELAY	DIGITAL	----	----
5.	Q4	DO	-K5	WATER TEMP. HIGH TRIP RELAY	DIGITAL	----	----
6.	Q5	DO	-K6	DG RUNNING	DIGITAL	----	----
7.	Q6	DO	-K7	ENGINE READY TO START	DIGITAL	----	----
8.	Q7	DO	-K8	HORN RELAY	DIGITAL	----	----
9.	Q8	DO	-K9	DG RUNNING RELAY	DIGITAL	----	----
10.	Q9	DO	-K10	ENGINE START RELAY	DIGITAL	----	----
11.	Q10	DO	-K17	HOURMETER	DIGITAL	----	----
12.	Q11	DO	-K13	ENGINE SPEED RAISE RELAY	DIGITAL	----	----
13.	Q12	DO	-K14	ENGINE SPEED LOWER RELAY	DIGITAL	----	----
14.	Q13	DO	-K15	COMMON ALARM RELAY	DIGITAL	----	----
15.	Q14	DO	-K16	COMMON TRIP RELAY	DIGITAL	----	----
16.	Q15	DO	--	SPARE DO	DIGITAL	----	----

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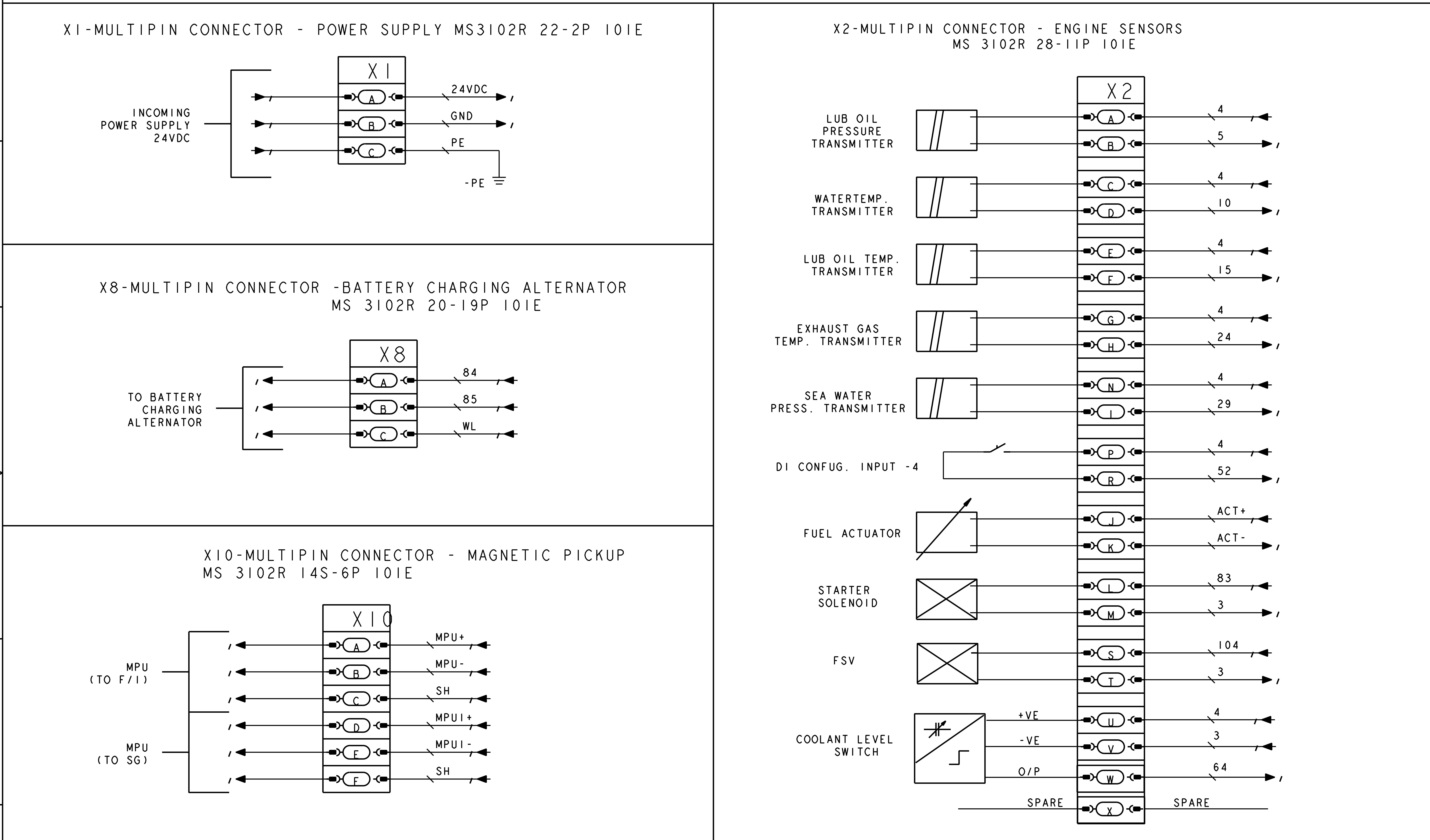


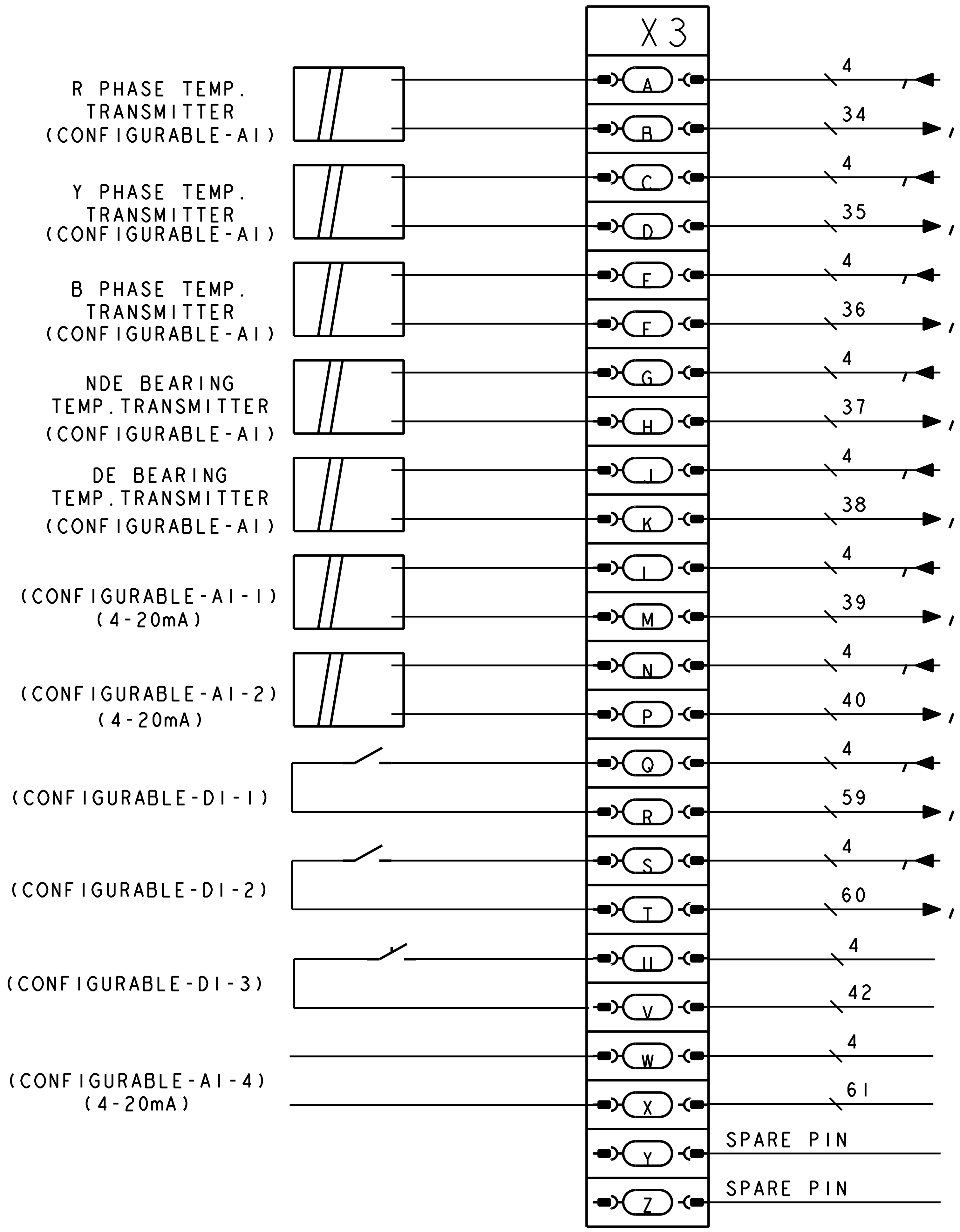
				Start Date	30-07-2018	PROJECT
02	EC-1003-452	11-09-2019	ALB	Drawn By	SPJ	STANDARD HMLD ENGINE
01	EC-1003-380	15-11-2018	ALB	Checked By	ALB	MARINE CONTROL PANEL
Rev	Change	Date	Name	Approved by	RMP	

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : PLUG DIAGRAM-X1,X8,X10,X2
DRG NO : 30066972
REF NO :

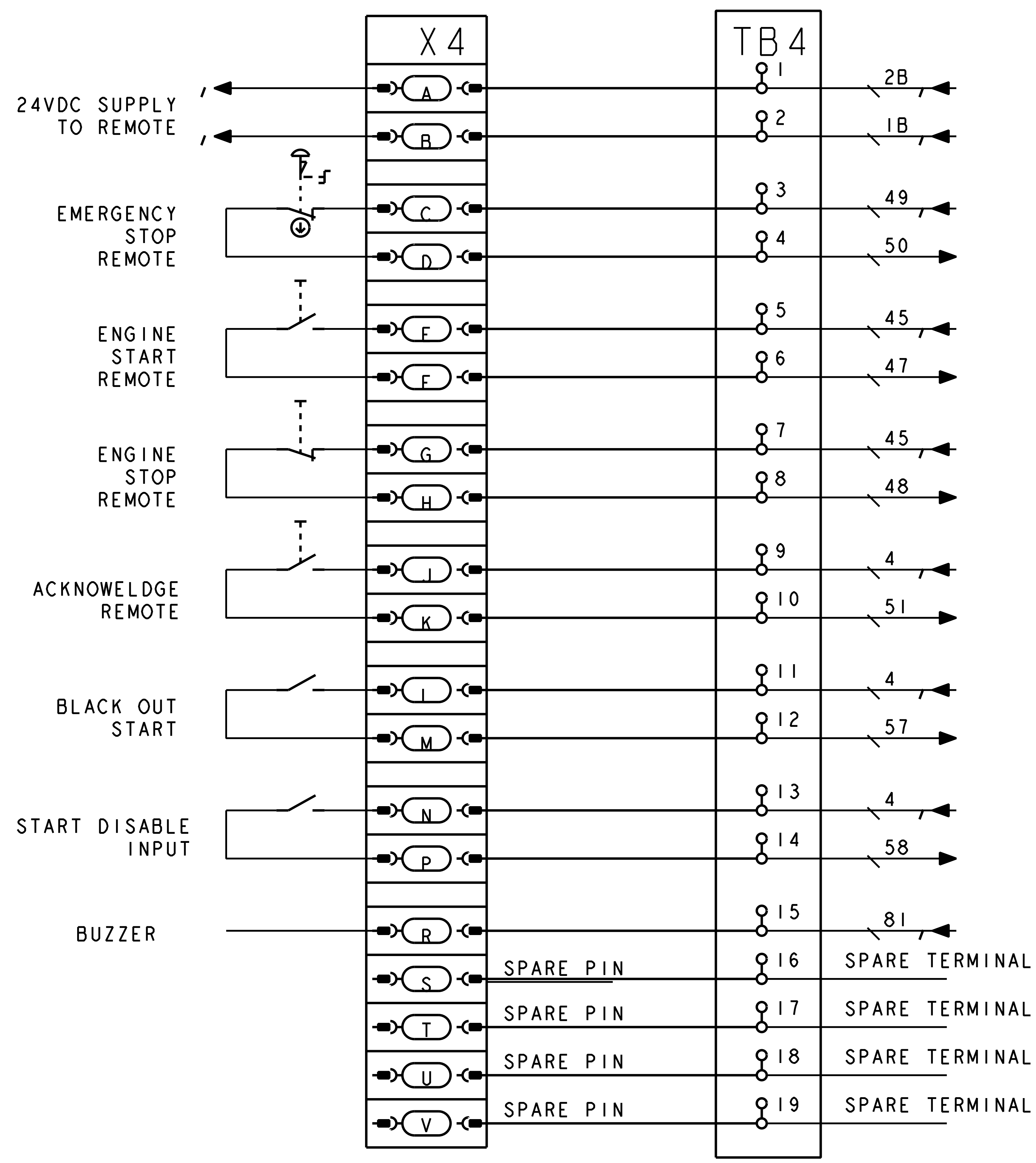
X3-MULTIPIN CONNECTOR - ALTERNATOR SENSORS
MS 3102R 24-28S 101E



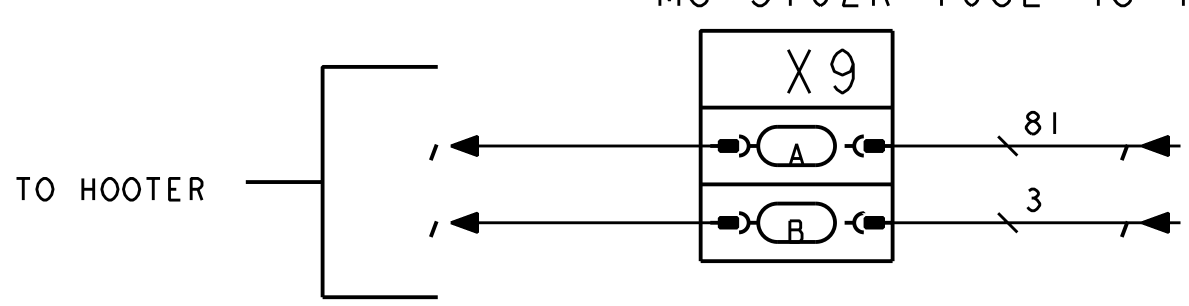
NOTE : DO NOT USED TB4 AND X4 SIMULTANEOUSLY

X4-MULTIPIN CONNECTOR
REMOTE CONTROL PANEL
MS 3102R 22-14S 101E

TB4-TERMINAL STRIP
REMOTE CONTROL PANEL
TERMINAL 1 - 19



X9-MULTIPIN CONNECTOR - HOOTER
MS 3102R 10SL-4S 101E



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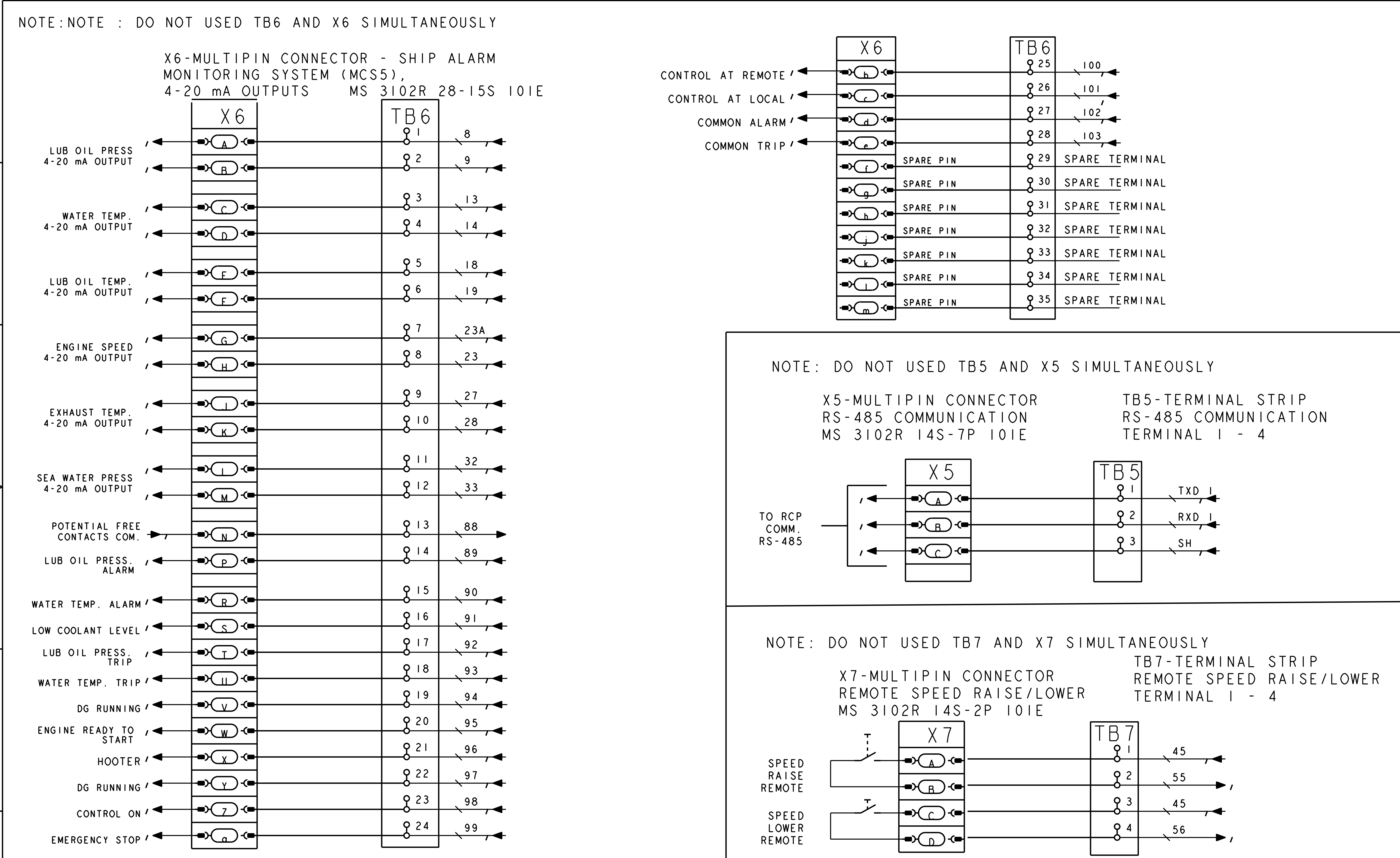
01	EC-1003-380	15-11-2018	ALB	Checked By	ALB
Rev	Change	Date	Name	Approved by	RMP

PROJECT
STANDARD HMLD ENGINE
MARINE CONTROL PANEL

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : PLUG/TB DIAGRAM-X3,X4,X9
DRG NO : 30066972
REF NO :



PAGE TITLE : PLUG/TB DIAGRAM-X5,X6,X7

DRG NO : 30066972

REF NO :

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Rev	Change	Date	Name		
02	EC-1003-452	11-09-2019	ALB	Start Date	30-07-2018
01	EC-1003-380	15-11-2018	ALB	Drawn By	SPJ
				Checked By	ALB
				Approved by	RMP

PROJECT
STANDARD HMLD ENGINE
MARINE CONTROL PANEL

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

BILL OF MATERIAL

SR. NO.	DEVICE TAG	FUNCTIONAL DESCRIPTION	MANUFACTURER	TYPE NUMBER	PCE PART NO	QTY.	PAGE REFERANCE
1	-A0	POWER SUPPLY MODULE	SCHNEIDER	BMXCPS2010	30062434	1	/17.3:E
2	-A1	PLC CPU	SCHNEIDER	BMXP342020	30066978	1	/16.3:E
3	-A2	DIGITAL INPUT MODULE	SCHNEIDER	BMXDDI1602	30062260	1	/11.3:C
4	-A2	DIGITAL INPUT MODULE-CONNECTOR	SCHNEIDER	BMXFTB2010	30065403	1	/11.3:C
5	-A3	DIGITAL OUTPUT MODULE	SCHNEIDER	BMXDDO1602	30062261	1	/12.2:A
6	-A3	DIGITAL OUTPUT MODULE-CONNECTOR	SCHNEIDER	BMXFTB2010	30065403	1	/12.2:A
7	-A4	ANALOG MODULE	SCHNEIDER	BMXAMI0810	30065400	1	/7.2:E
8	-A4	ANALOG MODULE-CONNECTOR	SCHNEIDER	BMXFTB2820	30062266	1	/9.3:A
9	-A5	ANALOG MODULE	SCHNEIDER	BMXAMI0810	30065400	1	/9.3:A
10	-A5	ANALOG MODULE-CONNECTOR	SCHNEIDER	BMXFTB2820	30062266	1	/9.3:A
11	-A6	BACK PANE	SCHNEIDER	BMXXBP0600	30066979	1	/9.3:A
12	-C11	SIGNAL ISOLATOR	RISHABH	SI101	30064585	1	/7.3:D
13	-C12	SIGNAL ISOLATOR	RISHABH	SI101	30064585	1	/7.4:D
14	-C13	SIGNAL ISOLATOR	RISHABH	SI101	30064585	1	/7.6:D
15	-C14	SIGNAL ISOLATOR	RISHABH	SI102	30066056	1	/8.3:D
16	-C15	SIGNAL ISOLATOR	RISHABH	SI101	30064585	1	/8.6:D
17	-C16	SIGNAL ISOLATOR	RISHABH	SI101	30064585	1	/8.7:D
18	-F1	MCB 2 POLE 6 AMP	SCHNEIDER	A9N2P06C	30061314	1	/6.4:C
19	-F2	MCB 2 POLE 10 AMP	SCHNEIDER	A9N2P10C	30061155	1	/6.5:C
20	-F3	MCB 2 POLE 6 AMP	SCHNEIDER	A9N2P06C	30061314	1	/6.2:C
21	-G1	AMMETER	RISHABH	PQ72 (0-30 AMP),24VDC	30061205	1	/14.6:C
22	-SG	ENGINE SPEED GOVERNOR	WOODWARD	CIL SCOPE	---	1	/14.1:C
23	-H6	REVOLVING LAMP WITH BUZZER	IDEAL	24 VDC RED	30061713	1	/14.4:E
24	-K1	LOP ALARM RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/12.2:C
25	-K2	HWT ALARM RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/12.3:D

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PROJECT
STANDARD HMLD ENGINE
MARINE CONTROL PANEL

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : BILL OF MATERIAL
DRG NO : 30066972
REF NO :

BILL OF MATERIAL

SR. NO.	DEVICE TAG	FUNCTIONAL DESCRIPTION	MANUFACTURER	TYPE NUMBER	PCE PART NO	QTY.	PAGE REFERENCE
26	-K3	LOW COOLANT LEVEL RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/12.4:D
27	-K4	LOT TRIP RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/12.5:D
28	-K5	HWT TRIP RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/12.6:D
29	-K6	LOT TRIP RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/12.6:D
30	-K7	ENGINE READY TO START RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/13.2:D
31	-K8	HORN RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/13.3:D
32	-K9	ENGINE RUN RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/13.3:D
33	-K10	ENGINE STARTER RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/13.4:D
34	-K11	CONTROL ON RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/6.6:C
35	-K12	EMERGENCY STOP RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/13.5:D
36	-K12A	EMERGENCY STOP RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/11.4:E
37	-K13	SPEED RAISE	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/11.4:E
38	-K14	SPEED LOWER	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/13.6:D
39	-K15	COMMON ALARM	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/13.7:D
40	-K16	COMMON TRIP	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/13.7:D
41	-K17	DG RUNNING RELAY	OMRON	G2R-2-SND24VDC+P2RF08E	30061318+30061398	1	/14.4:E
42	-SL1/H5	SELECTOR SWITCH LOCAL/REMOTE (ILLUMINATED)	SCHNEIDER	XB5AK123B1N	30066385	1	/10.4:B
43	-SL2	IDLE/RUN SELECTOR	SCHNEIDER	XB5-AD21N	30061321	1	/10.3:C
44	-SL3	SAFETY OVERRIDE SWITCH	SCHNEIDER	XB5-AG21N	30061563	1	/11.6:B
45	-SW1	MAINS ON/OFF SWITCH	SALZER	S16-61198-B03-TDYR	30061154	1	/6.2:C
46	-U1	F/I CONVERTOR	PCE	F/I CONVERTOR	30065525	1	/7.5:C
47	-U2	DC-DC CONVERTOR	PHOENIX CONTACT/ WEIDMULLER	2320034 24VDC 5A / PRO DCDC 120W 24V 5A	[illegible] / 30067177	1	/6.8:C
48	-H1	CONTROL ON	SCHNEIDER	XB7-EV03BPN	30061069	1	/6.6:C
49	-H2	CHARGING FAILURE	TECKNIC	2LHBR4-24 VDC	30061223	1	/6.6:D
50	-HMI	HUMAN MACHINE INTERFACE	SCHNEIDER	HMIGTO3510	30066981	1	/16.4:A

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PROJECT
STANDARD HMLD ENGINE
MARINE CONTROL PANEL

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : BILL OF MATERIAL
DRG NO : 30066972
REF NO :

BILL OF MATERIAL

SR. NO.	DEVICE TAG	FUNCTIONAL DESCRIPTION	MANUFACTURER	TYPE NUMBER	PCE PART NO	QTY.	PAGE REFERENCE
51	-X1	MULTIPIN CONNECTOR BASE -POWER SUPPLY	ALLIED ELE.CO	MS3102R 22-2P 101	30066849	1	/6.2:E
52	-X1	MULTIPIN CONNECTOR TOP -POWER SUPPLY	ALLIED ELE.CO	MS3106F 22-2S 101	30066850	1	/6.2:E
53	-X2	MULTIPIN CONNECTOR BASE -ENGINE	ALLIED ELE.CO	MS3102R 28-11P 101E	30067034	1	/7.3:A
54	-X2	MULTIPIN CONNECTOR TOP -ENGINE	ALLIED ELE.CO	MS3106F 28-11S 101E	30067035	1	/7.3:A
55	-X3	MULTIPIN CONNECTOR BASE -ALTERNATOR	ALLIED ELE.CO	MS3102R 24-28S 101E	30066892	1	/15.5:B
56	-X3	MULTIPIN CONNECTOR TOP -ALTERNATOR	ALLIED ELE.CO	MS3106F 24-28P 101E	30067033	1	/15.5:B
57	-X4	MULTIPIN CONNECTOR BASE -REMOTE	ALLIED ELE.CO	MS3102R 22-14S 101E	30066861	1	/10.7:C
58	-X4	MULTIPIN CONNECTOR TOP -REMOTE	ALLIED ELE.CO	MS3106F 22-14P 101E	30066862	1	/10.7:C
59	-X5	MULTIPIN CONNECTOR BASE -RS485	ALLIED ELE.CO	MS3102R 14S-7P 101E	30066874	1	/8.3:A
60	-X5	MULTIPIN CONNECTOR TOP -RS485	ALLIED ELE.CO	MS3106F 14S-7S 101E	30066875	1	/8.3:A
61	-X6	MULTIPIN CONNECTOR BASE -TO SHIP ALARM MONITORING SYSTEM (MCS 5)	ALLIED ELE.CO	MS3102R 28-15S 101E	30066878	1	/7.2:E
62	-X6	MULTIPIN CONNECTOR TOP -TO SHIP ALARM MONITORING SYSTEM (MCS 5)	ALLIED ELE.CO	MS3106F 28-15P 101E	30066879	1	/7.2:E
63	-X7	MULTIPIN CONNECTOR BASE -SPEED RAISE/LOWER	ALLIED ELE.CO	MS3102R 14S-2P 101E	30066870	1	/15.1:A
64	-X7	MULTIPIN CONNECTOR TOP -SPEED RAISE/LOWER	ALLIED ELE.CO	MS3106F 14S-2S 101E	30066871	1	/15.1:A
65	-X8	MULTIPIN CONNECTOR BASE -AMMETER	ALLIED ELE.CO	MS3102R 20-19P 101E	30066872	1	/15.4:E
66	-X8	MULTIPIN CONNECTOR TOP -AMMETER	ALLIED ELE.CO	MS3106F 20-19S 101E	30066873	1	/15.4:E
67	-X9	MULTIPIN CONNECTOR BASE -HORN	ALLIED ELE.CO	MS3102R 10SL-4S 101E	30066855	1	/15.4:E
68	-X9	MULTIPIN CONNECTOR TOP -HORN	ALLIED ELE.CO	MS3106F 10SL-4P 101E	30066856	1	/15.4:E
69	-X10	MULTIPIN CONNECTOR BASE -MPU	ALLIED ELE.CO	MS3102R 14S-6P 101E	30066869	1	/8.3:E
70	-X10	MULTIPIN CONNECTOR TOP -MPU	ALLIED ELE.CO	MS3106F 14S-6S 101E	30066984	1	/8.3:E
71	-TB4	TERMINALS -REMOTE	WAGO	280-833	30064978	19	/6.2:C
72	-TB5	TERMINALS -RS485	WAGO	280-833	30064978	4	/17.4:A
73	-TB6	TERMINALS -TO SHIP ALARM MOUNTIN SYSTEM (MCS 5)	WAGO	280-833	30064978	35	/7.3:E
74	-TB7	TERMINALS -SPEED RAISE/LOWER	WAGO	280-833	30064978	4	/10.7:C
75	-TBF	TERMINALS -FUSE	PHOENIX CONTACT	UK5-HESI-3004100	30063216	5	/7.3:B

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PROJECT
STANDARD HMLD ENGINE
MARINE CONTROL PANEL

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
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BILL OF MATERIAL

SR. NO.	DEVICE TAG	FUNCTIONAL DESCRIPTION	MANUFACTURER	TYPE NUMBER	PCE PART NO	QTY.	PAGE REFERENCE
76	-TPD	TERMINALS -POWER DISTRIBUTION	WAGO	2002-3208	30064972	4	---
77	-B1	ACKNOWLEDGE	SCHNEIDER	XB5-AA61N	30061070	1	/11.6:B
78	-B3/H3	ENGINE STOP PB	SCHNEIDER	XB5-AW34B2N	30066267	1	/10.5:D
79	-B4/H4	ENGINE START PB	SCHNEIDER	XB5-AW33B1N	30066266	1	/10.4:C
80	-B5	EMERGENCY STOP PB	SCHNEIDER	XB5-AS542N	30061073	1	/11.3:B
81	-B6	LAMP CHECK	SCHNEIDER	XB5-AA21N	30061071	1	/12.1:D
82	-B7	SPEED RAISE	SCHNEIDER	XB5-AA21N	30061071	1	/10.6:D
83	-B8	SPEED LOWER	SCHNEIDER	XB5-AA21N	30061071	1	/10.6:D
84	-H7	ENGINE RUNNING	SCHNEIDER	XB7-EV03BPN	30061069	1	/10.2:E
85	-PCB	SHORT CIRCUIT PROTECTION (FIVE CHANNEL)	PCE	30067032	30067032	5	/7.2:B
86	-HM	HOURMETER	KUBLER	H-57-24VDC	30061373	1	/13.5:E
87	-D1-D3	DIODE	SEMICONDUCTOR	BY1600	30061426	3	/14.8:B
88	---	GLAND	JBS	SIZE 2	30061211	2	---
89	---	GLAND	JBS	SIZE 3	30061179	2	---
90	---	MOUNT ANTIVIBRATION	AV MOUNTS INDIA	AIT03030B	30061178	4	---

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8 7 6 5 4 3 2 1

D

FUNCTIONAL REQUIREMENTS

DESCRIPTION	REQUIREMENT	CHECK METHOD
APPLICATION	MARINE - MAIN PROPULSION AND DG SET	-
MATERIAL	MS 2MM THICK CRCA SHEET	-
OPERATING VOLTAGE	24 VDC	-
OPERATING TEMPERATURE	55°C	-
SURFACE TREATMENT AND FINISH	CLEANING AND RED OXIDE COATING WITH PAINTING AS PER DGS 251	-
APPROX. WEIGHT	5 KG ±2 KG	-
COLOUR SHADE	ADMIRAL GRAY	-
DIMENSIONS IN MM	450 X 400 X 2	-
IP PROTECTION	IP 54	-
INTERNAL WIRING	LFH WIRES AS PER NES 518 / DEFENCE STANDARD 61-12 (PART 18) OF SUITABLE CAPACITY	-
DISPLAY	HMI 7 INCH	-
PUSH BUTTON	ENGINE START	-
	ENGINE STOP	-
	ACKNOWLEDGE	-
PUSH BUTTON SWITCH	EMERGENCY STOP INDUSTRIAL PUSH BUTTON SWITCH, SPST-NC, TURN TO RELEASE, SCREW, 1.2 A, 600V	-
BUZZER	BUZZER CUM FLASHER , RED 24 VDC	-
CONDUIT SIZE	25.4 X 1000.	-

1. HARDWARE: STAINLESS STEEL.
2. THIS DISPLAY PANEL IS TO BE USED WITH LOCAL CONTROL PANEL ONLY.
3. THIS DISPLAY PANEL HUMAN MACHINE INTERFACE (HMI) SHOWS THE EXACT REPETITION OF LOCAL CONTROL PANEL HMI, I.E. ALL THE PARAMETERS, INDICATIONS, ALARMS ETC... .DISPLAYED ON LOCAL CONTROL PANEL HMI WILL BE SHOWN ON DISPLAY PANEL HMI.
4. LOCAL CONTROL PANEL WHEN IN REMOTE MODE, ENGINE CAN BE START / STOP WITH PUSH BUTTONS ON DISPLAY PANEL.
5. EMERGENCY STOP CAN BE USED DURING EMERGENCY CONDITION.

D

C

C

B

B

A

A

PRELIMINARY

NOTE: THIS DRAWING HAS NOT COMPLETED ALL REQUIRED PRODUCT RELEASE CHECK PROCESSES.

DWN. 12/10/2019

Cummins Inc.

UNLESS OTHERWISE SPECIFIED THE INFORMATION WITHIN THIS TITLE BLOCK SHALL APPLY

DIMENSIONS ARE IN: MILLIMETERS [ ] ARE: INCHES

DIMENSIONING AND TOLERANCING PER ASME Y14.5-2009	LAST DATUM LETTER USED: -	LAST REF. LETTER USED: -
FINISH STOCK: .	REF. ITEM NO.: .	MADE FROM NO.: .
WALL THICKNESS: .	MFG. METHOD: 18111	
DRAFT ANGLES: .	INSP. STD.: 16061;16663	
EDGE RADII: .	ENGR. STD.: 10903	
FILLET RADII: .	PERF. STD.: .	
SURFACE FINISH PER: .	PROCESS: .	
SURFACE FIN.: Ramax .	MATERIAL: .	

THIRD ANGLE PROJECTION

SIZE D

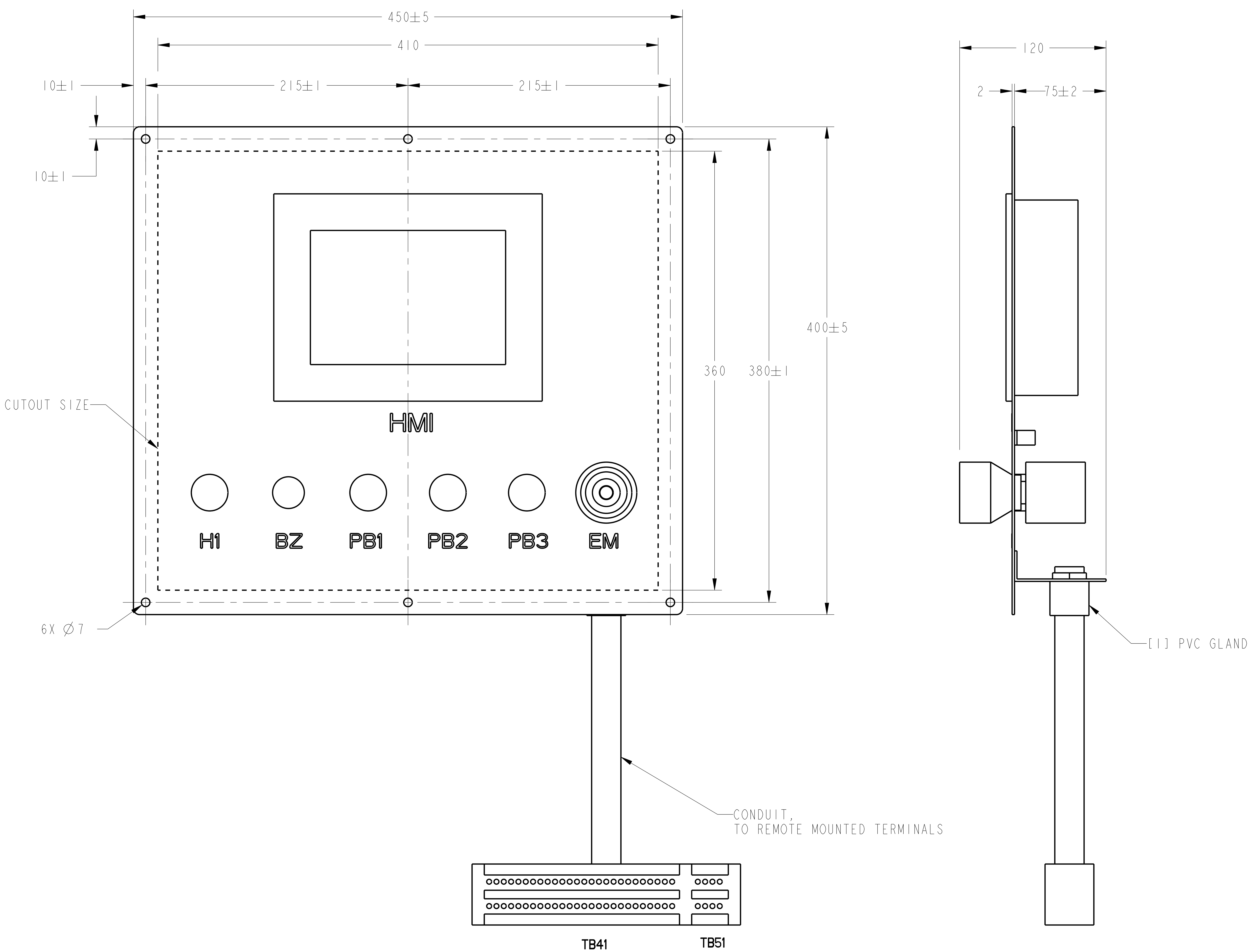
ITEM NAME: PANEL,DISPLAY

IDENTIFIER: NON-CUMMINS

ITEM NUMBER: 5569139

SCALE 0.5 | CODE IDENT NO. | SHEET 1 OF 2

8 7 6 5 4 3 2 1



LEGENDS:

HMI	: HUMAN MACHINE INTERFACE
H1	: CONTROL ON
BZ	: BUZZER
PB1	: ENGINE START
PB2	: ENGINE STOP
PB3	: ACKNOWLEDGE
EM	: EMERGENCY STOP
TB41, TB51	: REMOTE MOUNTED TERMINALS

Cummins Inc.

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DIMENSIONS ARE IN: MILLIMETERS	[ ] ARE: INCHES	
DIMENSIONING AND TOLERANCING PER ASME Y14.5-2009	LAST DATUM LETTER USED: -	LAST REF. LETTER USED: -
FINISH STOCK: -	REF. ITEM NO.: -	MADE FROM NO.: -
WALL THICKNESS: -	MFG. METHOD: 18111	
DRAFT ANGLES: -	INSP. STD.: 16061;16663	
EDGE RADII: -	ENGR. STD.: 10903	
FILLET RADII: -	PERF. STD.: -	
SURFACE FINISH PER: -	PROCESS: -	
SURFACE FIN.:Ramax -	MATERIAL: -	
THIRD ANGLE PROJECTION	SIZE D	THIS DOCUMENT (AND THE INFORMATION SHOWN THEREON) IS **CONFIDENTIAL AND PROPRIETARY** AND SHALL NOT BE DISCLOSED TO OTHERS IN HARD COPY OR ELECTRONIC FORM, REPRODUCED BY ANY MEANS, OR USED FOR ANY PURPOSE WITHOUT WRITTEN CONSENT OF CUMMINS INC.

ITEM NAME
PANEL,DISPLAY

IDENTIFIER NON-CUMMINS	ITEM NUMBER 5569139
SCALE 0.5	CODE IDENT NO.
	SHEET 2 OF 2

1. USE OF THIS DRAWING IS CONTROLLED BY THE TERMS OF AN AGREEMENT BETWEEN CUMMINS AND POWER CONTROL ENGINEERS. THIS AGREEMENT IS STORED IN ARIBA CONTRACT WORKBENCH UNDER CONTRACT ID CW258357.

2. THIS IS A SUPPLIER GRAPHIC FOR PART NUMBER 5569139.

SUPPLIER DRAWING

ONLY THE SUPPLIER MAY REVISE THIS DRAWING.

CUMMINS INC HAS THE RIGHT TO SHARE THIS DRAWING INTERNALLY AND WITH THIRD PARTIES LICENSED TO DESIGN, MANUFACTURE, ASSEMBLE OR ASSEMBLE WITH CUMMINS PRODUCTS.

CUMMINS ENGINEERING STANDARD 10084

PRELIMINARY

NOTE: THIS DRAWING HAS NOT COMPLETED ALL REQUIRED PRODUCT RELEASE CHECK PROCESSES.

DWN 16/10/2019

Cummins Inc.

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DIMENSIONING AND TOLERANCING PER ASME Y14.5-2009	LAST DATUM LETTER USED: .	LAST REF. LETTER USED: .
FINISH STOCK: .	REF. ITEM NO.: .	MADE FROM NO.: .
WALL THICKNESS: .	MFG. METHOD: 18111	
DRAFT ANGLES: .	INSP. STD.: 16061;16663	
EDGE RADII: .	ENGR. STD.: 10903	
FILLET RADII: .	PERF. STD.: .	
SURFACE FINISH PER: .	PROCESS: .	
SURFACE FIN.: Ramax .	MATERIAL: .	
THIRD ANGLE PROJECTION	SIZE C	THIS DOCUMENT (AND THE INFORMATION SHOWN THEREON) IS **CONFIDENTIAL AND PROPRIETARY** AND SHALL NOT BE DISCLOSED TO OTHERS IN HARD COPY OR ELECTRONIC FORM, REPRODUCED BY ANY MEANS, OR USED FOR ANY PURPOSE WITHOUT WRITTEN CONSENT OF CUMMINS INC.
ITEM NAME PANEL,DISPLAY		
IDENTIFIER REFERENCE DRAWING		ITEM NUMBER 5569140
SCALE NONE	CODE IDENT NO.	SHEET 1 OF 7

POWER CONTROL ENGINEERS
77/4,Shed No.3 Vishnumalti Industrial Estate,
Shivne,Pune : 411 023
Maharashtra, India
Phone : +91-020-25290771,
Fax : +91-020-25291011,

PROJECT DESCRIPTION	:	DROP IN PLATE
DRAWING NUMBER	:	30067174
REFERENCE NUMBER	:	
CUSTOMER	:	CUMMINS INDIA LTD.
END USER	:	
CUSTOMER PO NO	:	

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Rev	Change	Date	Name		
				Start Date	14-11-2018
				Drawn By	SPJ
			ALB	Checked By	ALB
				Approved by	RMP

PROJECT
DROP IN PLATE

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : TABLE OF CONTENTS

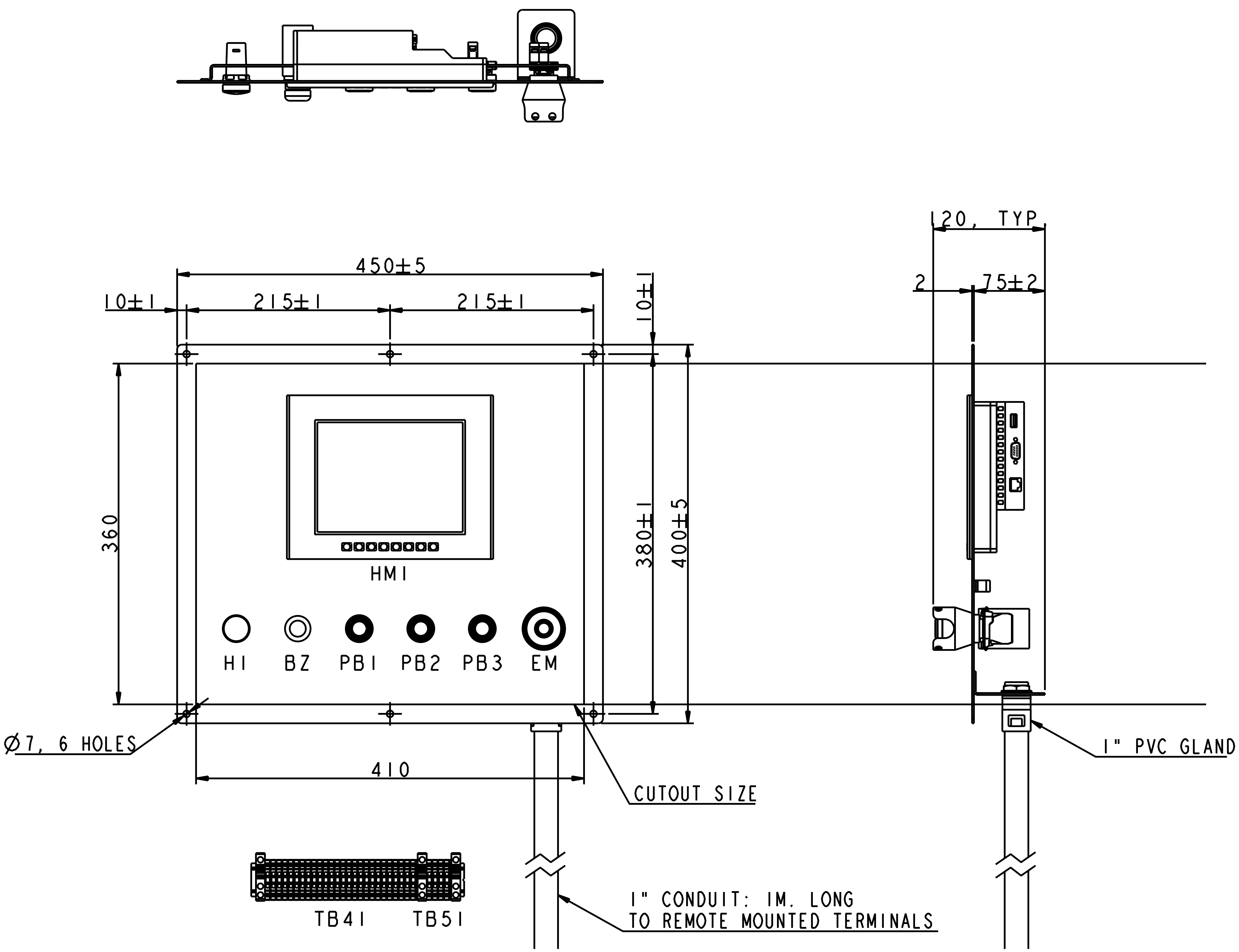
DRG NO : 30067174

REF NO :

NOTES :-

1. ALL DIMENSIONS ARE IN mm,UNLESS OTHERWISE SPECIFIED.
2. FABRICATION MATERIAL : MS ,2mm.THICK CRCA SHEET.
3. SURFACE TREATMENT : CLEANING & RED OXIDE COATING.
4. SURFACE FINISH : PAINTING AS PER DGS 251.
5. COLOUR SHADE : ADMIRAL GRAY.
6 .APPROXIMATE WEIGHT : 5KG (+/-2KG)
7. WIRING : LHF WIRE AS PER NES 518/DEFENCE STANDARD.61-12 (PART 18) OF SUITABLE CAPACITY.
8.HARDWARE : STAINLESS STEEL
9.PUT LINK AT TB41-18,19.

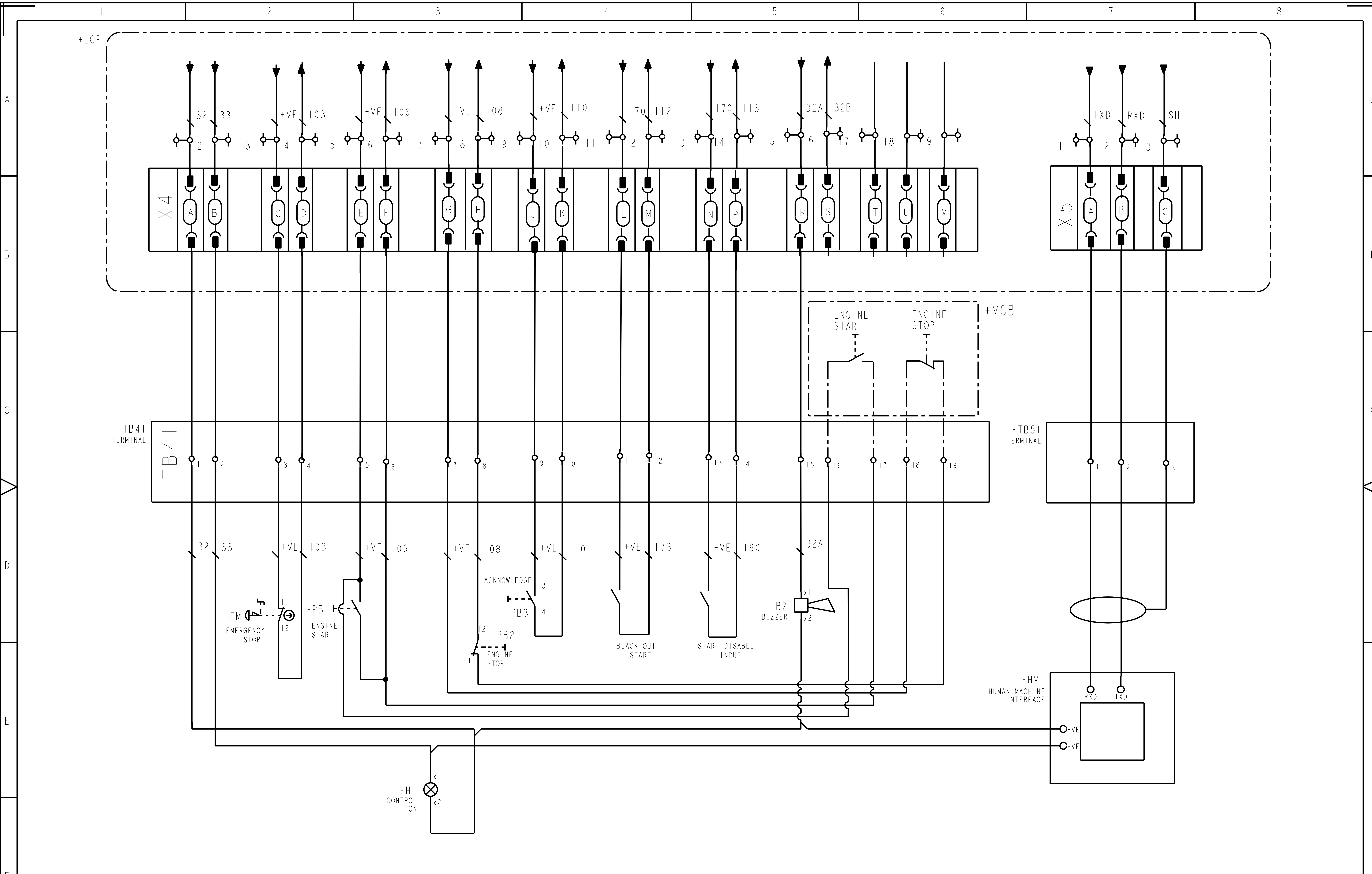
				Start Date	14-11-2018	PROJECT DROP IN PLATE	CUSTOMER CUMMINS INDIA LTD.	POWER CONTROL ENGINEERS SR. NO.77/4,SHED NO.3, VISHNU MALTI INDUSTRIAL ESTATE, SHIVANE,PUNE : 411 023 (INDIA)	PAGE TITLE :GENERAL NOTES	
				Drawn By	SPJ				DRG NO : 30067174	
			ALB	Checked By	ALB				REF NO :	Page 3 :Of 6
Rev	Change	Date	Name	Approved by	RMP					



LEGENDS:
HMI: HUMAN MACHINE INTERFACE
H1: CONTROL ON
BZ: BUZZER
PB1: ENGINE START
PB2: ENGINE STOP
PB3: ACKNOWLEDGE
EM: EMERGENCY STOP
TB41, TB51: REMOTE MOUNTED TERMINALS

PAGE TITLE :GENERAL ARRANGEMENT

				Start Date	14-11-2018	PROJECT DROP IN PLATE	CUSTOMER CUMMINS INDIA LTD.	POWER CONTROL ENGINEERS SR. NO.77/4,SHED NO.3, VISHNU MALTI INDUSTRIAL ESTATE, SHIVANE,PUNE : 411 023 (INDIA)	DRG NO : 30067174
				Drawn By	SPJ				
			ALB	Checked By	ALB				REF NO :
Rev	Change	Date	Name	Approved by	RMP				Page 4 :Of 6



				Start Date	14-11-2018	PROJECT DROP IN PLATE	CUSTOMER CUMMINS INDIA LTD.
				Drawn By	SPJ		
			ALB	Checked By	ALB		
Rev	Change	Date	Name	Approved by	RMP		

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : CONTROL WIRING

DRG NO : 30067174

REF NO :

Page 5 :Of 6

SR NO	DEVICE TAG	FUNCTIONAL DESCRIPTION	MANUFACTURER	TYPE NUMBER	PCE PART NO	QTY.	PAGE REFERANCE
1	-BZ	BUZZER	MIMIC	24V DC RED	30061417	1	/5.5:D
2	-EM	EMERGENCY STOP	SCHNEIDER	XB5-AS542N	30061073	1	/5.2:D
3	-HMI	HUMAN MACHINE INTERFACE	SCHNEIDER	HMIGTO3510	30067179	1	/5.7:E
4	-PB1	ENGINE START	SCHNEIDER	XB5-AA31N	30061307	1	/5.3:D
5	-PB2	ENGINE STOP	SCHNEIDER	XB5-AA42N	30061308	1	/5.3:E
6	-PB3	ACKNOWLEDGE	SCHNEIDER	XB5-AA61N	30061070	1	/5.4:D
7	-H1	CONTROL ON	SCHNEIDER	XB7-EV03BPN	30061069	1	/5.6:D
8	-TB41	TERMINALS REMOTE	PHOENIX CONTACT	UK2.5	30061083	19	/5.1:D
9	-TB51	TERMINALS REMOTE	PHOENIX CONTACT	UK2.5	30061083	4	/5.1:D
10	-G1	GLAND	FLEXICON	FLK25-M25B	30064654	1	----

Rev	Change	Date	Name		
				Start Date	14-11-2018
				Drawn By	SPJ
			ALB	Checked By	ALB
				Approved by	RMP

PROJECT
DROP IN PLATE

CUSTOMER
CUMMINS INDIA LTD.

POWER CONTROL ENGINEERS
SR. NO.77/4,SHED NO.3,
VISHNU MALTI INDUSTRIAL ESTATE,
SHIVANE,PUNE : 411 023 (INDIA)

PAGE TITLE : BILL OF MATERIAL
DRG NO : 30067174
REF NO :

COMMERCIAL MARINE INSTALLATION DIRECTIONS
TABLE OF CONTENTS

INTRODUCTION

This manual is intended as a guide for the proper installation of Cummins marine diesel engines which are used in commercial applications. The manual is divided into sections which cover Cummins Inc. installation requirements and recommendations for each engine system.

The requirements for each system are highlighted in bold text and must be met on any installation in order to obtain Cummins' concurrence to that installation. Failure to meet the installation requirements may result in poor performance, shorter engine life, higher maintenance costs or engine failure. Installations that do not comply with Cummins requirements may also be excluded from Warranty consideration.

The purpose of the recommendations is to help the engine installer meet the requirements of a particular system. The recommendations are intended as an aid and their use is strictly optional so long as all of the installation requirements are met. If you have any questions concerning these requirements or anticipate any problems meeting any of the requirements, contact a Cummins Marine Application Engineer at your local Cummins distributor.

This manual is applicable to the following engine families:

CUMMINS COMMERCIAL MARINE ENGINES			
ENGINE FAMILY	**CYL**	**DISPLACEMENT LITERS (CUBIC IN.)**	**ASPIRATION**
4B	4	3.9 (239)	Natural, Turbocharged, Turbocharged and Aftercooled
6B	6	5.9 (359)	Natural, Turbocharged, Turbocharged and Aftercooled
QSB	6	5.9 (359)	Turbocharged and Aftercooled
6C	6	8.3 (505)	Turbocharged and Aftercooled
QSC	6	8.3 (505)	Turbocharged and Aftercooled
QSL	6	8.9 (542)	Turbocharged and Aftercooled
QSM	6	10.8 (661)	Turbocharged and Aftercooled
N14, N855	6	14.0 (855)	Turbocharged, Turbocharged and Aftercooled
K19	6	19 (1150)	Turbocharged, Turbocharged and Aftercooled
QSK19	6	19 (1150)	Turbocharged and Aftercooled
K38	12	38 (2300)	Turbocharged and Aftercooled
K50	16	50 (3067)	Turbocharged and Aftercooled
QSK60	16	60.2 (3672)	Turbocharged and Aftercooled

ENGINE APPLICATION

Marine Installation Requirements

- **The engine must be used in accordance with the application guidelines for that particular rating.**
- **Engines must achieve or exceed rated speed at full throttle under any steady state operating condition; except engines in variable displacement boats, which must achieve no less than 100 rpm below rated at full throttle during a dead push or bollard pull.**

Marine Installation Recommendations

Proper application of your Cummins marine engine is important to assure that the engine gives you the reliability and durability it was designed for.

- **The engine must be used in accordance with the application guidelines for that particular rating.**

Cummins develops its marine engines to meet demanding customer expectations for performance, reliability and durability. In order for the engine to perform as it is intended, it must be used in accordance with Cummins' published marine ratings guidelines. It is important to choose the proper engine rating to provide the optimum performance in a given application. Listed below are the Cummins marine ratings guidelines.

Continuous Duty

This power rating is intended for continuous use in applications requiring uninterrupted service at full power. This rating is the ISO 3046 Standard Power Rating.

Heavy Duty

This power rating is intended for continuous use in variable load applications where full power is limited to eight hours out of every ten hours of operation. Also, reduced power operations must be at or below 200 rpm of the maximum rated rpm. This is an ISO 3046 Fuel Stop Power Rating and is for applications that operate 5,000 hours per year or less.

Medium Continuous Duty

This power rating is intended for continuous use in variable load applications where full power is limited to six hours out of every twelve hours of operation. Also, reduced power operations must be at or below 200 rpm of the maximum rated rpm. This is an ISO 3046 Fuel Stop Power Rating and is for applications that operate less than 3,000 hours per year.

Intermittent Duty

This power rating is intended for intermittent use in variable load applications where full power is limited to two hours out of every eight hours of operation. Also, reduced power operations must be at or below 200 rpm of the maximum rated rpm. This is an ISO 3046 Fuel Stop Power Rating and is for applications that operate less than 1,500 hours per year.

Light Commercial

This power rating is intended for use in variable load applications where full power is limited to one hour out of every twelve hours of operation. Also, reduced power operations must be at or below 400 rpm of the maximum rated rpm.

Prime Power (Fixed Speed Auxiliary Only)

Engines with this rating are available for an unlimited number of hours per year in variable load applications. Variable load is not to exceed a 70 percent average of the rated power during any operating period of 250 hours. Total operating time at 100 percent Prime Power shall not exceed 500 hours per year.

A 10 percent overload capability is available for a period of one hour within a twelve hour period of operation. Total operating time at the 10 percent overload power shall not exceed 25 hours per year. This power rating conforms to ISO 8528 guidelines.

- ❖ **Engines must achieve or exceed rated speed at full throttle under any steady state operating condition; except engines in variable displacement boats, which must achieve no less than 100 rpm below rated at full throttle during a dead push or bollard pull.**

Another important part of proper engine application is choosing the correct marine gear ratio and propeller size. Cummins develops its marine engines around loads based on propellers that are properly sized to absorb full engine horsepower under fully loaded conditions. Therefore, the marine gear ratio and propeller size must be chosen to allow the engine to achieve rated speed under fully loaded conditions (full fuel, water, passengers and maximum equipment load). This does not apply to bollard pull conditions, in which the boat is stationary in the water at full throttle. Under these conditions, the engines must achieve no less than 100 rpm below rated rpm.

Controllable Pitch Propellers

If controllable pitch propellers are to be used, the maximum pitch on the propeller should be determined under fully loaded conditions. The vessel should be taken out fully loaded and the pitch slowly increased until the engines are operating at rated speed at full throttle. This is the maximum amount of pitch that should be used under any operating conditions.

ENGINE MOUNTING/DRIVE SYSTEM

Marine Installation Requirements

- **The mounting system must be constructed so that the supporting structure deflections do not overstress the engine castings.**
- **The engine must be installed so that the static bending moment at the point where the flywheel housing is attached to the engine does not exceed the maximum value on the Engine General Data Sheet.**
- **Front trunnion type mounts must be adjusted to achieve end play clearance of 3.8 - 5.0 mm (.150 - .200") for the QSK19/K19 and 2.8 - 4.0 mm (.110 - .160") for the K38/K50 and QSK60 with the trunnion support bolted to the foundation.**
- **The trunnion must be lubricated such that grease can be seen to flow from between the pivot and trunnion joint.**
- **The static installation angle of the engine in a waterborne vessel must not be less than the minimum value given on the Engine General Data Sheet.**
- **The static installation angle of the engine in a waterborne vessel must not be greater than the maximum value given on the Engine General Data Sheet.**
- **Engine movement must be restrained sufficiently to prevent damage from physical contact between the engine components and adjoining structures; and the movement must not exceed the flexural limits of connecting systems.**
- **On flexible mounted systems, the vibration isolators must be installed parallel to the engine centerline in both the vertical and horizontal directions. The mount must be free to deflect and must not be fully compressed under a static load.**
- **The propeller shaft flange bore and face alignment must be within the marine gear manufacturer's limits.**
- **A TVA must be performed on all new high horsepower engine installations (K19 and above) excluding gensets.**

Marine Installation Recommendations

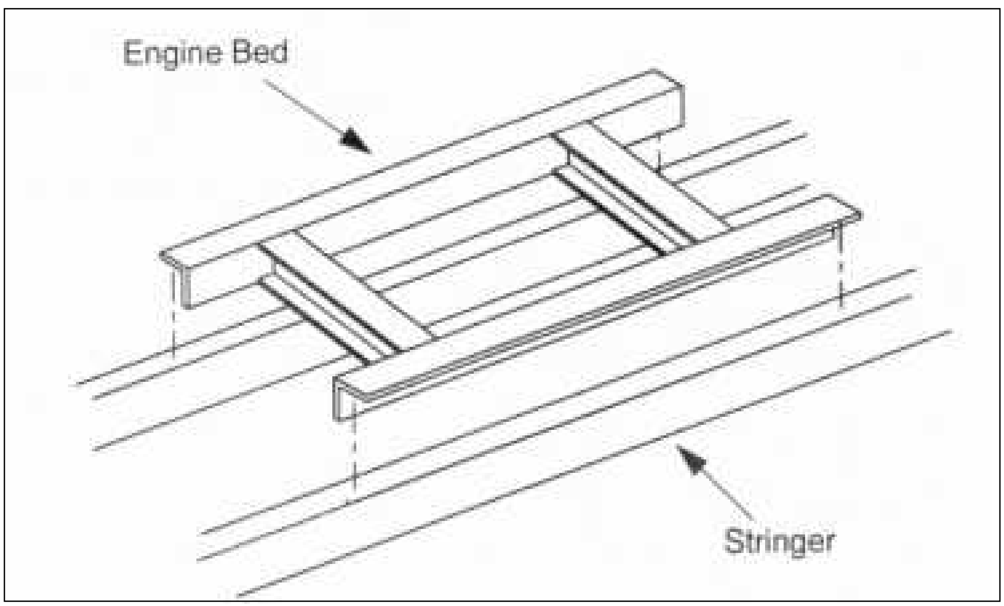
Engine Foundation

The engine foundation, consisting of longitudinal stringers and the engine bed, provides the attachment points for the engine and marine transmission to the vessel framework. This system should be rigid enough to resist excessive flexing in any part of the hull and securely hold the engine in place during all operating conditions.

The longitudinal stringers are a part of the hull structure and are primarily used to stiffen the hull against stresses and deflections. They also provide support for the engine bed and distribute the engine and marine gear weight throughout the hull.

- **The mounting system must be constructed so that the supporting structure deflections do not overstress the engine castings.**

The engine bed provides attachment points for the engine and marine gear. It should be made of welded steel or aluminum and welded or bolted to the stringers. The bed should be of a box type construction or have cross bracing to provide lateral support. This will assure that structural deflections are not transmitted to engine castings and will also limit the amount of lateral engine movement that is transferred to the hull causing vibration.



Mount Location

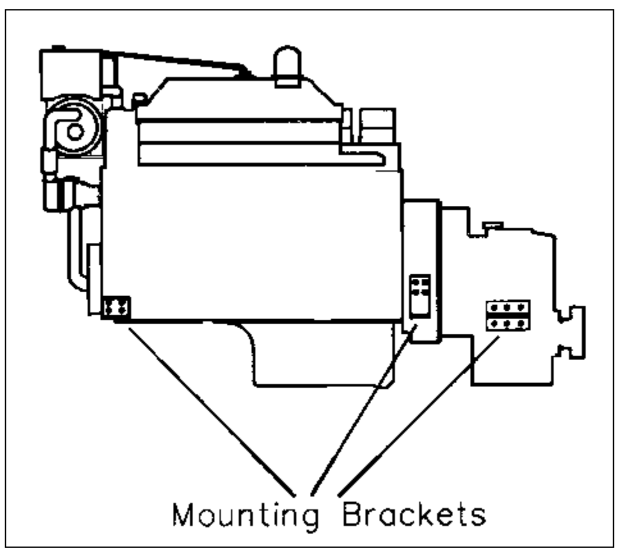
- ❖ **The engine must be installed so that the static bending moment at the point where the flywheel housing is attached to the engine does not exceed the maximum value on the Engine General Data Sheet.**

The following table summarizes the requirements for engine families covered by this document.

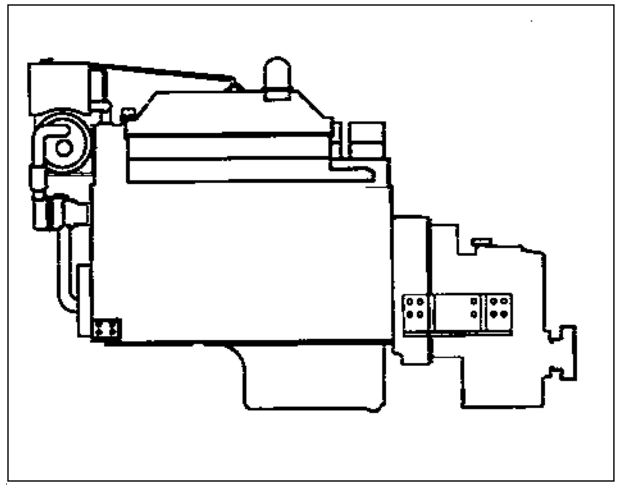
ENGINE FAMILY	**MAXIMUM BENDING MOMENT, REAR FACE OF BLOCK**	
	N-m	**lb-ft**
4B	1356	(1000)
6B	1356	(1000)
QSB	1356	(1000)
6C, 480C-E	1356	(1000)
QSC	1356	(1000)
QSL	1356	(1000)
QSM	1356	(1000)
N14, N855	1356	(1000)
K19	1356	(1000)
QSK19	1356	(1000)
K38	6100	(4500)
K50	6100	(4500)
QSK60	10,350	(7634)

In order to properly support the weight of the engine and marine gear, a six-point mounting system is recommended on all commercial engines. Cummins supplied engine and gear supports are recommended and should be located at the front, on the flywheel housing and on the marine gear on each side of the engine.

When using a six-point mounting system, the engine should be aligned using the mounts at the front and at the marine gear. Once the alignment is complete, the flywheel housing mounts should be added.

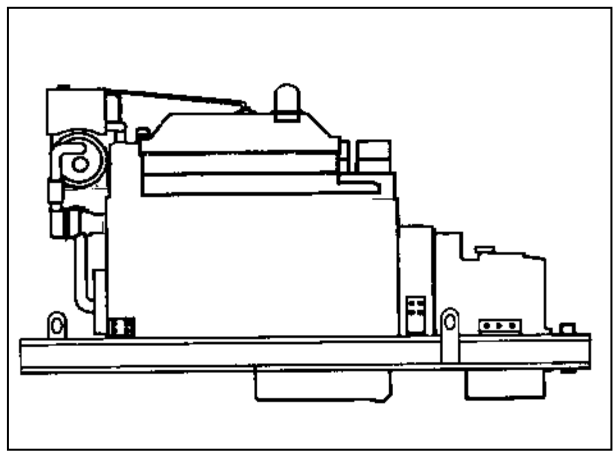


On flexible mounted engines, brackets which connect both the marine gear and the flywheel housing to a single isolator may be used if the bracket design is approved by Cummins Marine Engineering.



If a six point mounting system cannot be used, your local Cummins Marine Application Engineer should be contacted for assistance in meeting this requirement.

NOTE: If the gear must be mounted prior to installation in the hull, the engine and gear should be mounted on base rails and the whole system installed together. The lifting brackets on the engine will not support the weight of the engine and gear.



Trunnion Mounting

- ❖ **Front trunnion type mounts must be adjusted to achieve end play clearance of 3.8 - 5.0 mm (.150 - .200") for the QSK19/K19 and 2.8 - 4.0 mm (.110 - .160") for the K38/K50 and QSK60 with the trunnion support bolted to the foundation.**
- ❖ **The trunnion must be lubricated such that grease can be seen to flow from between the pivot and trunnion joint.**

Some high-horsepower engines feature a front trunnion mount arrangement which allows for thermal expansion of the engine as well as flexure of the vessel hull relative to the engine. The trunnion mount requires special considerations as follows:

- The trunnion carries no thrust reaction. The rear mounts must be designed to handle full propeller thrust.

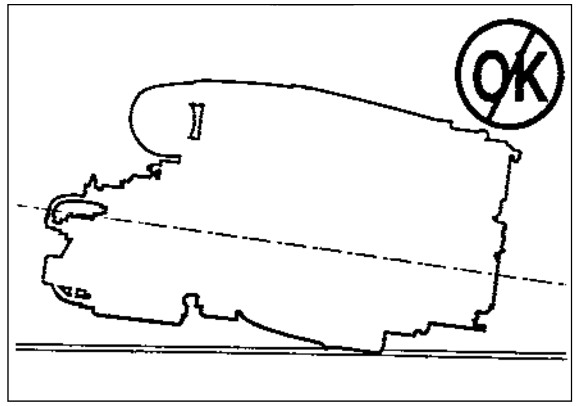
- The front mounting feet must be aligned axially with the centerline of the trunnion housing. There must be no offset or the trunnion may cock on the support.
- The trunnion must be installed with the proper end clearance and must be properly lubricated.
- If a flexible mounting system is used, it is recommended that a remote fixed gear be used to carry propeller thrust reaction, and a flexible coupling is chosen which is designed to handle relative movement between the engine and fixed gear.

NOTES:

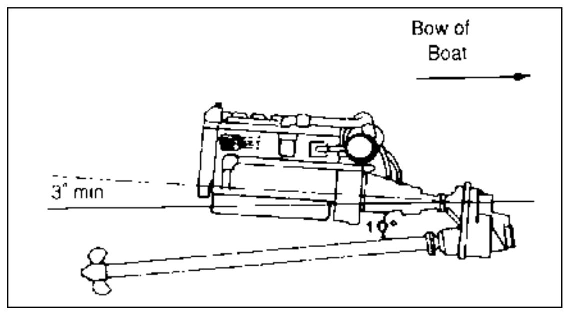
Engine Installation Angle

- ❖ **The static installation angle of the engine in a waterborne vessel must not be less than the minimum value given on the Engine General Data Sheet.**

For engines with no vent provision at the rear of the engine block, a nose down installation will not allow proper venting of the engine during fill and normal operation. This can lead to localized hot spots within the engine and possibly engine or component failures.



In a vee-drive system, the engine sits with the nose towards the stern of the vessel. The typical planing angle of a planing hull is about 3 degrees. If the engine is installed with an angle of less than 3 degrees, it will be running nose down when the vessel is on plane.



NOTE: If the planing angle of the vessel is going to be more than 3 degrees, then the minimum installation angle for a vee-drive is the planing angle of the vessel.

- ❖ **The static installation angle of the engine in a waterborne vessel must not be greater than the maximum value given on the Engine General Data Sheet.**

Installing the engine at an angle greater than that listed for the particular engine model may result in poor operation and performance and possible engine failure.

If the installation angle is too large, the connecting rods may begin dipping into the oil in the pan. This may aerate the oil causing poor lubrication and decreased engine life. It may also cause high oil consumption, increased fuel consumption, low power and an increase in smoke levels.

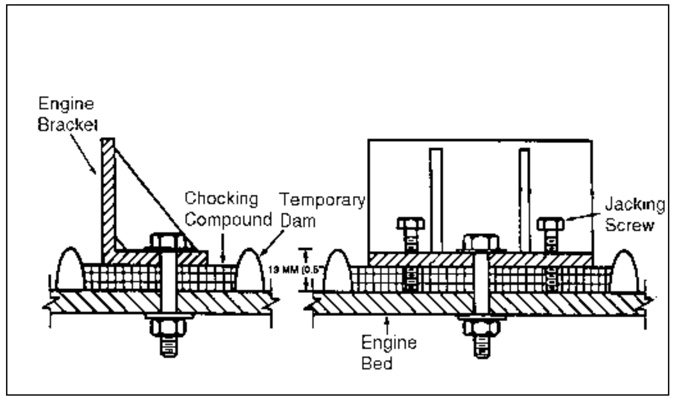
Too high of an installation angle may also result in a loss of oil supply to the lubricating oil pump and a loss of oil pressure to the engine. This can result in major engine damage and possible engine failure.

Refer to the latest Engine General Data Sheet for the particular engine family for maximum installation angle requirements.

❖ **Engine movement must be restrained sufficiently to prevent damage from physical contact between the engine components and adjoining structures; and the movement must not exceed the flexural limits of the connecting systems.**

Solid Engine Mounting

Solid mounting an engine is usually done by using brass or steel shims, pourable chocking compound or Fabreeka type washers and pads. The use of pourable chocking compounds is the simplest and preferred way to solid mount the engine. When using a chocking compound, the alignment of the marine transmission and propeller shaft is accomplished using jacking screws between the support brackets and the engine bed. The mounting bolts can be loosely put into place at this point or a hole can be drilled through the chocking compound later. The jacking screws, mounting bolts and bottom of the engine bracket should be coated with a grease or anti-bonding substance to allow them to be removed later. Temporary dams are put on the engine bed and should extend approximately 13mm (0.5") above the bottom of the engine beds. The chocking compound is poured in to fill the space between the bracket and engine bed. Once the compound has solidified, the jacking screws can be removed or left in place and the final mounting bolts are torqued down.

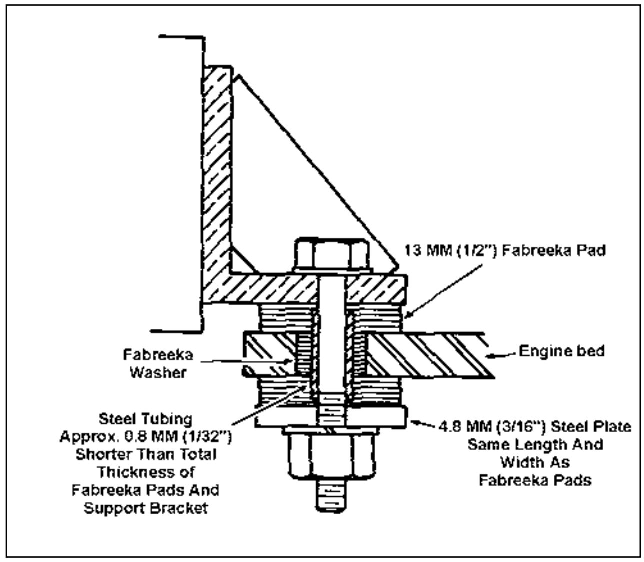


When using jacking screws on wood or fiberglass engine beds, steel plates should be used under the jacking screws to prevent damage to the engine bed.

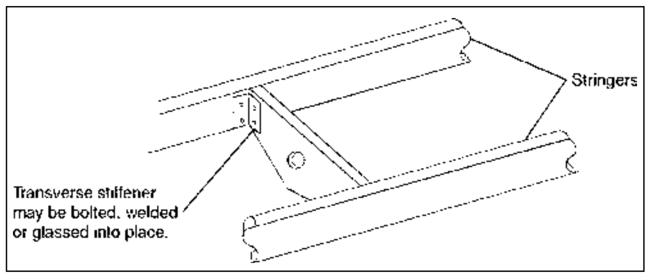
The chocking compound manufacturer should be consulted for further recommendations.

NOTES:

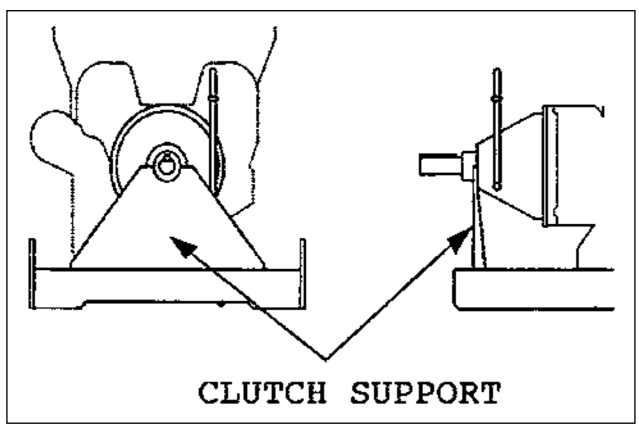
Fabreeka type washers and pads consist of layers of rubber-impregnated canvas and will provide a small amount of flexibility for minor misalignment and a degree of protection from shock loading. A steel plate is required between the nut and Fabreeka pad to protect the pad from wear and should be the same size as the pad. It is still necessary to use brass or steel shims to align the engine and gear with the shafting.



Transverse cross bracing on the engine bed and stringers should be used to prevent lateral engine movement on solid mounted systems.



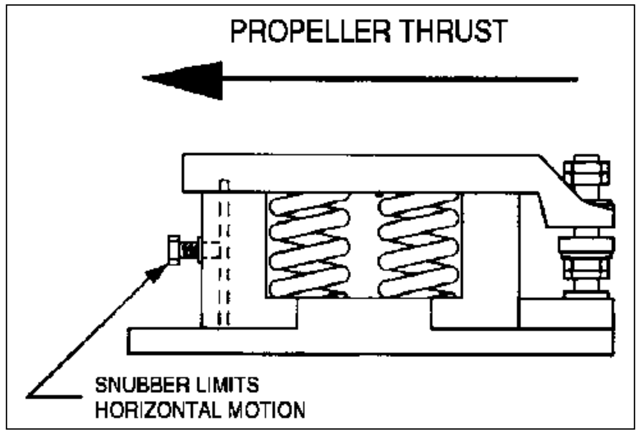
If a front power take-off clutch is used, it is a good practice to support the clutch. Clutch options available from Cummins must be supported to avoid over-stressing the nose of the crankshaft due to the overhung weight.



Flexible Engine Mounting

Flexible engine mounts use either rubber or spring isolators to absorb engine vibration before it is transmitted to the hull. This will reduce noise and vibration in the vessel. There is a wide variety of flexible mounts available on the market. Any mount selected must hold the engine in alignment and provide for acceptable mount life. The isolator manufacturer should be consulted for further recommendations.

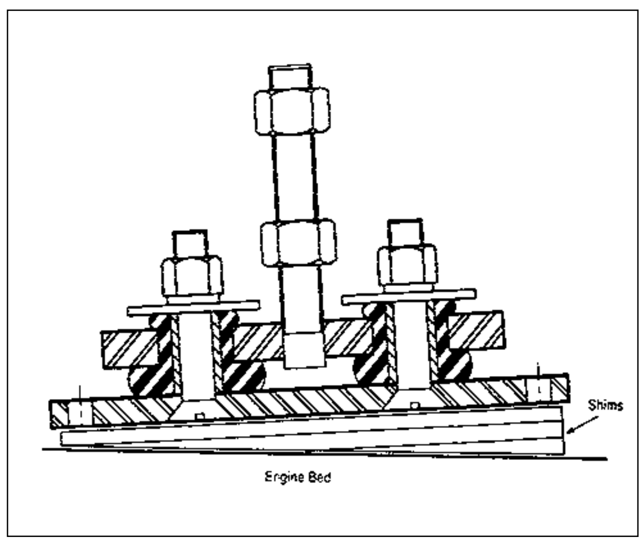
The engine should be installed with sufficient clearance on all sides so that the allowable engine movement will not cause structural or component damage. Snubbers may be required on softer mounts to prevent excessive engine movement due to propeller thrust.



If a front power take-off clutch is required on a flexible mounted engine, the clutch and engine should be mounted on common base rails with isolators between the base rails and engine bed.

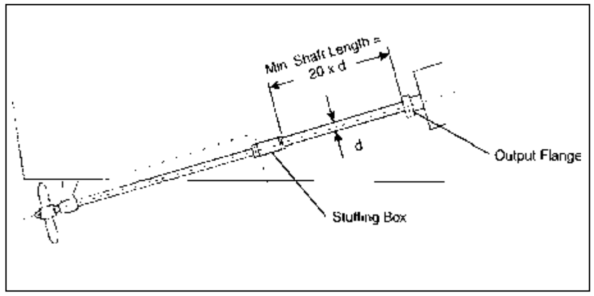
- ❖ **On flexible mounted systems, the vibration isolators must be installed parallel to the engine centerline in both the vertical and horizontal directions. The mount must be free to deflect and must not be fully compressed under a static load.**

If the engine bed is not parallel to the engine crankshaft, it may be necessary to use wedges beneath the isolators to assure the isolator springs or rubber bushings are properly and evenly compressed.

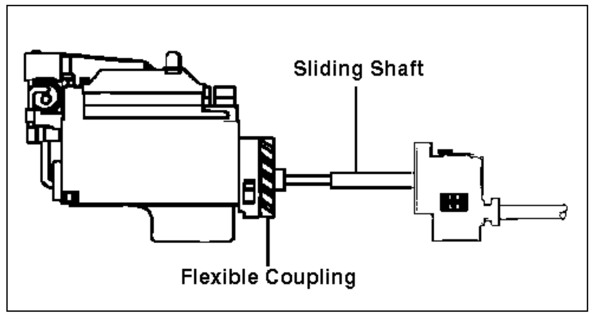


Driveline

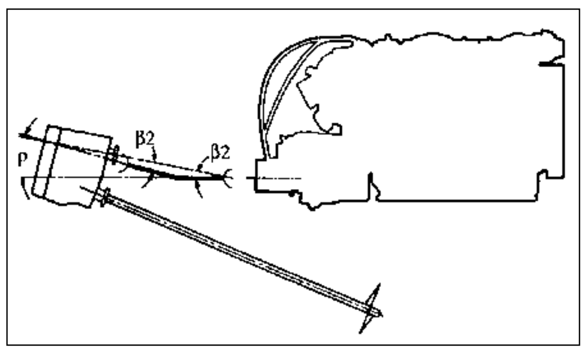
In order to isolate engine vibration and prevent it from being transferred to the hull through the propeller shaft, Cummins recommends that the distance from the marine gear output flange to a fixed stuffing box or first fixed bearing be a minimum of 20 times the shaft diameter. If the distance is less than this, a flexible coupling may be necessary to isolate the engine vibration.



If the driveline is to have a remote mounted transmission, a constant velocity joint, or a pair of universal joints, and a sliding shaft must be used to allow for the relative motion between the flexible mounted engine and the fixed marine gear.



If universal joints are to be used, it is important to remember that it is necessary to have the exact same angle at each joint under all operating conditions in order for the system to work properly.

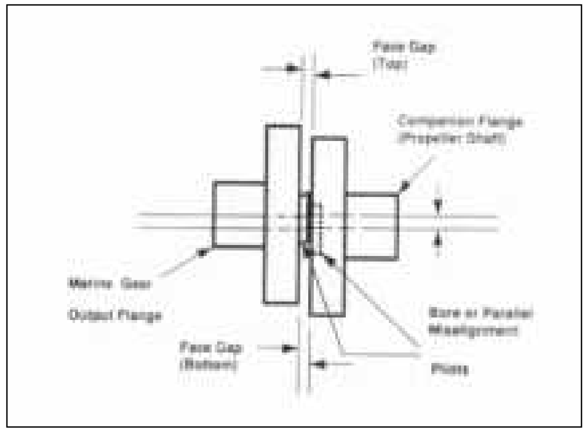


The driveline component manufacturer should always be consulted for more details on the installation of their product.

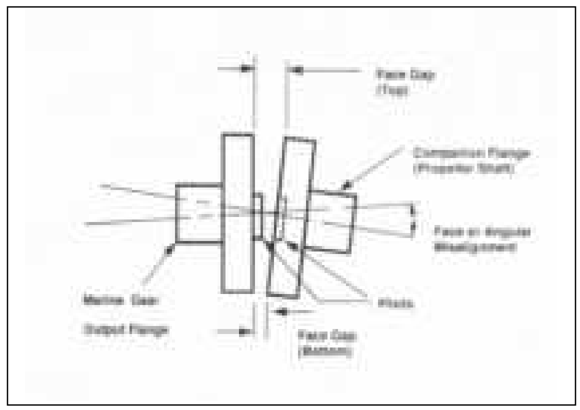
Propeller Shaft Alignment

- ❖ **The propeller shaft flange bore and face alignment must meet the gear manufacturer's requirements.**

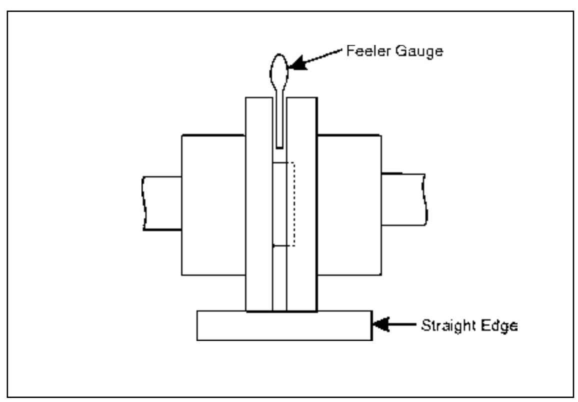
The alignment of the engine and marine transmission with the propeller shafting is essential to minimize vibration, noise, power loss and stress in the driveline components.



While aligning the engine and gear, check both the propeller shaft flange bore and face. The shaft and gear flanges should fit together without deflecting either the engine or the shaft from its operating position. This will allow the propeller shaft flange and marine gear output flange to mate properly without over stressing the driveline components.

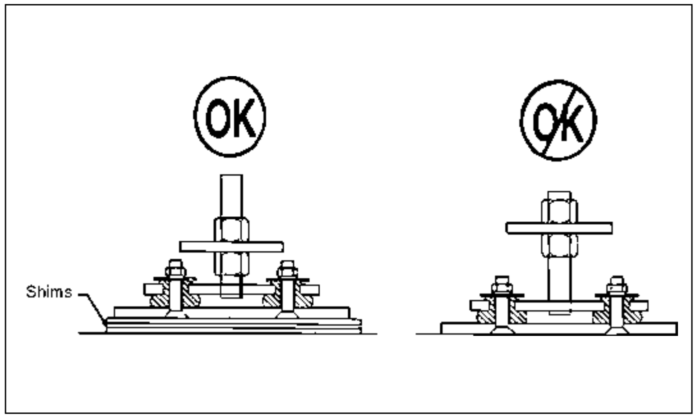


Cummins requires that the face alignment be within the gear manufacturer's specifications when checked with a feeler gauge at the top, bottom, and each side of the flanges. The shaft should then be rotated 180 degrees and checked again. The propeller shaft flange bore and face alignment should not be done until after the vessel is in the water and, on a solid mounted engine, should be rechecked after the vessel has been in the water and loaded to its normal operating condition.



On solid mounted engines, temporary alignment is made with jacking screws and final alignment is made using shim stock or chocking compound underneath the supports

On flexible mounted engines the engine is aligned by shimming under the isolator and then the final alignment is accomplished using the adjusting nuts on the isolator. The mounting brackets should always be located as low as possible on the isolator stud to prevent over-stressing the stud. The alignment must be redone each time a flexible mounting system is disconnected from the propeller shaft since the system is not rigid.



If the system uses a flexible stuffing box, it will be necessary to block the propeller shaft into the center of the stuffing box bore. This will assure that the shaft passes through the center of the stuffing box when the mounting is complete and will not prematurely wear out the bearing in the stuffing box.

NOTES:

ENGINE DRIVEN ACCESSORIES

Marine Installation Requirements

- **Belt driven accessories must be mounted on the engine when a flexible mounting system is used.**
- **Brackets used to mount accessories must provide adequate strength to hold the static and dynamic load of the accessory and avoid resonant vibration within the normal operating range of the engine.**
- **Variance in accessory loads must be considered when selecting accessory drive location and capacity. The design service factor given in the installation recommendations should be used when determining accessory loads. The maximum accessory load must not exceed the rated drive limit.**
- **Belt driven equipment must be held in alignment to a tolerance of 1 mm in 200 mm (1/16 inch in 12 inches).**
- **A TVA must be performed on all new engine installations with a front power takeoff.**
- **The total power taken off of the front of the crankshaft cannot exceed the capacity of the FPTO clutch and the total power required of the engine may not exceed the value published in the option notes for that particular rating.**
- **The engine must have sufficient crankshaft end clearance with the marine gear, and/or any FPTO installed, per the requirement on the Engine General Data Sheet.**
- **All exposed rotating components must have a protective guard.**

Marine Installation Recommendations

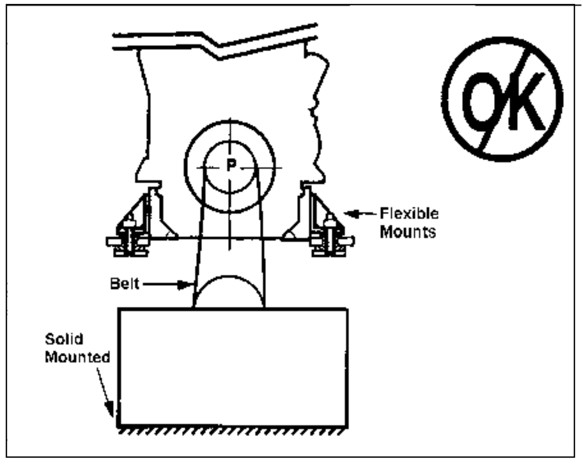
Belt Drive

Cummins marine engines may have belt drives for an alternator, raw water pump, and at least one open drive pulley for other accessories. Many engines also have crankshaft pulleys available for driving accessories. All Cummins belt drives use pulleys that are designed to SAE standards.

New belts require a run-in period of 10-15 minutes under tension and should then be retensioned. This allows for the initial stretch of the belt and will help prevent it from jumping off the pulley.

❖ **Belt driven accessories must be mounted on the engine when a flexible mounting system is used.**

If the engine uses flexible mounts, then the engine will have significant motion in relation to the hull. This will cause the belt to slip or jump off of the pulley and subject the shaft and bearings to concentrated intermittent loads if the accessory is mounted off of the engine.



Any engine mounted accessories should have flexible connections to any components which they are driving. If solid connections or lines are used, they are likely to fatigue and fail as a result of engine vibration.

❖ **Brackets used to mount accessories must provide adequate strength to hold the static and dynamic load of the accessory and avoid resonant vibration within the normal operating range of the engine.**

If a bracket has a natural frequency within the operating range of the engine, operation at that speed will result in resonant vibration and failure of the bracket. Since Cummins has no control over the design or material of the component, they are not responsible for any damage resulting from the failure of a non-Cummins supplied part.

When accessories are mounted on the engine, the mounting brackets should be attached to a basic part of the engine such as the cylinder block or cylinder head whenever possible. Accessories should not be mounted where they must be removed for normal engine maintenance or where they are supported through a gasketed joint.

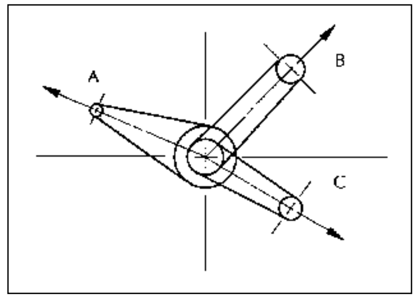
❖ **Variance in accessory loads must be considered when selecting accessory drive location and capacity. Design service factors given in the installation recommendations should be used when determining accessory loads.**

Since engine driven accessories will experience fluctuations in the load during normal operation, the rated load of the accessory should be multiplied by a design service factor when determining the load imposed on the engine by the accessory.

ACCESSORY TYPE	DESIGN SERVICE FACTOR
Bilge Pumps and Alternators	1.3
Air Compressors	1.4
Hydraulic Pumps	2.0

The direction as well as the load is important when considering belt driven accessories. The load capacity of crankshaft pulleys and other drive locations will vary at different angles due to the loading capability of the bearings.

If two or more accessories are being driven from a single multigroove pulley, the accessories should be arranged to have opposing belt pulls so that the resulting force on the drive shaft is kept to a minimum.



Accessory drive locations can be found on the particular engine installation drawing.

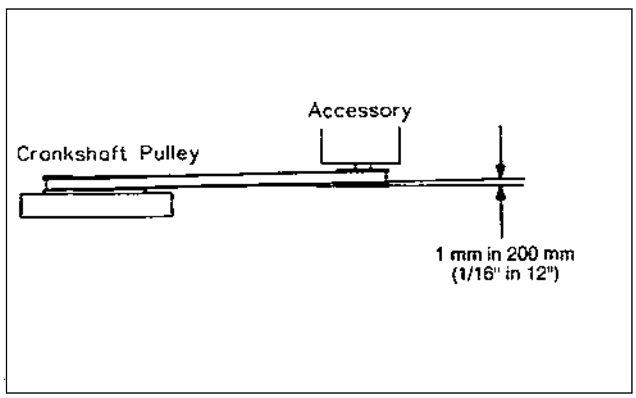
Increasing the belt and pulley width may exceed the safe loading of the crankshaft or drive location and is not recommended unless the design has been reviewed by Cummins Marine Engineering.

The amount of power that can be taken off of the front of the crankshaft is dependent upon the angle at which it is taken and the distance of the load from the nose of the crankshaft. Refer to the engine data sheets for the particular engine for maximum allowable crankshaft side loads and maximum torque that can be taken from the crankshaft.

Any device rigidly attached to the front of the crank, other than an approved option, must be analyzed for the effects on crank bending, side-pull loading, mean and vibratory torques, and the capability of the crank bolted joint capacity.

Belt driven equipment must be held in alignment to a tolerance of 1 mm in 200 mm (1/16 inch in 12 inches).

Misalignment between the belt driven equipment and the engine will result in bending forces on the shafts involved, wearing of the belt, belt jumping and can result in bearing or belt failure. This can usually be checked with a straight edge.



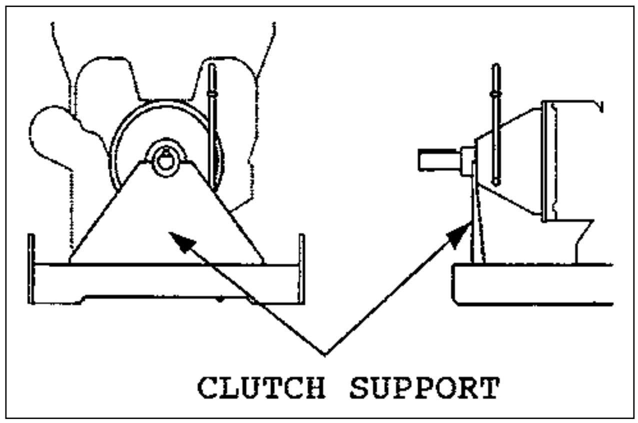
Front Power Take-off Clutches

More power may be taken from a direct drive at the front of the crankshaft than any other accessory drive location. Many Cummins engines can be fitted with a front power take-off clutch for driving accessories such as a winch, fire pump, hydraulic pump or generator.

- ❖ **A TVA must be performed on all new engine installations with a front power takeoff.**

All direct driven equipment will have some effect on torsional vibration. Excessive torsional vibration in a system can result in excessive noise, gear failure or, in the most severe cases, crankshaft failures. If a front power take-off arrangement is to be used, a torsional vibration analysis must be performed prior to installation. The torsional compatibility of the system is the responsibility of the installer (ref. ISO 3046-5) and not Cummins.

If a front power take-off clutch is used, it is a good practice to support the clutch. Clutch options available from Cummins must be supported to avoid over-stressing the nose of the crankshaft due to the overhung weight.



- ❖ **The total power taken off of the front of the crankshaft cannot exceed the capacity of the FPTO clutch and the total power required of the engine may not exceed the values published in the option notes for that particular rating.**

The total power capacity of each Cummins offered FPTO clutch is listed in the option notes found in the on-line sales e-book. This is the maximum amount of power that can be transmitted through the particular clutch and cannot be exceeded.

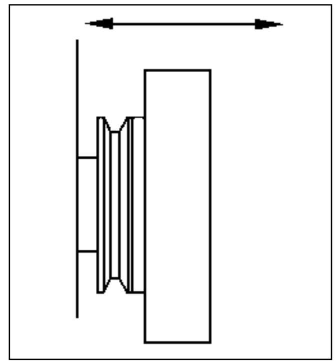
Additionally, the total power required by the propeller and FPTO cannot exceed the full load torque curve at any given rpm. If the propeller is engaged, this means that the power available at the front is equal to the difference between the propeller curve and full load torque curve as seen on the engine performance data sheet.

- **The engine must have sufficient crankshaft end clearance with the marine gear, and/or any FPTO installed, per the requirement on the Engine General Data Sheet.**

THE ENGINE MUST NOT BE RUN WITHOUT SUFFICIENT END CLEARANCE!

Without end clearance, the crankshaft will be turning in solid contact with the engine thrust bearing surface and will damage the thrust bearing, crankshaft and engine block.

To find the crankshaft end clearance, push the crankshaft vibration damper hub in until the crankshaft contacts the thrust bearing. Then pull the crankshaft forward. Refer to the applicable Troubleshooting and Repair manual which lists the minimum and maximum amount of allowable free axial movement for the engine model.



- **All exposed rotating components must have a protective guard.**

Since any rotating component may potentially injure someone through direct contact or through contact with loose clothing, a protective guard must be placed around any exposed rotating parts.

Guards provided by Cummins must not be modified or altered without approval from Cummins Marine Engineering.

Hydraulic Pump Drives

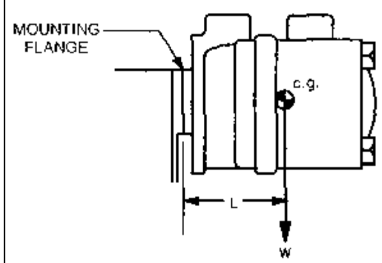
Many of the Cummins engines covered in this manual have hydraulic pump drives as available options. The locations for the various hydraulic pump drives can be found on the installation drawing or in the on-line sales e-book.

When using the hydraulic pump drives, it is important to not exceed the torque or bending moment limits of the drive location. All of Cummins' hydraulic pump drives are available with either an SAE type A or B flange and the limits for each are listed below.

SAE FLANGE TYPE	TORQUE LIMIT	MAXIMUM BENDING MOMENT
A	58.4 N-m (571 in-lb)	8.5 N-m (75 in-lb)
B	209 N-m (1852 in-lb)	28.3 N-m (250 in-lb)

The example to the right illustrates how to calculate the bending moment on the flange. In order to calculate the bending moment it is necessary to know the weight and center of gravity of the accessory.

$M = L \times W$



L = DISTANCE FROM MOUNTING FLANGE TO ACCESSORY'S C.G

W = WEIGHT OF THE ACCESSORY

M = BENDING MOMENT.

NOTES:

Marine Installation Requirements

- **Protective guards, jacketing, and/or covers must be used wherever persons or gear may come in contact with any section of the exhaust system where the surface temperature exceeds 93ºC (200ºF).**
- **Piping must not be installed near combustible material.**
- **All exhaust system surfaces with temperatures above 220ºC (428ºF) which may be impinged as a result of a fuel system failure must be properly insulated.**
- **The exhaust back pressure must not exceed 3 in. Hg (10 kPa).**
- **The exhaust system components must not impose excessive load or bending moments on the exhaust manifold or turbocharger due to weight, inertia, relative motion of the components or dimensional change due to thermal growth.**
  - **The maximum allowable bending moment at the turbine outlet mounting flange must not exceed the maximum specified on the Engine General Data Sheet.**
  - **The maximum allowable direct load at the turbine outlet mounting flange must not exceed the maximum specified on the Engine General Data Sheet.**
- **A flexible connection must be installed directly to the engine exhaust outlet connection.**
- **The exhaust system must prevent the entrance of water into the engine or turbocharger whether it be from spray, rain, washing, wave action, boat motion or any other source.**
  - **The highest point in the exhaust system must be dry and at least 12 in (305mm)* above the loaded water line (LWL). *For the 1.7, 2.8 and 4.2 liter inboard and sterndrive engines, the required dimension above the LWL is 11 in (279 mm) to the top of the elbow or riser.**
  - **The point of water injection is downstream of and at least 8 in (203mm) from the internal high point of the elbow, or 2 in (50 mm) below the highest dry point.**
  - **The injected water must not be able to flow backward into engine.**
- **The exhaust gas must be dispersed so that it does not detrimentally affect the air cleaner function, the engine ambient environment, the crew or passengers.**

- ❖ **There must be no bends within 305 mm (12 inches) downstream of the point of water injection.**
- ❖ **Wet exhaust piping must have a continuous downward slope of at least 2 degrees (35 mm per meter or 1/2" per foot).**
- ❖ **A service port must be provided in the exhaust system. The service port must be internally threaded with standard pipe threads not larger than 12.7 mm (0.5 in). The port must be located between the engine exhaust outlet connection and the point where it mixes with sea water (for sea water cooled exhaust systems) or exits to ambient air (for dry exhaust systems).**

Marine Installation Recommendations

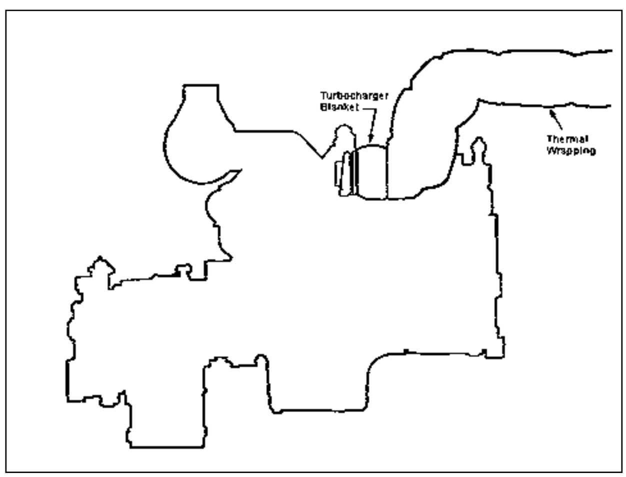
The purpose of the exhaust system is to carry the exhaust gas from the engine to the atmosphere with minimal flow restriction. Marine applications have two types of exhaust systems, wet and dry.

Dry Exhaust Systems

Dry exhaust systems use steel or iron pipe for the exhaust piping, stainless steel flexible sections, and steel for the mufflers. Due to the high exhaust temperatures and the thermal conductivity of the metal components, they can be dangerous unless certain precautions are taken.

- ❖ **Protective guards, jacketing, and/or covers must be used wherever persons or gear may come in contact with any section of the exhaust system where the surface temperature exceeds 93ºC (200ºF).**

For safety reasons, and to help maintain low engine room temperatures, thermal insulation or shields are required on all parts of a non-cooled, dry exhaust system. The insulation should be sufficient to maintain a surface temperature of less than 93° C (200° F).



- ❖ **Piping must not be installed near combustible material.**

Due to the high temperatures of a dry exhaust system, dry exhaust piping should never be installed near combustible materials. Cummins recommends that the wrapped exhaust piping be at least 15 cm (6 inches) from any combustible materials.

NOTES:

❖ **The exhaust back pressure must not exceed 3 in. Hg (10 kPa).**

Excessive exhaust back pressure can lead to low power, black smoke, poor fuel economy and decreased engine life. It is important to keep the exhaust back pressure to a minimum.

Any bends in the exhaust system should be made as smooth as possible. Sharp bends will increase the back pressure and should be avoided.

In general, the minimum exhaust pipe diameter for various engine models and ratings can be determined from the size of the exhaust outlet connection. The actual exhaust piping size may vary depending upon the complexity of the routing and the silencer used in the system. In order to determine what diameter should be used on a particular system, Cummins has developed a computer program that will estimate the exhaust diameter required for a particular system. Your local Cummins distributor can assist you in determining what size exhaust should be used for your particular system.

❖ **The exhaust system components must not impose excessive load or bending moments on the exhaust manifold or turbocharger due to weight, inertia, relative motion of the components or dimensional change due to thermal growth.**

- **The maximum allowable bending moment at the turbine outlet mounting flange must not exceed the maximum specified on the Engine General Data Sheet.**
- **The maximum allowable direct load at the turbine outlet mounting flange must not exceed the maximum specified on the Engine General Data Sheet.**

The exhaust components attached to the engine are designed to support short sections of piping but not major exhaust system components or piping. The table below lists the maximum load and bending moments allowable at the turbocharger outlet mounting flange. Due to the variety and complexity of exhaust systems, calculation of these values should be done for the specific proposed configuration.

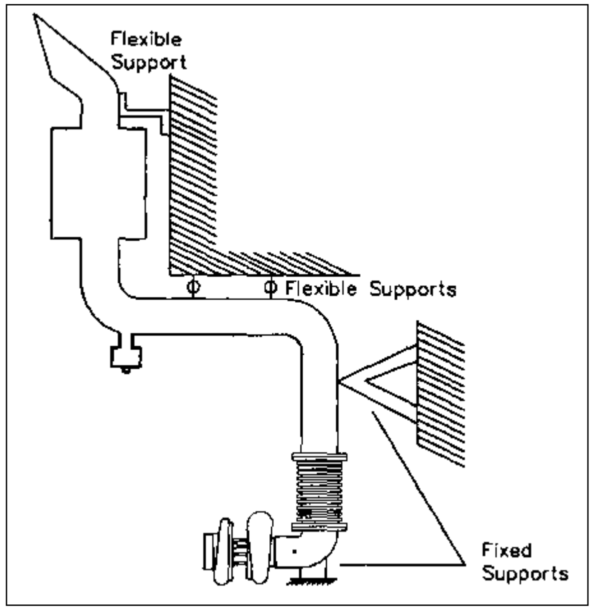
MAXIMUM BENDING MOMENT AND LOAD		
ENGINE GROUP	**MAXIMUM BENDING MOMENT**	**MAXIMUM LOAD (ZERO MOMENT ARM)**
Mid-Range	12 Nm (9 lb.ft.)	6 kg (13 lb.)
Heavy Duty	19 Nm (14 lb.ft.)	9 kg (20 lb.)
High Horsepower	21 Nm (16 lb.ft.)	9 kg (20 lb.)

- **A flexible connection must be installed directly to the engine exhaust outlet connection.**

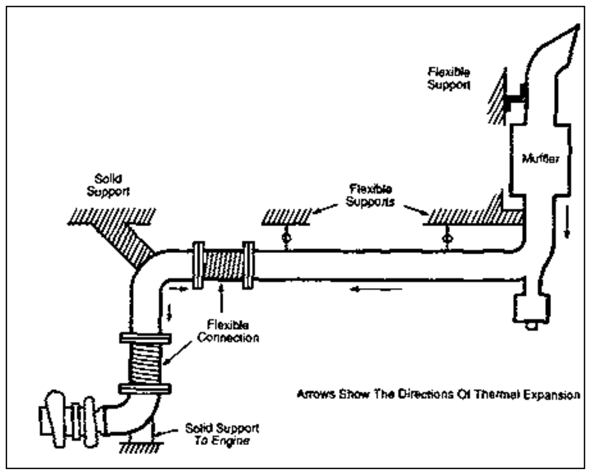
For dry systems a flexible section must be utilized between the engine and shipboard piping, using a Cummins-supplied option or a customer-supplied flexible section. This connection protects the engine exhaust manifold and turbocharger from the stresses due to thermal expansion or relative movement of the engine and exhaust components. It also minimizes the transmission of vibration from the engine to the exhaust pipe.

NOTES:

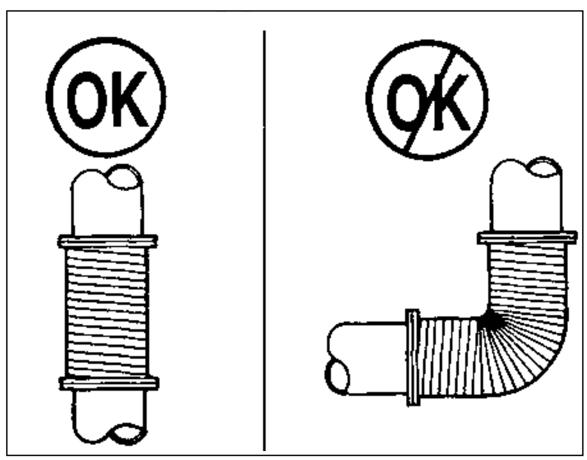
Dry exhaust systems must be designed to accommodate the thermal growth of the piping without over stressing any components in the exhaust system or on the engine. One method to allow for this growth is to use a fixed support at the engine end and let the other end "float." All supports except the fixed support must be flexible to allow for the growth of the exhaust piping. This method is not suitable for systems which have long horizontal and vertical sections of piping in the same system.



If the exhaust system has both long vertical and horizontal sections, separate flexible exhaust sections must be used to absorb the thermal growth in each direction. The horizontal flexible sections should be installed as far away from the vertical piping as possible to avoid collecting soot and condensation in the bellows.

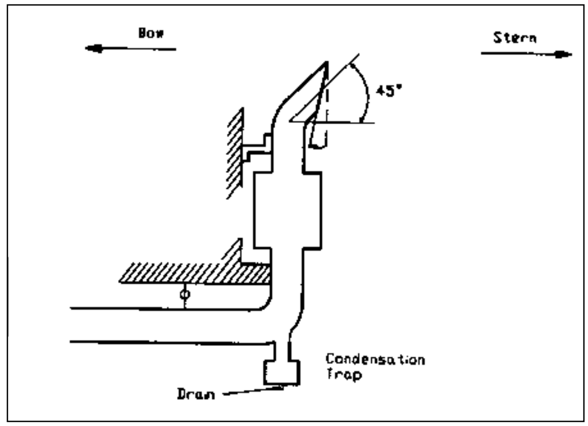


Flexible exhaust sections must be installed in straight runs of piping without bends or offset.



- **The exhaust system must prevent the entrance of water into the engine or turbocharger whether it be from spray, rain, washing, wave action, boat motion or any other source.**

If water enters the turbocharger or engine it will damage the turbocharger and, if it enters the exhaust manifold, may cause a hydraulic lock and engine failure upon start-up.

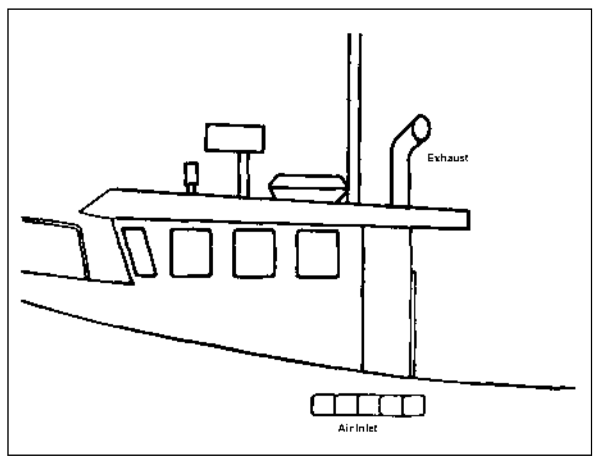


This can usually be prevented in a dry exhaust system by using a 45 degree or greater bend at the top of the piping. The pipe should also have a slight overhang to make the entrance of water more difficult

The exhaust outlet should face the stern of the boat so that any water that comes over the bow will not enter the exhaust system.

Cummins also recommends a condensation trap and drain at the bottom of any vertical section.

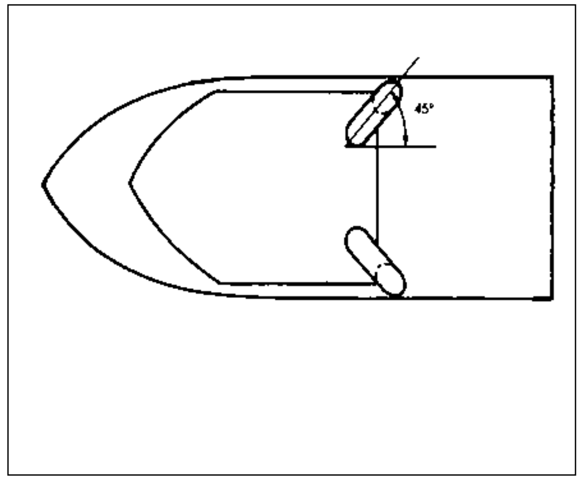
- **The exhaust gas must be dispersed so that it does not detrimentally affect the air cleaner function, the engine ambient environment, the crew or passengers.**



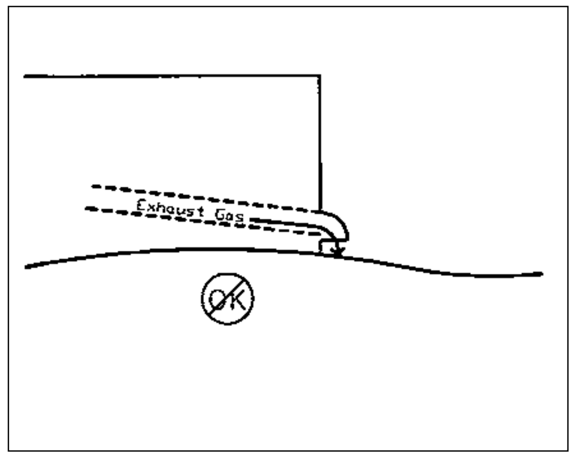
All exhaust outlets should be located aft of and above all air intake locations so as to prevent exhaust gases from re-entering the engine room.

The exhaust outlet should be high enough above the deck or far enough aft so that the exhaust gases are dispersed into the atmosphere without adversely affecting the passengers or crew.

The exhaust outlet should also be angled out to the side of the vessel to allow the exhaust gas to disperse and not be drawn back onto the deck.



The exhaust outlets should not be angled directly into the water as this will result in higher noise levels and the sudden quenching of the exhaust gases may result in a visible film of carbon deposits on the water.

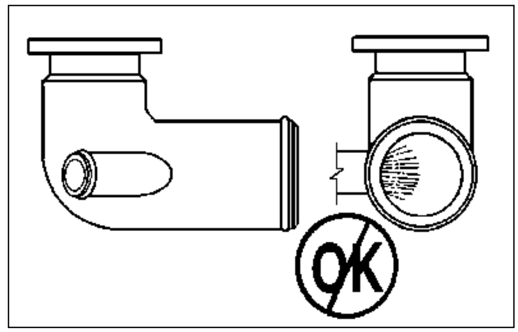


Wet Exhaust Systems

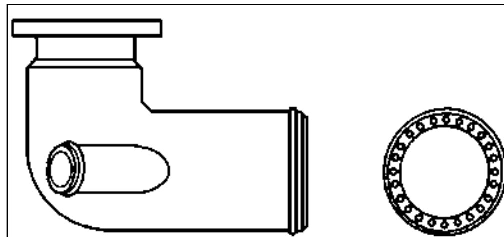
Water Injection

In a wet exhaust system, raw water is sprayed into the exhaust pipe at some point downstream of the turbocharger. Heat is transferred from the exhaust gases to the raw water and the exhaust gas temperature drops low enough to allow the use of hard rubber hose, fiberglass tube or other corrosion resistant materials downstream of the water injection.

Wherever water is injected in the exhaust system, it is important that an even spray pattern is achieved. If the spray pattern is uneven, parts of the exhaust piping may not be sufficiently cooled. This can result in failure of the exhaust piping system due to overheating and a possible safety hazard from high surface temperatures. The surface temperature of the exhaust piping should not exceed 93ºC (200ºF) under any operating conditions.



Cummins recommends using evenly distributed holes with an 8 mm (0.31 in) diameter, with the number of holes being dependent upon the raw water flow. The following equation can be used to determine the number of holes:

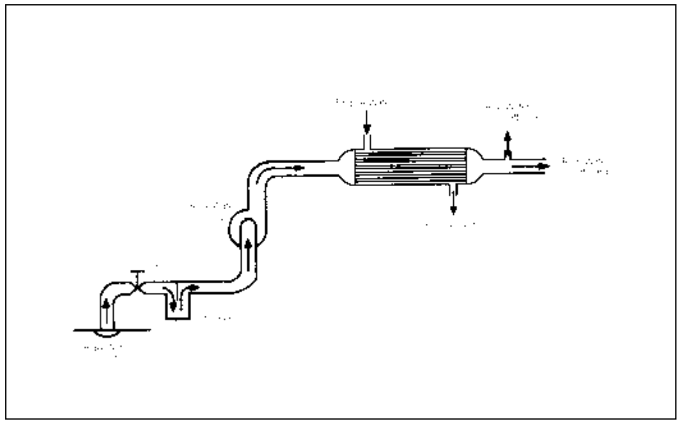


Minimum Number of 0.31 inch (8mm) Diameter Spray Holes

$$= \frac{\text{Liters/Min Sea Water Flow}}{10} = \frac{\text{GPM Sea Water Flow}}{2.6}$$

$$\text{No. Of Holes} = \frac{\text{L/min raw water flow}}{10} = \frac{\text{G/min raw water flow}}{2.6}$$

If raw water is desired for shaft seal cooling, the water should be taken between the heat exchanger and the exhaust riser or elbow, or another approved location per the installation drawing. The amount of water should be limited so that the surface temperature of the exhaust piping does not exceed 93ºC (200ºF) under any operating conditions. The highest exhaust piping temperatures will usually be at lower engine speeds due to the decreased raw water flow.

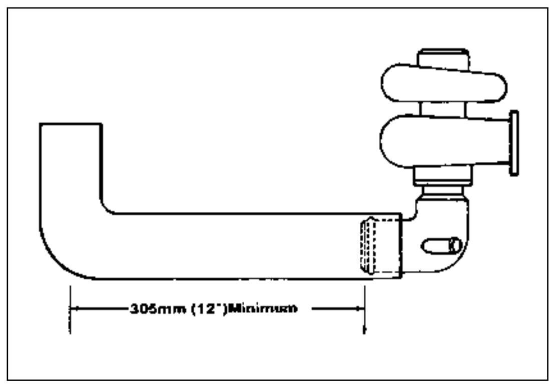


- ❖ **The exhaust back pressure must not exceed 3 in. Hg (10 kPa).**
- ❖ **There must be no bends within 305 mm (12 inches) downstream of the point of water injection.**

Excessive exhaust back pressure can lead to low power, black smoke, poor fuel economy and decreased engine life. It is important to keep the exhaust back pressure to a minimum.

Any bends in the exhaust system should be made as smooth as possible. Sharp bends will increase the back pressure and should be avoided.

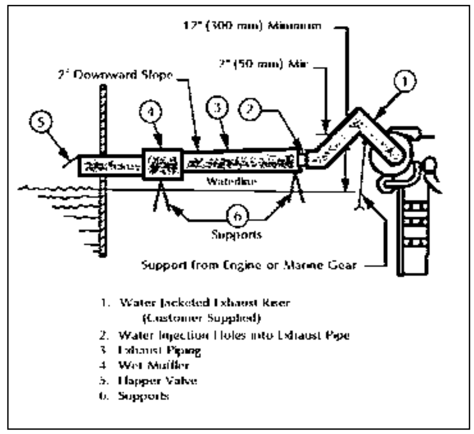
The location of the water injection must be at least 305 mm (12 inches) from any sharp bends in the exhaust system to prevent a water build-up that would result in high back pressure, and to prevent hot spots in the bend.



The diameter of the exhaust piping will have a large effect on the exhaust back pressure in the system. In general, the minimum exhaust pipe diameter for various engine models and ratings can be determined from the size of the exhaust outlet connection. Wet exhaust should be TWICE the diameter of the exhaust outlet connection. The actual exhaust piping size may vary depending upon the complexity of the routing and the silencer used in the system. In order to determine what diameter should be used on a particular system, Cummins has developed a computer program that will estimate the exhaust diameter required for a particular system. Your local Cummins distributor can assist you in determining what size exhaust should be used for your particular system.

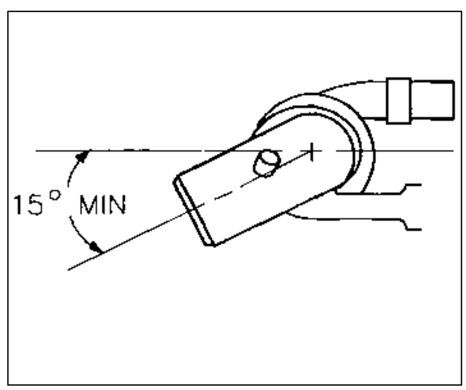
- **The exhaust system must prevent the entrance of water into the engine or turbocharger whether it be from spray, rain, washing, wave action, boat motion or any other source.**
    - **The highest point in the exhaust system must be dry and at least 12 in (305mm)* above the loaded water line (LWL). *For the 1.7, 2.8 and 4.2 liter inboard and sterndrive engines, the required dimension above the LWL is 11 in (279 mm) to the top of the elbow or riser.**
    - **The point of water injection is downstream of and at least 8 in (203mm) from the internal high point of the elbow, or 2 in (50 mm) below the highest dry point.**
    - **The injected water must not be able to flow backward into engine.**
- **Wet exhaust piping must have a continuous downward slope of at least 2 degrees (35 mm per meter or 1/2" per foot).**

Whenever possible, the engine should be installed with the exhaust manifold or turbocharger outlet at least 12" above the loaded waterline. The exhaust pipe must then have a continuous downward slope of at least 2 degrees (35 mm per meter or 1/2" per foot). A surge pipe is recommended to keep water from entering the engine through the exhaust system.



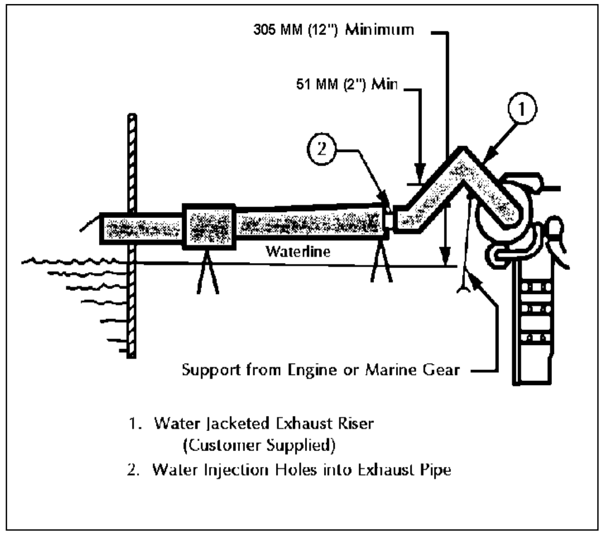
All exhaust outlets should be located above the loaded waterline. A flapper valve may also be installed at the exhaust outlet to help prevent water from entering the exhaust system while slowing down or when the boat is at rest.

If a water injection elbow is used, the elbow should be directed downward at a minimum of 15 degrees to prevent the water being injected from getting back into the turbocharger and should have a 1/8" pipe tap for exhaust restriction measurements.

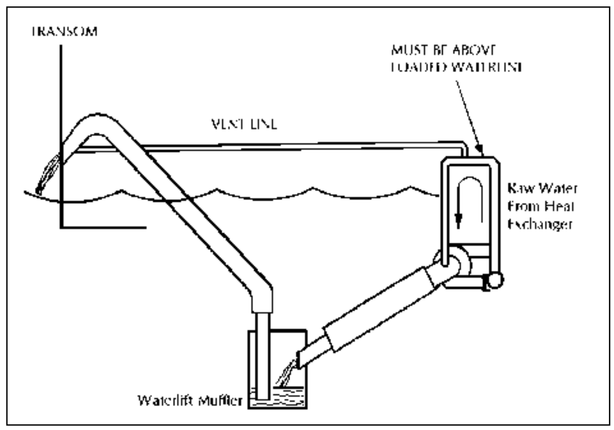


If the engine cannot be installed with the turbocharger or exhaust manifold outlet 305 mm (12 in.) above the loaded waterline, then an exhaust riser or waterlift muffler should be used.

An exhaust riser routes the exhaust above the vessel's normal waterline before injecting raw water into the exhaust pipe.



A waterlift muffler may be used to route the exhaust gas and raw water above the loaded water line and out of the vessel. Waterlift mufflers are very restrictive and often require larger diameter exhaust piping than other systems.



If the turbocharger or exhaust manifold outlet is below the loaded waterline, a siphon break is necessary to prevent the system from filling with water during engine shutdown. The line should be routed from the heat exchanger, above the waterline, then to the exhaust elbow.

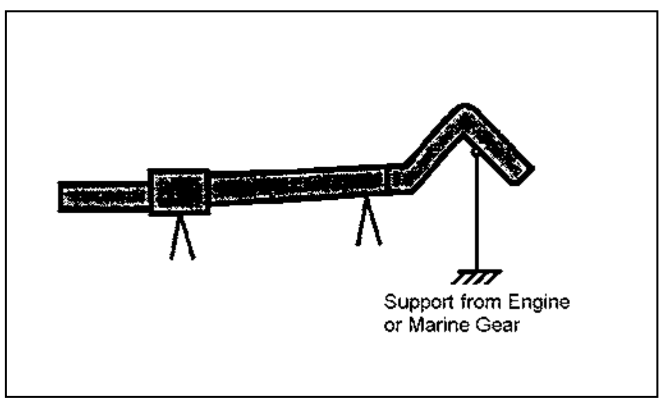
A vent line must also be incorporated since this will be the highest point in the raw water system.

- **The exhaust system components must not impose excessive load or bending moments on the exhaust manifold or turbocharger due to weight, inertia, relative motion of the components or dimensional change due to thermal growth.**
  - **The maximum allowable bending moment at the turbine outlet mounting flange must not exceed the maximum specified on the Engine General Data Sheet.**
  - **The maximum allowable direct load at the turbine outlet mounting flange must not exceed the maximum specified on the Engine General Data Sheet.**

The exhaust components attached to the engine are designed to support short sections of piping but not major exhaust system components or piping. The table below lists the maximum load and bending moments allowable at the turbocharger outlet mounting flange. Due to the variety and complexity of exhaust systems, calculation of these values should be done for the specific proposed configuration.

MAXIMUM BENDING MOMENT AND LOAD		
ENGINE GROUP	**MAXIMUM BENDING MOMENT**	**MAXIMUM LOAD (ZERO MOMENT ARM)**
Mid-Range	12 Nm (9 lb.ft.)	6 kg (13 lb.)
Heavy Duty	19 Nm (14 lb.ft.)	9 kg (20 lb.)
High Horsepower	21 Nm (16 lb.ft.)	9 kg (20 lb.)

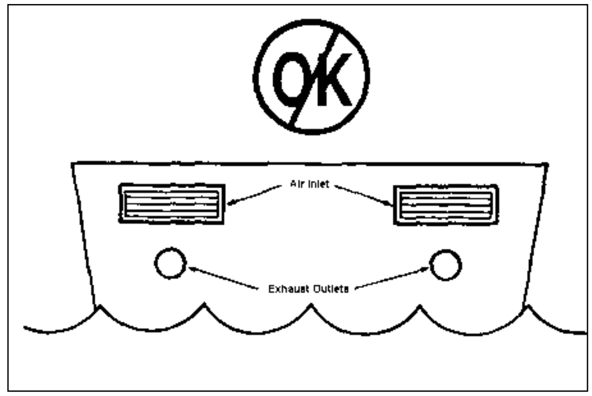
All water cooled exhaust risers should be supported due to the added weight of the water in the riser.



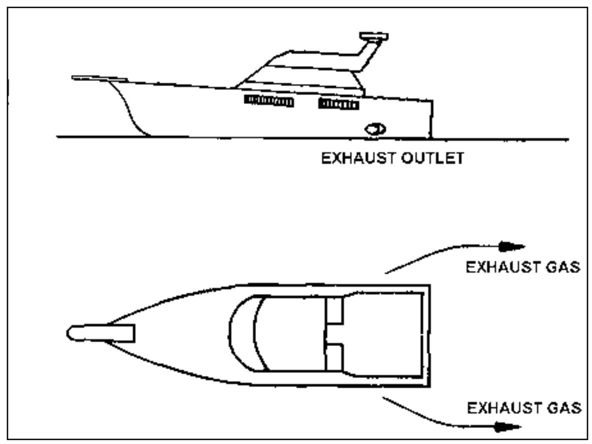
To provide flexibility in a wet exhaust system, a hose is usually installed immediately downstream of the water injection point. It is recommended that the gap, between the end of the piping at the water injection point and the downstream exhaust piping, be at least equal to the diameter of the exhaust piping.

- **The exhaust gas must be dispersed so that it does not detrimentally affect the air cleaner function, the engine ambient environment or the crew or passengers.**

All exhaust outlets should be a sufficient distance from all intake and exhaust ventilation areas so as to prevent exhaust gases from re-entering the engine room.



Whenever possible, it is recommended that the exhaust outlets be situated on the side of the vessel. As the air flows around the vessel, a slight vacuum will be created at the stern. If the exhaust outlets are located on the transom, the exhaust gas may be drawn back onto the deck of the boat. Locating the outlets on the side will help prevent this from occurring.



- **A service port must be provided in the exhaust system. The service port must be internally threaded with standard pipe threads not larger than 12.7 mm (0.5 in). The port must be located between the engine exhaust outlet connection and the point where it mixes with sea water (for sea water cooled exhaust systems) or exits to ambient air (for dry exhaust systems).**

All engines subject to EPA Tier 1/Tier 2 emission standards must be equipped with a connection in the engine exhaust system that is located downstream of the engine and before any water injection point. This is for the temporary attachment of emissions sampling equipment. This connection must be internally threaded with standard pipe threads of a size not larger than one-half inch to meet EPA requirements.

COOLING SYSTEM

Marine Installation Requirements

- **Marine engine coolants must contain at least a minimum of 25% antifreeze concentration.**
- **Marine engine coolants using less than 40% antifreeze concentration must maintain higher minimum SCA levels as prescribed in Service Bulletin No. 3666132, Section 8, except engines with parent bore blocks (non-linered engines) do not require SCA.**
- **The expansion tank volume must provide for a minimum excess coolant volume that is equal to 20% of the engine coolant capacity listed on the Engine General Data Sheet AND 5% of the total coolant system volume.**
- **Remote mounted expansion tanks must be mounted above the highest point in the cooling system.**
- **The engine must have a closed cooling system that will maintain the system pressure between 103 kPa and 138 kPa (15 psi and 20 psi).**
- **The overflow line from the pressure cap must be routed to safely drain excess coolant.**
- **The system must vent during initial fill to allow filling of the total cooling system volume to 95% of its full capacity.**
- **The cooling system must be designed and installed so that the maximum jacket water temperature does not exceed 96ºC (205ºF) under any operating conditions.**
- **The pressure at the water pump inlet must be greater than atmospheric when the engine is run at rated speed with a coolant temperature of 82ºC to 88ºC (180ºF to 190ºF), and the system fill cap removed.**
- **The pressure drop from the coolant outlet to the coolant inlet must not exceed 34.5 kPa (5 psi).**
- **Keel coolers must be submerged in seawater under all operating conditions.**
- **Separate cooling circuits must be used for each engine.**
- **Flexible lines must be installed between the engine and shipboard piping to allow for relative motion.**
- **The cooling system must remove entrained air at engine start-up, and must continuously remove air that enters the cooling system during normal operation.**
- **The cooling system vent lines must be routed to the top air gap section of the expansion tank.**

- ❖ **Cooling system vent lines must be routed continuously upward, and must not be teed together.**
- ❖ **The makeup line must be at least 6 times the cross-sectional area of all vent lines.**
- ❖ **Engines with a separate LTA cooler must not have a gear oil cooler installed in the main engine cooling circuit.**

Heat Exchanger Cooled

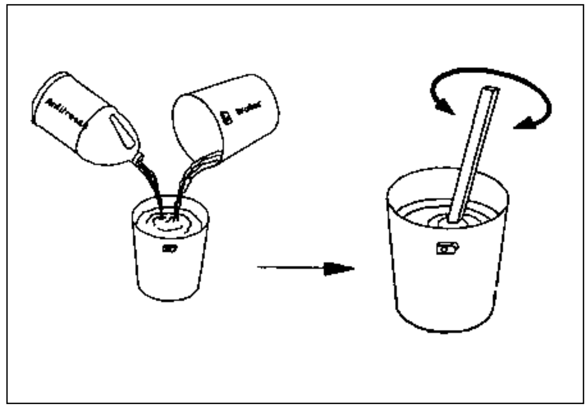
- ❖ **The location of the sea water pickup must be below the water line at all operating conditions.**
- ❖ **When measured by Cummins' recommended method, the sea water inlet restriction and discharge pressure must not exceed the value listed on the Engine General Data Sheet.**
- ❖ **A sea water strainer/scoop with a maximum hole diameter of 1.6 mm (1/16 in.) must be used.**
- ❖ **A seacock valve must be installed before the sea water pump and strainer.**
- ❖ **All cooling system accessories must be located below the top coolant level of the expansion tank, and must have a minimum pressure rating of 414 kPa (60 psi).**

NOTES:

Marine Installation Recommendations

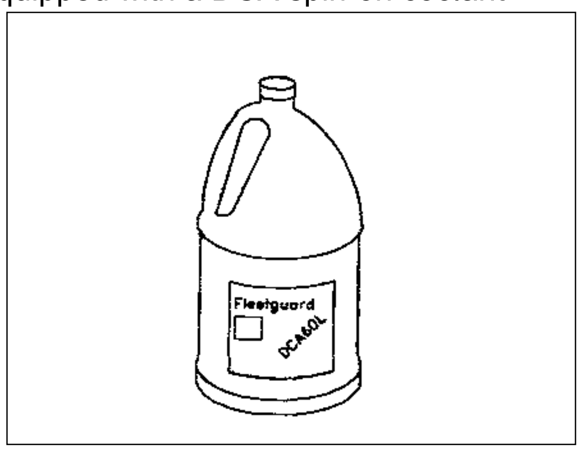
- **Marine engine coolants must contain at least a minimum of 25% antifreeze concentration.**
- **Marine engine coolants using less than 40% antifreeze concentration must maintain higher minimum SCA levels as prescribed in Service Bulletin No. 3666132, Section 8, except engines with parent bore blocks (non-linered engines) do not require SCA.**

Cummins marine engines are designed to use a coolant that is 50% water and 50% ethylene or propylene glycol antifreeze. This mixture raises the boiling point of the coolant and prevents vapor pockets from forming in the engine as well as lowering the freezing temperature. The antifreeze will also provide additional protection from cavitation and liner erosion.



The antifreeze concentration may be increased to 60% ethylene/propylene glycol for operation below -37ºC (-34ºF).

All Cummins marine engines covered in this manual are designed to use Fleetguard's "DCA" system of chemical protection and are equipped with a DCA spin-on coolant treatment filter. DCA is a formulation of supplemental coolant additives specifically designed for Cummins engines and inhibits rust formation, helps prevent cavitation and neutralizes acids in the cooling system.



The precharge DCA elements that come on many engines are designed for a standard Cummins heat exchanger cooling system. Since keel cooling systems have a much larger coolant volume, an additional DCA charge must be added at initial fill. Spin-on cartridges are available with 2 to 23 units of DCA. Larger coolant volumes are treated with DCA liquid or powder.

The recommended DCA precharge levels are as follows:

ANTIFREEZE CONCENTRATION	DCA LEVEL REQUIRED
40-60% ethylene/propylene glycol	3 units per gallon of cooling system volume
25-40% ethylene/propylene glycol	5 units per gallon of cooling system volume

To help reduce costs of fill and maintenance of high volume cooling systems, Service Bulletin No. 3666132, Section 8, contains provisions for using reduced levels of antifreeze in marine engines. When maximum freeze protection is not required, adequate cooling system protection may be achieved with reduced antifreeze concentration and higher minimum levels of DCA as described above.

For instructions on checking and maintaining the cooling system refer to your Cummins Marine Operation and Maintenance manual.

- **The expansion tank volume must provide for a minimum excess coolant volume that is equal to 20% of the engine coolant capacity listed on the Engine General Data Sheet AND 5% of the total coolant system volume.**

The engine coolant will expand approximately 5% between its high and low temperatures. The expansion tank must have enough capacity to accommodate this plus additional capacity for any evaporation or minor leaks.

The following formula is used to calculate the minimum required deaeration expansion tank size:

$$V = T/18 + E/4.5$$

Where: V = Minimum Expansion Tank Volume

T = Total System Coolant Volume (including engine)

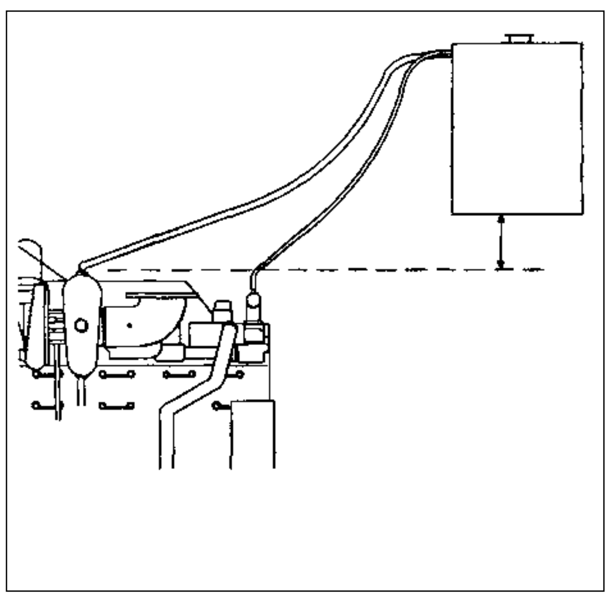
E = Engine Coolant Volume

For heat exchanger cooled engines, the expansion tank system has been properly sized for a Cummins supplied heat exchanger. If a customer is using a different heat exchanger or wishes to build their own expansion tank, the equation shown above should be used.

- **Remote mounted expansion tanks must be mounted above the highest point in the cooling system.**

Since air will always travel to the highest point in the cooling system, it is necessary for the bottom of a remote mounted expansion tank to be above any other point in the cooling system.

The bottom of the tank must be above all vent locations on the engine at any vessel trim and operating angle and all vent lines must have a continuous upward run to prevent air traps from forming.



- ❖ **The engine must have a closed cooling system that will maintain the system pressure between 103 kPa and 138 kPa (15 psi and 20 psi).**

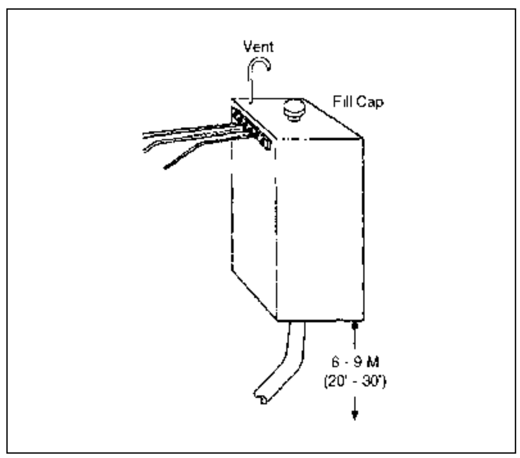
Dirt or debris must not be allowed to enter the engine cooling system. All cooling systems on Cummins engines should have a 103 kPa (15 psi) pressure cap unless the expansion tank is more than 1.5 meters (5 feet) above the engine. This will maintain the proper pressure in the cooling system which will in turn raise the boiling point of the coolant and help prevent overheating and cavitation. The recommended combinations of pressure caps and expansion tank height are as follows:

Expansion Tank Height Above Engine Meters (Feet)	Minimum Pressure Cap kPa (PSI)
0 to 1.5 (0 to 5)	103 (15)
1.5 to 4 (5 to 13)	48 (7)
3 to 7 (10 to 23)	28 (4)
6 to 9 (20 to 30)	Fill Cap & Vent

Expansion tanks more than 9 meters (30 feet) above the engine crankshaft are not recommended.

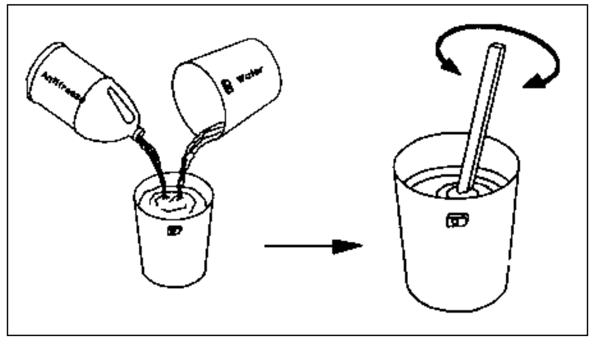
Cummins also recommends that the expansion tank be located no more than 6 meters (18 feet) horizontally from the front of the engine.

Expansion tanks that do not require a pressure cap must have a fill cap and a vent tube from the top of the tank to allow air and gases to escape from the cooling system. The vent must have a gooseneck to prevent dust and debris from contaminating the cooling system.



- **The system must vent during initial fill to allow filling of the total cooling system volume to 95% of its full capacity.**

The engine should be filled slowly (less than 5 gpm) to allow the coolant to fill from the bottom of the cooling system up. Whenever possible, the antifreeze and water should be mixed before being added to the system. If this is not possible, they should be added in equal increments.



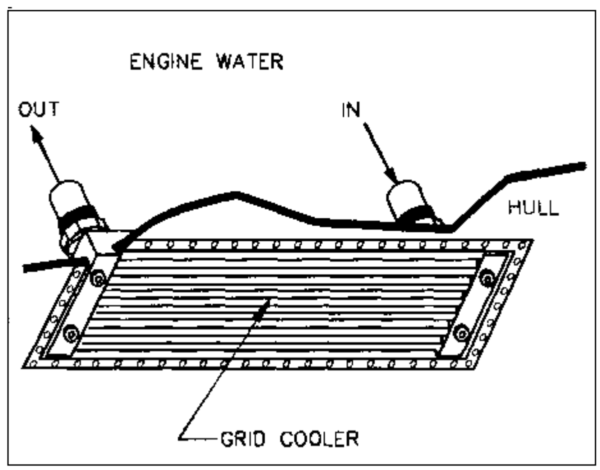
The system should never be half filled with antifreeze and then topped off with water. Pure antifreeze may restrict the venting of the system due to the higher viscosity and prevent proper filling of the system.

All petcocks should be open during filling, especially those on the keel cooler, to allow the air to escape, and then closed when the cooling system is full.

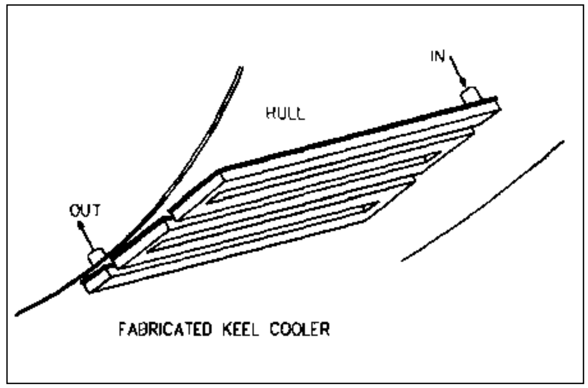
Keel Coolers

Keel cooling is a cooling system that uses a group of tubes, pipes, or channels in direct contact with the surrounding water to transfer heat from the coolant to the water. Keel cooling is widely used in river push boats and fishing boats, especially in areas of heavy silt, ice or other debris which may clog raw water inlets or erode heat exchanger tubes.

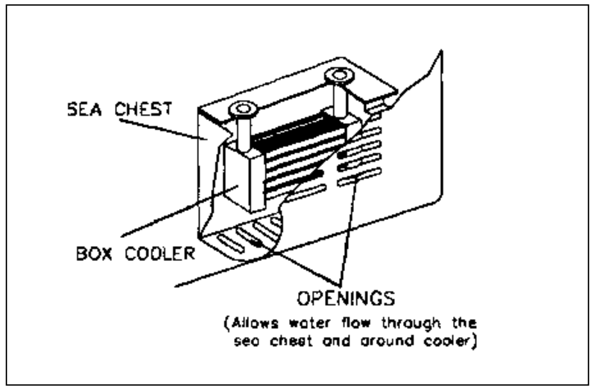
Keel coolers may be manufactured units or fabricated. The manufactured type of keel cooler, or grid cooler, is generally much more compact and efficient than a fabricated unit. They are made of a "grid" of tubes that is attached to the bottom of the hull with an inlet and outlet connection for the engine water. The manufacturer of the unit should be consulted for proper sizing and installation.



Fabricated keel coolers will generally be a series of pipes or channels that are welded to the bottom of the hull. These tend to be less efficient, and therefore larger than a manufactured unit. Your local Cummins distributor can help with sizing and proper installation of these units.



The other type of keel cooler that is used is a box cooler. This type uses a box or sea chest that sits inside the hull with openings to allow raw water to flow through it. The tube bundle sits inside the box and carries the engine water. These units are useful since they can be checked or serviced without pulling the boat out of the water and the cooler is protected from any impact with foreign objects. The manufacturer of the box cooler should be consulted for proper sizing and installation of the unit.



Keel Cooler Location

The keel cooler should be installed far enough below the waterline to avoid the aerated water close to the surface. Good keel cooler performance requires a constant water flow over the cooler. Locations that are in the water flow and flush on the hull are preferred over side locations and recessed installations. Recessed and shielded installations must allow for unobstructed raw water flow over the keel cooler tubes.

Slow moving boats should have the keel coolers installed close to the propeller to benefit from movement of water through the propeller. Dredges and other vessels that will be operated with little movement through the water should have the keel coolers installed on an incline or vertically to promote water circulation by convection.

Keel coolers should not be located in areas that are exposed to pounding seas, hull flexing or excessive vibration. The bow of a ship is subjected to tremendous water forces and is generally a poor location for a keel cooler. The area of the ship’s bottom adjacent to the keel is the strongest section and is the best keel cooler location.

- **The cooling system must be designed and installed so that the maximum jacket water temperature does not exceed 96ºC (205ºF) under any operating conditions.**

Operating the engine with high engine coolant temperatures will result in shorter engine life and possible engine or component failure. The keel cooler must be sized properly to assure sufficient cooling under all operating conditions.

If a manufactured keel cooler or box cooler is used, the system should be sized by the cooler manufacturer. All of the engine information required by the manufacturer can be found on the particular engine data sheet.

Commercially made keel coolers are designed for the marine environment and should not be painted as this will adversely affect their performance.

In order to assist boat builders who wish to fabricate their own keel coolers, Cummins has developed a computer program to calculate keel cooler size. Your local distributor can assist you with this calculation.

Fabricated keel coolers should be painted with bottom paint to protect the metal from corrosion.

- **The pressure at the water pump inlet must be greater than atmospheric when the engine is run at rated speed with a coolant temperature of 82ºC to 88ºC (180ºF to 190ºF), and the system fill cap removed.**

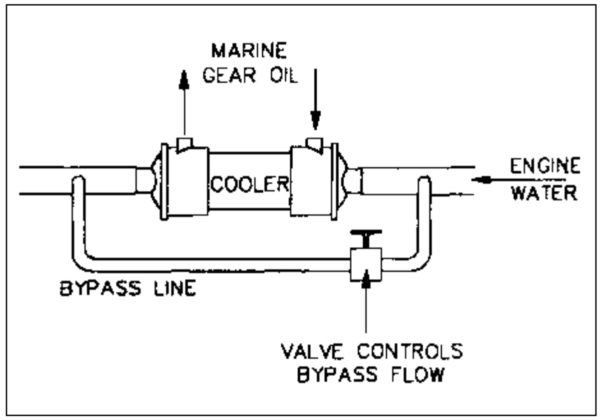
If the pressure on the suction side of the water pump is negative, the pump will cavitate and, in some cases, lose its prime. This will result in a loss of coolant flow and overheating of the engine. Any external cooling system components must be sized such that there is always a positive pressure at the water pump. Your Cummins distributor can help you in proper selection and sizing of cooling system components.

- **The pressure drop from the coolant outlet to the coolant inlet must not exceed 34.5 kPa (5 psi).**

Pressure drops greater than 34.5 kPa (5 psi) will result in insufficient coolant flow through the engine and engine overheating. Any external cooling system components must be sized so that the external pressure drop is kept to a minimum. If a fabricated keel cooler is used, your Cummins distributor can help with proper sizing of the system.

On some systems it may be necessary to bypass some of the water around an external cooler (gear oil, fuel, etc.) at high speeds in order to keep the restriction within the 34.5 kPa (5 psi) limit.

This may be done by using a bypass line with a valve. The valve is opened gradually until the pressure drop across the system is less than 5 psi. The control knob on the valve is then removed to prevent the valve position from being changed.



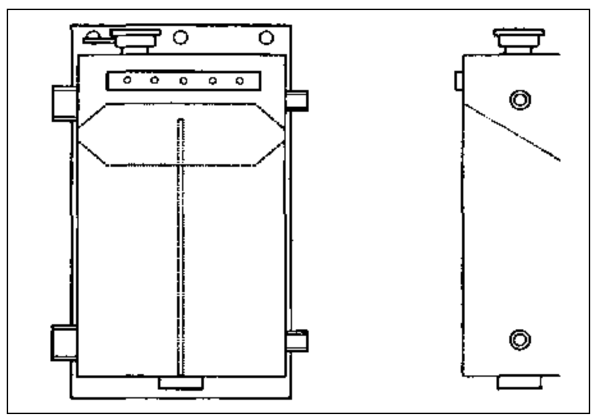
Care should be taken to ensure that the gear oil temperatures are maintained within the manufacturer's limits when adjusting bypass flow.

- **The cooling system must remove entrained air at engine start-up, and must continuously remove air that enters the cooling system during normal operation.**

If air becomes trapped in the engine cooling system it can lead to isolated hot spots in the engine and water pump cavitation. This will decrease engine life and may cause engine or component failures. A deaeration system consists of a properly designed expansion tank, vents and a make-up line.

Expansion Tank

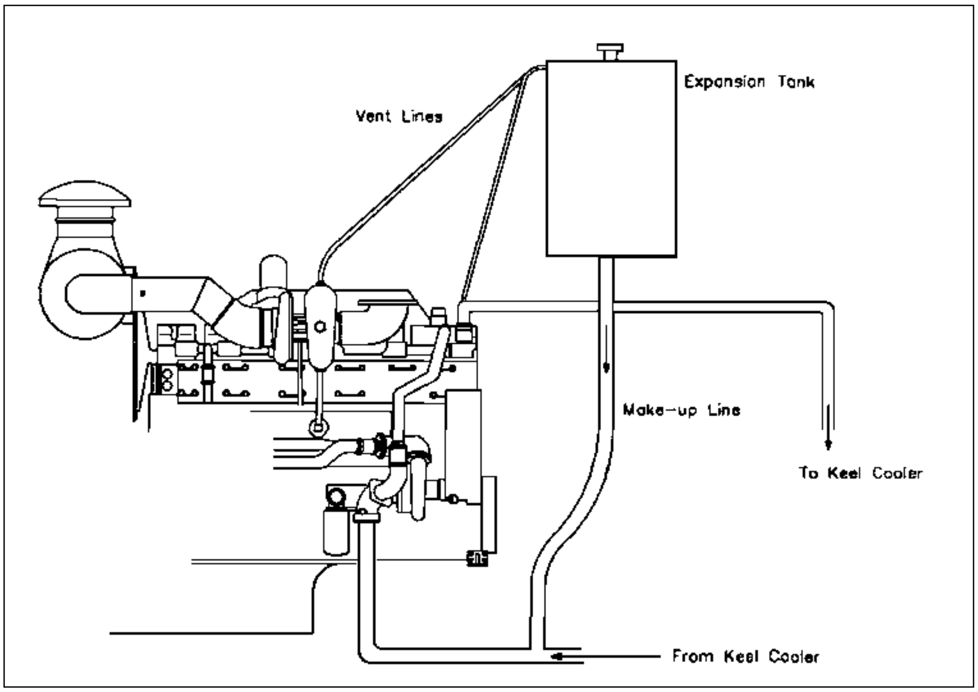
A properly designed expansion tank is necessary to remove air from the cooling system during initial fill and during operation. If a customer wishes to build their own expansion tank, they should consult their local Cummins distributor for assistance.



Engine Vents

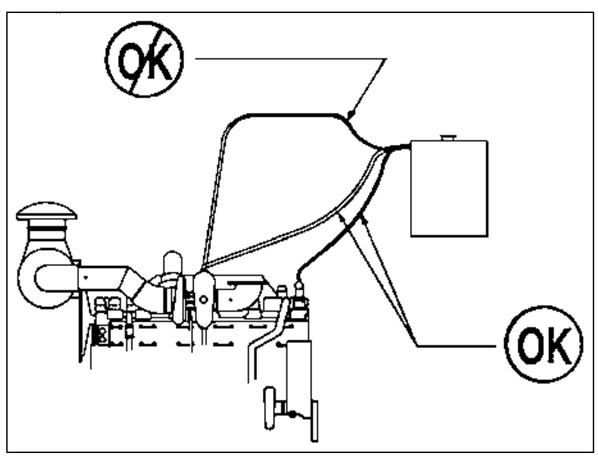
The engine vent system provides a continuous flow of water through the expansion tank as a method of removing air and gases from the engine coolant. The highest points in the engine coolant circuit are the best vent locations. All Cummins engines have venting provisions at the thermostat housing and water outlet connection. Other vent locations on a particular engine are shown on some engine installation drawings. These may include the turbocharger (water cooled), exhaust manifold, aftercooler and any other locations requiring vents.

Additional vents are also required to allow air to escape from the top of the keel cooler during initial engine coolant fill.



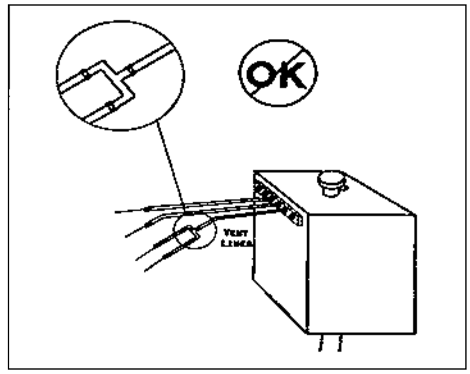
- ❖ **Cooling system vent lines must be routed continuously upward, and must not be teed together.**

All vent lines must be installed with a continuous upward run from the engine or keel cooler to the expansion tank at all vessel operating angles.



Since vent lines run from points of different pressures, teeing the vent lines together may result in reduced vent water flow and inadequate venting of the system.

Each vent line must be connected to the expansion tank without using tees or other fittings that would join the vent line together in a common vent. Joining the vents into a common line will reduce the total vent water flow and may result in aerated water flowing back into the engine.



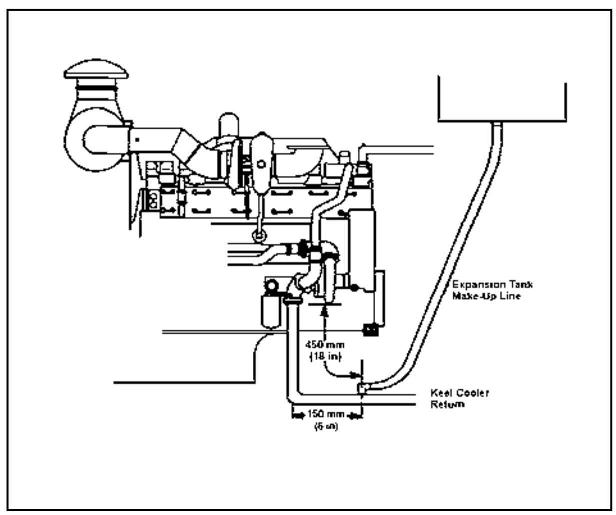
NOTE: On K38 and K50 engines shipped from Cummins Engine Co., some of the vent lines will be teed together. The size and arrangement of these lines has been designed around the coolant pressures at the venting locations to avoid this problem. As a result, these lines are NOT interchangeable on the engine.

Make-up Lines

The deaerated water return, or make-up line, connection is located in the bottom of the expansion tank. The purpose of the make-up line is to provide a means for filling the engine and to feed the water from the vent lines back to the engine after it has been deaerated during operation.

The make-up line should be plumbed from the bottom of the expansion tank to the engine water inlet line. The make-up line should not be plumbed to the water pump housing or body.

When the make-up water enters the engine water inlet line, the turbulence created in the flow may cavitate the water pump. Therefore, the line should be plumbed at least 450 mm (18 inches) from the engine water pump inlet connection and at least 150 mm (6 inches) from any bends or elbows in the piping. This will reduce the chances of pump cavitation.

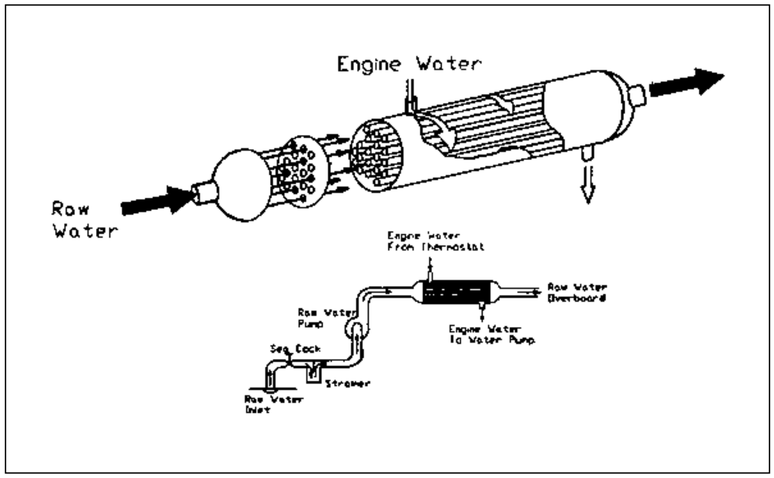


- ❖ **The makeup line must be at least 6 times the cross-sectional area of all vent lines.**

The size of the make-up line is also important. The line must be large enough to allow proper coolant fill and to provide adequate return flow from the expansion tank without allowing air back into the system. The size of the make-up will depend on the number and size of the vent lines. In general, the cross-sectional area of the make-up line must be 6 times the sum of the vent line areas.

Heat Exchanger Cooling

A heat exchanger cooling system circulates engine coolant through a heat exchanger to remove heat from the engine. The engine coolant flows around the outside of the tubes in the heat exchanger and sea water flows through the tubes. The engine coolant leaves the heat exchanger and is recirculated through the engine by the engine water pump. The sea water flows in through the sea water pump, through the heat exchanger and then is injected into the exhaust piping or is discharged overboard.



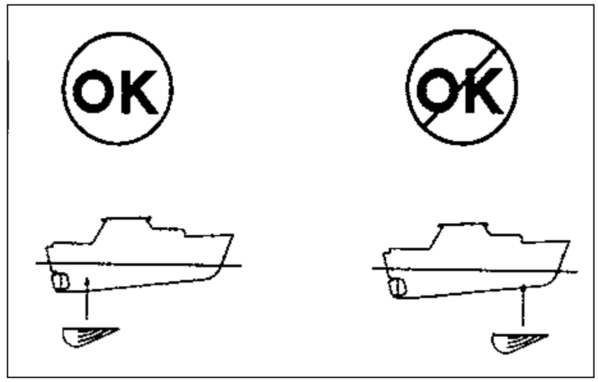
A heat exchanger cooled engine may have either a sea water gear oil cooler or a fresh water gear oil cooler. Additionally, a fuel cooler and aftercooler may be found in the sea water system.

- **The cooling system must be designed and installed so that the maximum jacket water temperature does not exceed 96ºC (205ºF) under any operating conditions.**

Operating the engine with high engine coolant temperatures will result in shorter engine life and possible engine or component failure. The heat exchangers that are optionally available from Cummins Engine Company have an excess heat rejection capacity to allow for intermittent operation at high ambient temperatures and are recommended. Engine power levels must be reduced if high ambient temperatures raise the engine coolant temperature above 96ºC (205ºF).

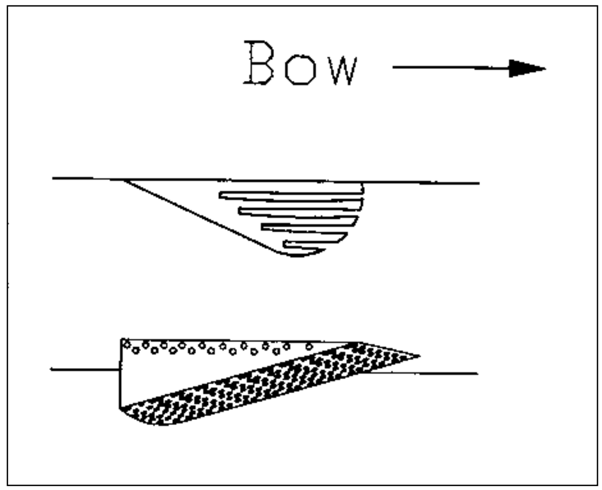
- **The location of the sea water pickup must be below the water line at all operating conditions.**

The sea water inlet must be in a location that provides a solid water flow to the sea water pump at all times and in all operating conditions. If air is ingested in the sea water system it can cause failure of the sea water pump and result in overheating the engine.



If a scoop is used on the bottom of the hull at the sea water inlet it should be positioned as shown.

The hull, forward of the sea water scoop, should be free of obstruction for undisturbed flow.



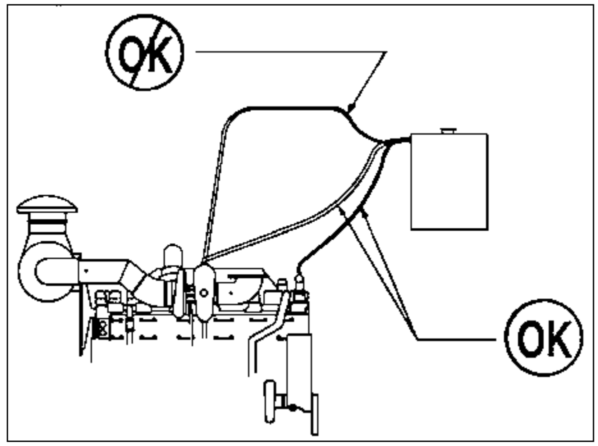
- **The cooling system must remove entrained air at engine start-up, and must continuously remove air that enters the cooling system during normal operation.**

If air becomes trapped in the engine cooling system it can lead to isolated hot spots in the engine and water pump cavitation. This will decrease engine life and may cause engine or component failures. A deaeration system consists of a properly designed expansion tank, vents and a make-up line.

Cummins supplied expansion tanks and plumbing are designed for proper deaeration of the system and are recommended. If another system is desired, refer to the keel cooling section for proper design of the deaeration system or consult your local Cummins distributor.

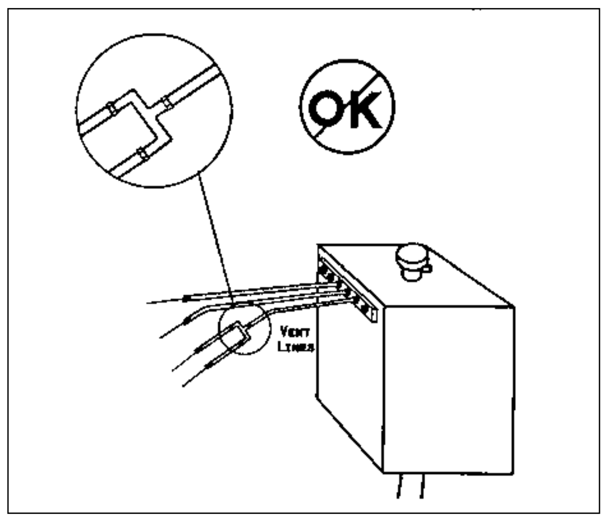
- **Cooling system vent lines must be routed continuously upward, and must not be teed together.**

All vent lines must be installed with a continuous upward run from the engine at all vessel operating angles.



Since vent lines run from points of different pressures, teeing the vent lines together may result in reduced vent water flow and inadequate venting of the system.

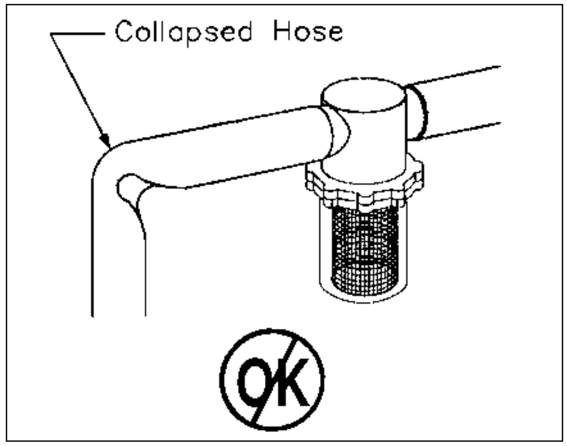
Each vent line must be connected to the expansion tank without using tees or other fittings that would join the vent line together in a common vent. Joining the vents into a common line will reduce the total vent water flow and may result in aerated water flowing back into the engine.



- **When measured by Cummins' recommended method, the sea water inlet restriction and discharge pressure must not exceed the value listed on the Engine General Data Sheet.**

If the sea water inlet restriction is too great, the sea water pump will not be able to supply enough water to the heat exchanger to satisfactorily cool the engine water. Excess restriction can also lead to sea water pump cavitation with reduced impeller life and, if rubber hose is used, collapse of the sea water piping.

The piping from the sea water inlet on the bottom of the hull to the sea water pump should be short and as free of sharp bends as possible. Any sharp bends will cause an increase in the inlet restriction.



Cummins has developed a computer program that will estimate the sea water piping diameter required for a particular system. Your local Cummins distributor can assist you in determining what size piping should be used for your particular system.

The thru hull fittings and sea cock connections should be at least as large as the sea water piping and any scoop used on the bottom of the hull should be sized for the sea water flow of the engine.

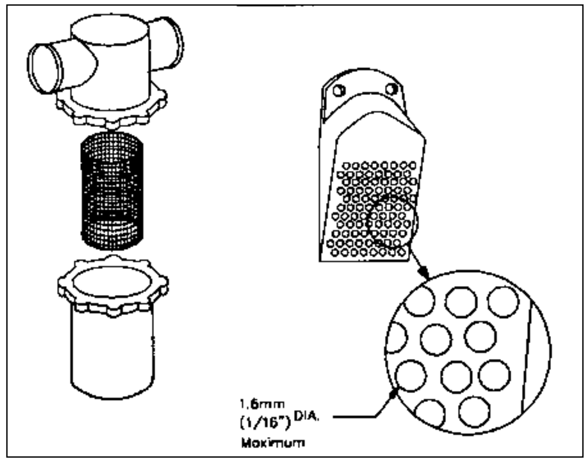
Each engine should have its own sea water inlet. This will prevent overheating all engines in the vessel if a sea water inlet should become plugged.

All hose bead connections should have double hose clamps.

- **A sea water strainer and/or scoop with a maximum hole diameter of 1.6 mm (1/16 in.) must be used.**

Debris in the sea water system can lead to sea water pump damage or clogging of the heat exchanger. This will in turn result in overheating and possible failure of the engine.

Cummins recommends the use of a wire mesh strainer in the sea water system prior to the sea water pump in addition to a scoop on the bottom of the hull. These strainers are generally much more effective than the scoop type strainers and can be checked for clogging and serviced more easily.



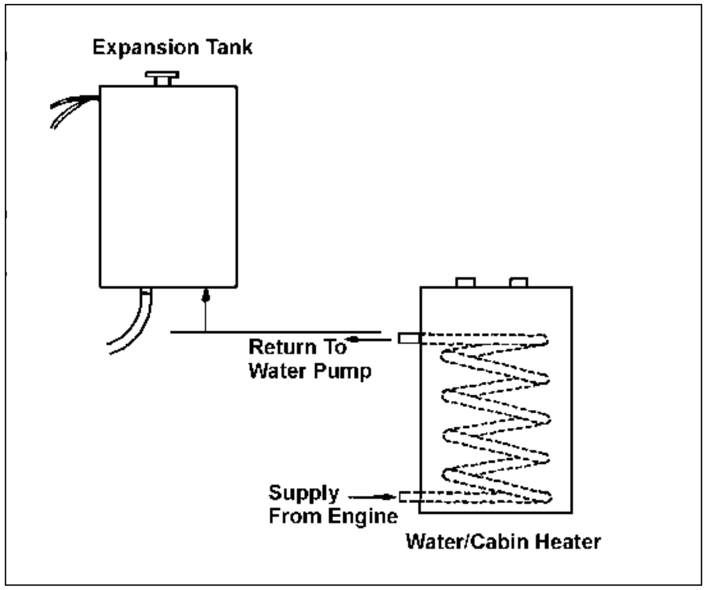
If a scoop is used on the bottom of the hull, it must be able to handle the volume of sea water flow listed on the engine data sheet.

Water/Cabin Heaters

Whenever a water heater or cabin heater is added to the cooling system, the cooling system becomes dependent upon the integrity of the heater. Since a failure, leak or improper installation of a heater can result in progressive or catastrophic engine failure, Cummins is not responsible for any engine damage caused by the operation or installation of these components.

To prevent overcooling of the engine water and to assure sufficient water flow in the engine, the water circulated to the water heater should be less than 5% of the engine water flow. This can be done with the proper sizing of the lines to the water heater or the use of a restrictor fitting.

The water heater should be located below the expansion tank with a vent line running continuously upward to the expansion tank to allow the system to vent completely with the engine off.



- ❖ **All cooling system accessories must be located below the top coolant level of the expansion tank, and must have a minimum pressure rating of 414 kPa (60 psi).**

The water/cabin heater should have a minimum pressure rating of 414 kPa (60 psi). If the heater core has a lower pressure limit, it may result in a failure of the core, loss of coolant and engine failure.

Plumbing

When a water/cabin heater is used, the hot water supply and return should be to the ports indicated on the engine installation drawing.

AIR INTAKE SYSTEMS & ENGINE ROOM VENTILATION

Marine Installation Requirements

- When tested by Cummins' recommended method, the air inlet system restriction must not exceed the value shown on the Engine General Data Sheet.
- All engines must have an effective air cleaner to remove airborne dirt particles from the intake air. The air cleaner must have the minimum dirt holding capacity listed in the installation directions for the particular application.
- The air inlet location, air piping and engine room ventilation must be designed so that the air inlet temperature measured at the inlet connection to the manifold or turbocharger is not more than 17ºC (30ºF) above the outside ambient temperature at rated speed and load. Maximum engine room temperature must not exceed 150ºF under any operating conditions.
- All ducts, components, and connections are capable of operating in a maximum temperature of 92ºC (200ºF).
- The air inlet must be located or shielded to prevent direct ingestion of water, snow, ice, exhaust gases, blowby gases, and other combustible vapors.
- All remote mounted air cleaner plumbing must be routed away from high heat sources.
- Remote mounted air cleaner plumbing must allow for thermal expansion and relative motion between the engine and shipyard piping.
- Remote mounted air cleaner plumbing joints must be capable of functioning in an ambient temperature of 92º C (200º F), must be free from leaks, and must withstand a negative pressure (vacuum) of -8 kPa (-32 in. H2O) without collapsing.
- Hoses connected to the compressor inlet must be rated for a continuous temperature of 205ºC (400ºF).
- All piping must be free from chafing points.
- Oil bath type air cleaners are not approved for use on Cummins Marine engines.
- The air cleaner media must be reinforced to prevent media from being ingested by the engine.
- Forced ventilation systems must operate continuously any time the engines are running.
- The integrity of the piping between the air cleaner and the engine must not be broken during routine operation or maintenance functions.

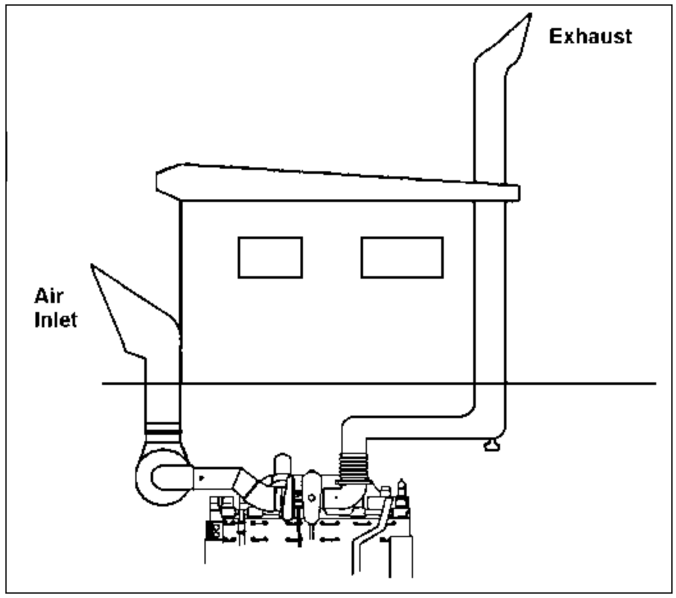
Marine Installation Recommendations

❖ **When tested by Cummins' recommended method, the air inlet system restriction must not exceed the value shown on the Engine General Data Sheet.**

High air inlet restriction will lead to decreased air flow through the engine for combustion. This in turn will lead to a decrease in power, performance and engine life as well as an increase in smoke.

The air cleaner should be mounted in an area that is free of dirt, dust, fish scales or other debris that may plug the filter during regular operation, net handling or deck operations.

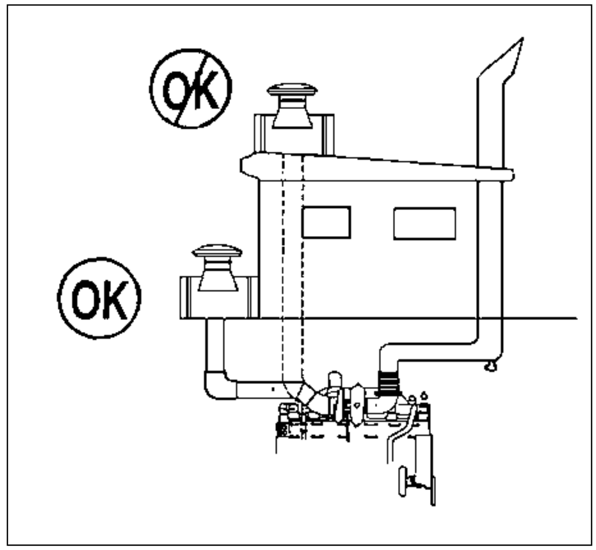
If the exhaust and air intake are both above the vessel, the exhaust should be located higher and aft of the intake. If the exhaust gas is drawn back into the intake, the air cleaner can quickly become clogged.



NOTES:

Remote mounted air cleaners should not have inlets located where water can enter the element, either during operation or wash down.

Avoid large flat areas where the intake can pull water into the engine during rain, rough weather or wash down operations.

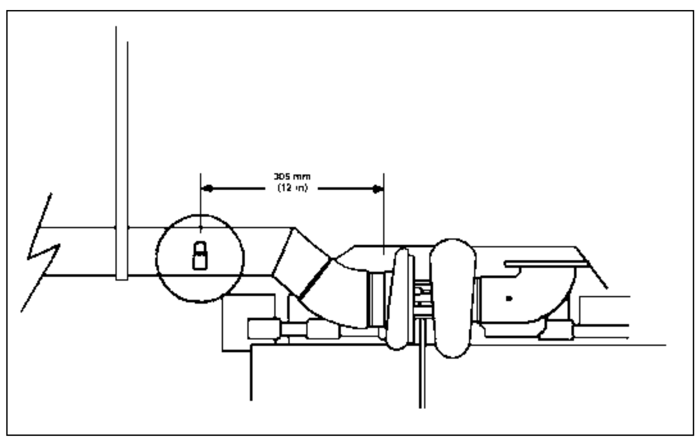


A water or condensation trap should be located prior to the air cleaner on remote mounted systems. The air cleaner should be easily serviced without removing other parts of the air system and should be checked at air cleaner service intervals or if the air inlet restriction increases unexpectedly.

Remote Mounted Air Cleaner Piping

The air inlet piping must be sized to provide inlet air to the engine without exceeding the air inlet restriction limit. Your Cummins distributor can assist you in properly sizing the intake air system.

Engines with remote air cleaners should have a restriction indicator or vacuum gauge installed in the piping between the air cleaner and the engine. The preferred connection point for restriction indicators is in a straight section of pipe approximately 305 mm (12 inches) upstream of the engine or turbo inlet.



- **All engines must have an effective air cleaner to remove airborne dirt particles from the intake air. The air cleaner must have the minimum dirt holding capacity listed in the installation directions for the particular application.**

Dirt is the primary cause of wear in an engine. Reducing the amount of dirt that enters the engine will increase the engine life.

Although no universal standard for air cleaners has been established, the following guidelines are recommended:

Rating	Efficiency at 15% to 100% Air Flow	Dirt Holding Capacity g/cfm (g/l/s)	Type Construction
Normal Duty	99.5	3 (6.4)	Single Stage
Medium Duty	99.7	10 (21)	Single Stage
Heavy Duty	99.9	25 (53)	Two Stage

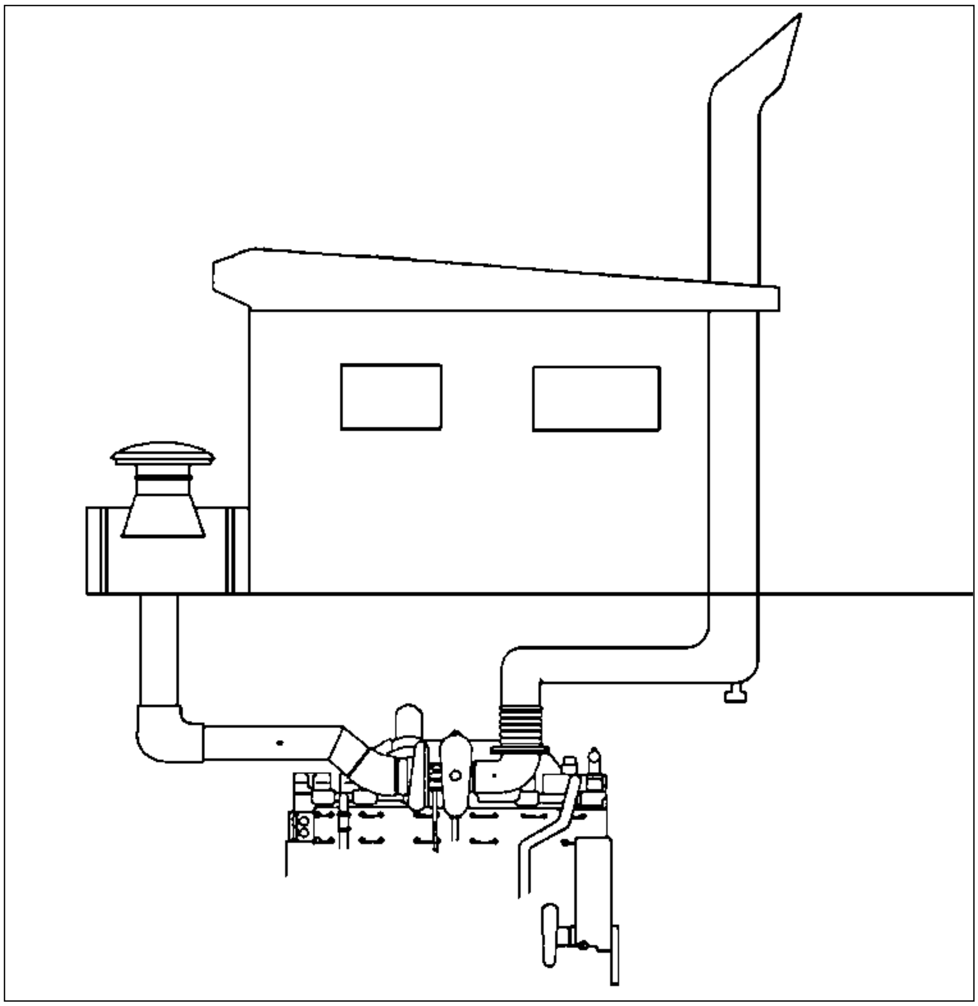
Most pleasure boat applications have engine rooms that are relatively free of dirt and may use a normal duty air cleaner. Commercial applications that operate in a protected, clean environment may use a medium duty air cleaner. However, if the engine operates in an environment that contains debris that may clog the air cleaner (fish scales, coal/ grain dust, etc.) or a longer service interval is needed, then a heavy duty air cleaner should be used.

- **The air inlet location, air piping and engine room ventilation must be designed so that the air inlet temperature measured at the inlet connection to the manifold or turbocharger is not more than 17ºC (30ºF) above the outside ambient temperature at rated speed and load. Maximum engine room temperature must not exceed 150ºF under any operating conditions.**

High air inlet temperatures will lead to high thermal stresses, high exhaust temperatures, poor engine performance, decreased fuel economy and shorter engine life. Inlet air temperatures above 27ºC (81ºF) will reduce engine power by approximately 1% for every additional 5.6ºC (10ºF) temperature rise. At lower engine speeds and loads, such as idle, temperatures may be higher without sacrificing engine life or performance.

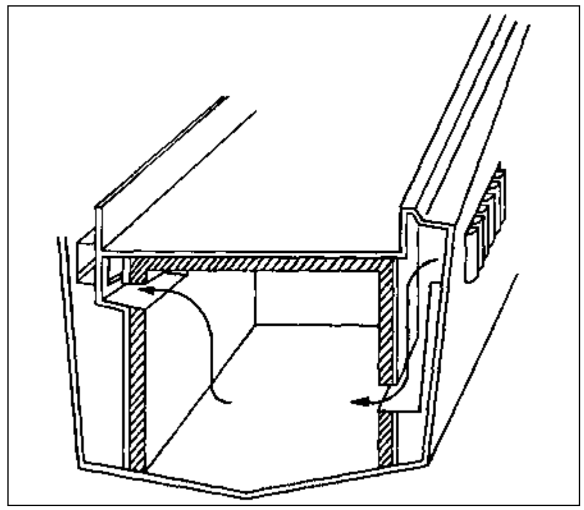
If the air cleaner is to be remote mounted, the inlet location should be outside the engine room. The inlet should be located so that a supply of air at or near the ambient temperature is always available. Locations with high inlet air temperature should be avoided. Areas to consider as heat sources are exhaust components, mufflers, air conditioner and refrigeration condensers, boilers and heating system components and auxiliary engines.

Marine engines with engine mounted air cleaners may draw air from the engine room. Engine rooms with natural draft ventilation must have vent openings of adequate size and location to ensure an ample supply of air at a reasonable temperature to the engine, and carry away heat from the machinery in the engine room.



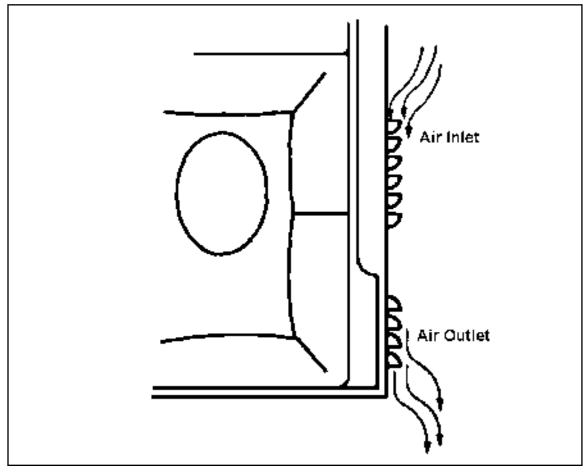
Cummins has developed a computer program that will estimate the recommended minimum total ventilation area required for each engine in the engine room (including any auxiliary engines). The ventilation area will vary depending on location of the vents and the resulting flow of air through the engine room. Some systems may require larger ventilation areas in order to meet the installation requirement. Your local Cummins distributor can assist you in determining what ventilation area should be used for your particular engine room.

Good circulation in the engine room is a key factor in keeping down the engine room temperature. Air inlets should be louvered or pointed forward to increase air circulation through the engine room.

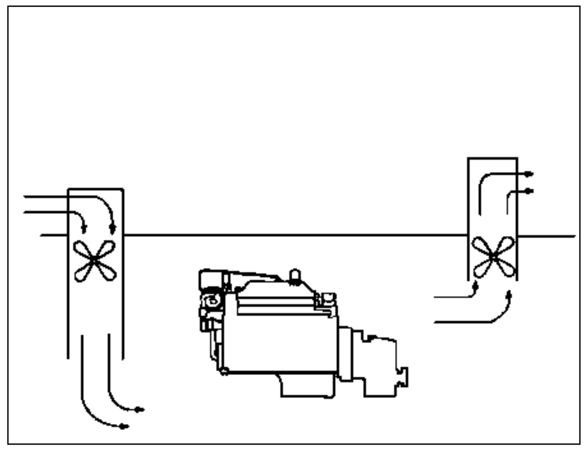


NOTES:

The inlet vents should be ducted to the bottom of the engine room to promote bottom up circulation of the fresh air and to clear fumes and moisture from the bilge. The exhaust vents should be located near the top of the engine room to carry away the hot air in the engine room. In planning the ventilation ports, two-thirds of the area should be used for intake air and one third of the area should be for exhaust ventilation.



If it is not possible to install sufficient ventilation ports to maintain the required engine room temperature, blowers and exhaust fans can be used to circulate fresh air through the engine room. The inlet blowers must have a capacity of two times the engine's rated air consumption listed on the engine performance data sheet. Exhaust fans should be from one-half to one times the rated air consumption of the engines to carry away the excess heat.



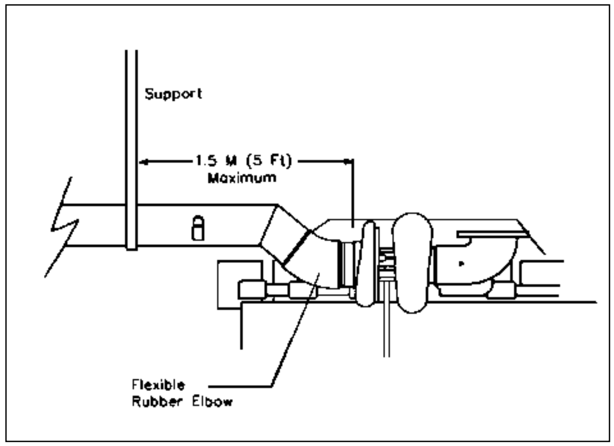
With both engine mounted and remote mounted air cleaners, there should be enough ventilation to keep the engine room temperature below 54ºC (130ºF). Temperatures above this may cause a deterioration in the hoses and/or wiring on the engine. Maintaining reasonable engine room temperatures can be aided by insulating as many hot surfaces as possible (i.e., exhaust piping, turbocharger, muffler, heating system).

- **The integrity of the piping between the air cleaner and the engine must not be broken during routine operation or maintenance functions.**

Any breaks or leaks in the air system after the air cleaner will allow dirt to enter the engine and decrease engine life.

Relative movement between the engine, air cleaner and air inlet requires flexibility in the pipe components and flexible connections. Any deflections must occur in the flexible components and not in the rigid piping.

On turbocharged engines a flexible connection must be provided between the compressor casing and the first piping support. The first support should be less than 1.5 meters (5 feet) from the turbocharger.

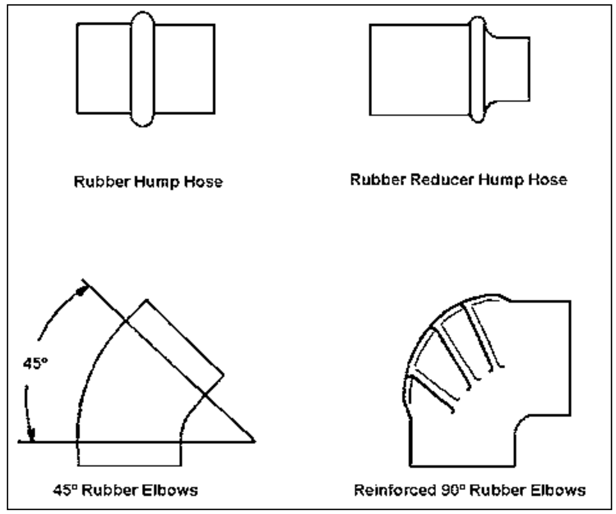


Steel, aluminum and fiberglass reinforced plastic tubing have been used for air intake piping. Some of the factors to be considered in selecting tubing are:

1. If the tubing lacks strength or rigidity, tightening of the hose clamps to provide an adequate seal may deform or crack the tube and allow dirt into the engine.
2. Rough end surfaces can cut or abrade the flexible connectors and prevent a proper seal.
3. Inside and outside walls of tubing need to be smooth and leak-free to assure a perfect seal and lessen air flow resistance. Butt welded tubing should have a flat surface (no bead) and be air tight.

The installer should use caution during any pipe welding in order to prevent slag on the inside of the pipe that may be drawn into the turbocharger.

Flexible rubber fittings designed for use on diesel engines are available from Cummins and most air cleaner manufacturers. These fittings include hump hoses, reducers, reinforced rubber elbows and a variety of special shapes and sizes. Wire reinforced hose is not recommended for intake air system piping.



Hose clamps which provide a full 360 degree seal should be used. Either "T" bolt type or SAE F are preferred.

Reinforced plastic tubing is not suitable for temperatures above 150ºC (300ºF). Do not expose rubber parts to continuous temperatures above 120ºC (250ºF). Avoid locating these near high temperature components such as exhaust components, mufflers, air conditioner and refrigeration condensers, boilers and heating system components, engine room vents and auxiliary engines.

FUEL SYSTEM

Marine Installation Requirements

- **The engine must be installed with the fuel filter supplied with the engine.**
- **The maximum static pressure at the fuel pump inlet must not exceed the value specified on the Engine General Data Sheet.**
- **The maximum fuel return line restriction must not exceed the value specified on the Engine General Data Sheet when measured immediately after the engine mounted check valve.**
- **The maximum restriction at the inlet of the fuel pump must not exceed the value specified on the Engine General Data Sheet.**
- **The maximum fuel inlet temperature must not exceed the value listed on Engine Performance Data Sheet.**
- **The supply line must be routed to prevent pressure surges and must be free from vertical loops.**
- **The fuel tank must be equipped with a vent, and this vent must also be designed to prevent the entry of dirt and water.**
- **The return fuel line must be routed at least 12” (0.3 m) from the supply line. It must be routed to the top of the tank for engine with PT and HPI fuel systems, and to the bottom of the fuel tank for all other engines.**
- **A primary 30-micron fuel filter and water separator must be installed before the engine fuel inlet (all except common rail systems). A primary fuel water separator with a 10 micron rating and a drain valve must be installed between the engine and the fuel tank (common rail fuel systems only).**
- **The fuel piping used between the engine and shipboard piping must have a flexible section to allow for relative movement of the engine and hull.**
- **Non-Cummins hoses and fittings connected to the engine must comply to SAE J1942/J1527.**
- **Fuel lines must be routed away from heat sources.**
- **A shut-off valve must be installed on the supply line.**
- **The fuel system must not contain any zinc, zinc plated or galvanized components.**
- **Teflon tape must not be used on any fittings or threaded connections in the fuel system.**

Marine Installation Recommendations

The fuel system must deliver an adequate supply of clean fuel that is free of air and water to the engine. Fuel is drawn from the fuel tanks, through a fuel/water separator and fuel filters, and into the fuel pump.

The fuel is also used to lubricate and cool many fuel system components.

- ❖ **The engine must be equipped with the fuel filter supplied with the engine.**

All Cummins engines are supplied with an engine mounted or remote (kitted) fuel filter to remove contamination from the fuel. These filters are designed for Cummins engines and provide the protection necessary for the fuel pump and injectors.

- ❖ **The maximum static pressure at the fuel pump inlet must not exceed the value specified on the Engine General Data Sheet.**

In the PT fuel system with open injectors, some of the injectors will be open at any time during engine shutdown, and any fuel that is allowed to flow through the supply or return lines will flow into one or more cylinders. When the engine is started, this may result in hydraulic lock and possible engine failure.

All Cummins marine engines are supplied with engine mounted check valves to prevent fuel from flowing back into the cylinders during shutdown. These check valves should not be removed from the system under any circumstances. Static pressures at the fuel pump inlet in excess of the stated limits (while the engine is shut down) can allow fuel to leak past the check valve and shutoff valve, potentially flooding the cylinders.

- ❖ **The maximum fuel return line restriction must not exceed the value specified on the Engine General Data Sheet when measured immediately after the engine mounted check valve.**

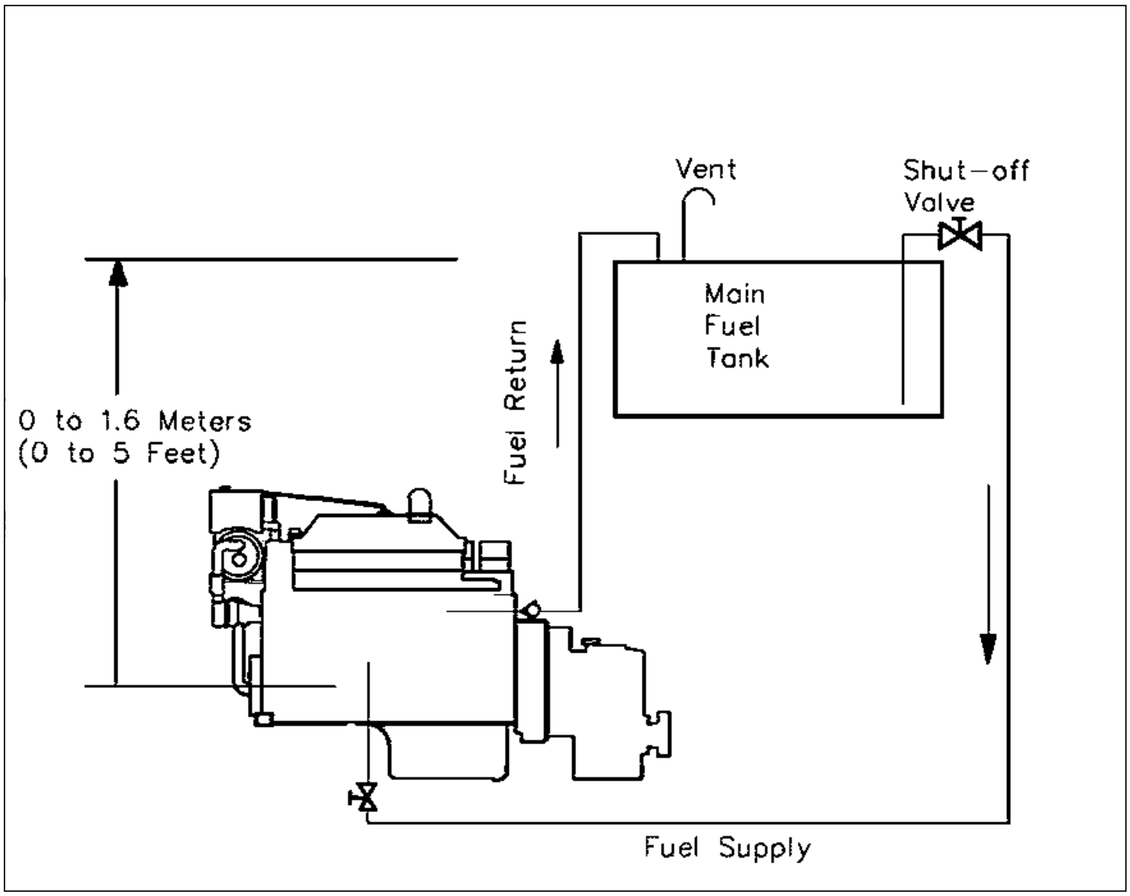
If the fuel return restriction is too high, excess fuel may be injected in the cylinder. This will cause higher cylinder pressures, higher temperatures, increased smoke, poor performance and a decrease in the engine life.

The fuel return line size required for an engine will depend on the engine return flow rate, the length of the line, the number of bends and the number and type of fittings. In general, the minimum recommended return line pipe size will be the same as the fuel return fitting size. However, larger line sizes may be required when several bends, valves or fittings are used in the fuel plumbing. Whatever line size is used, the fuel return line restriction must not exceed the value specified on the Engine General Data Sheet.

If the fuel tanks are mounted above the engine, the fuel return line restriction will also be affected by the static pressure of the fluid above the engine.

Fuel Tanks 0 to 1.6 M (0 to 5 Ft) Above Crankshaft Centerline

When the fuel tank is located up to 1.6 meters (5 feet) above the crankshaft centerline, an engine mounted check valve in the return line will prevent flooding an engine cylinder through the return line.



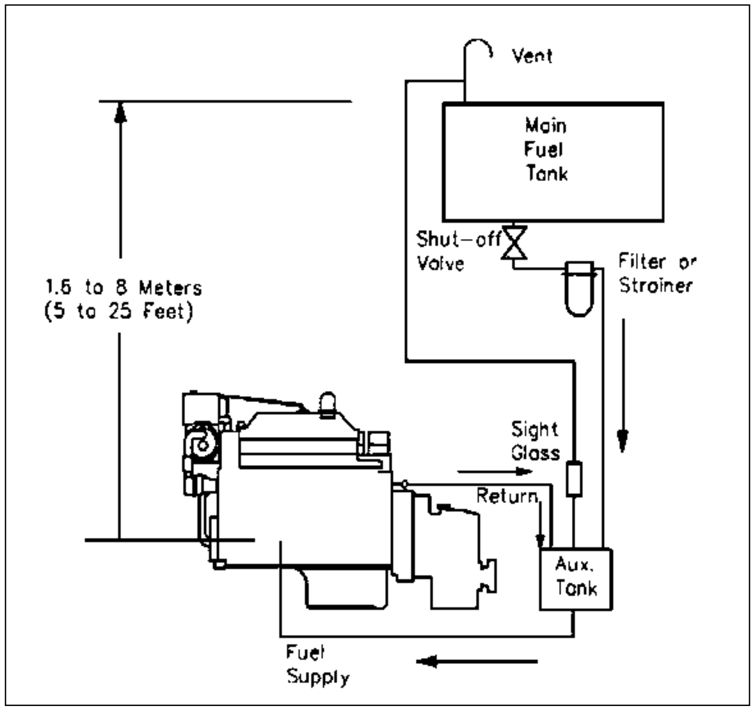
Fuel Tanks 1.6 to 8 M (5 to 25 Ft) Above Crankshaft Centerline

For fuel tanks located up to 8 meters (25 feet) above the crankshaft centerline, a float tank or day tank should be used.

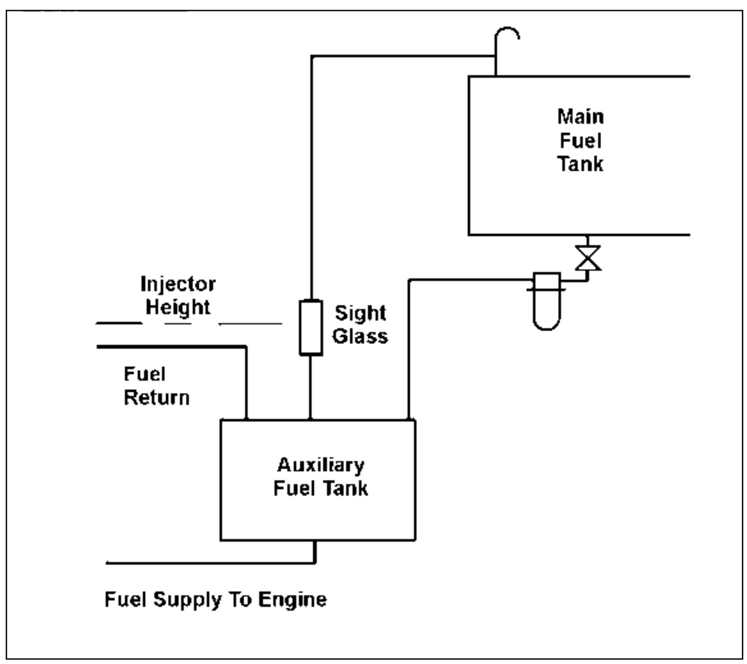
If a float tank is used, it should be large enough so that the returning fuel does not significantly raise the temperature of the fuel supplied to the engine.

A day tank requires a shut-off valve between it and the main tank so that it can be filled and then the supply can be shut off.

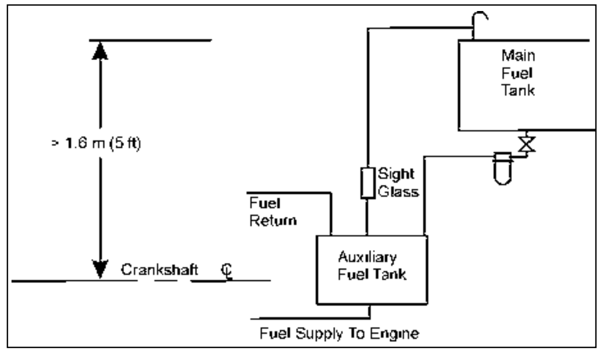
In both cases a fuel filter should be used between the main tanks and the float/day tank, with a shut-off valve between the filter and the main tank to allow the filter to be serviced without spilling fuel.



All auxiliary tanks (day or float) require a vent and should have a sight glass. The sight glass should be located in the vent line at the same height as the injectors. If the float valve should fail or the shut-off valve is left open, there will be fuel in the sight glass. If this happens, it is possible that fuel has entered the cylinders and the engine should not be started.



If the fuel tank is more than 1.6 meters (5 feet) above the crankshaft centerline, the return line should be run to the auxiliary tank.



The fuel return system must have at least one return line that cannot be shut off. This prevents accidental closure of all return lines. Since the PT fuel system will return up to five times the amount of fuel that is burned, this will result in excessive fuel consumption, high cylinder pressures and temperatures, increased smoke and failure of the fuel pump, injectors or engine.

If selector valves are used in the fuel return line, the valve ports should be at least as large as the fuel return line I.D.

- ❖ **The maximum restriction at the inlet of the fuel pump must not exceed the value specified on the Engine General Data Sheet.**

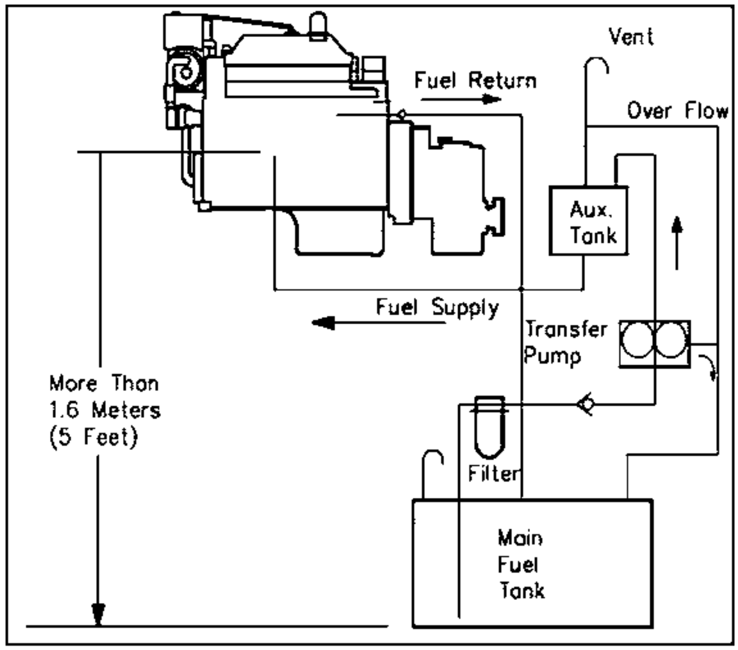
Excessive fuel inlet restriction can lead to insufficient fuel flow to the pump and injectors. This will affect fuel pump and injector life and the power output of the engine.

The fuel line size required for an engine will depend on the engine flow rate, the length of the line, the number of bends and the number and type of fittings. In general, the minimum recommended supply line pipe size will be the same as the fuel inlet fitting size. However, larger line sizes may be required when several bends, valves or fittings are used in the fuel plumbing. Whatever line size is used, the fuel inlet restriction must not exceed the value specified in the Engine General Data Sheet.

Fuel Tanks 1.6 M (5 Ft) or More Below Crankshaft Centerline

The fuel pump lift capability is limited by its design. In general, any fuel system where the bottom of the main fuel supply tank is more than 1.6 meters (5 feet) below the crankshaft centerline will require a fuel transfer pump to deliver fuel to the engine.

A float tank should use a continuously running transfer pump to deliver fuel to the float tank at a regulated pressure of 55 kPa (8 psi) maximum.



All auxiliary tanks must have vent and overflow piping. The overflow piping returns fuel to the main fuel supply tank if the float valve or switch should malfunction and overfill the auxiliary tank.

Valves

A fuel shut-off valve should be used on the supply line between the fuel tank and the fuel pump. Valves installed in the fuel supply line should have low flow resistance and not be a source for the entry of air into the fuel system. These requirements are best met with a plug type valve. Globe valves and other types of packed valves may be used, but they require periodic repacking to maintain an air tight seal. Some valves are not designed to seal in a suction line, and therefore, cannot be used in the fuel supply line.

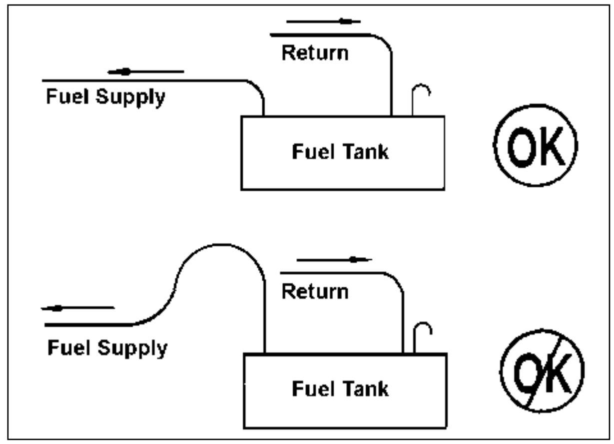
When a manual engine shut-down valve is used, the linkage should completely open and close the valve under all conditions.

Selector valve ports should be at least as large as the fuel supply line I.D.

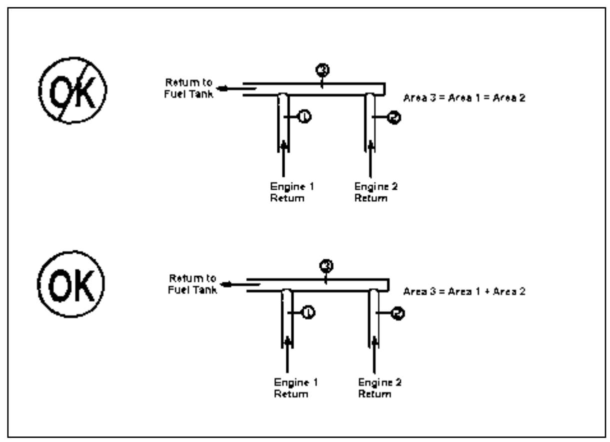
All valves used in the fuel system should be clearly marked as to their function and position (open/close).

❖ **The supply line must be routed to prevent pressure surges and must be free from vertical loops.**

The fuel supply and return line must be routed without loops. Any loops in the fuel plumbing will cause pressure surges in the line and result in engine speed instability.

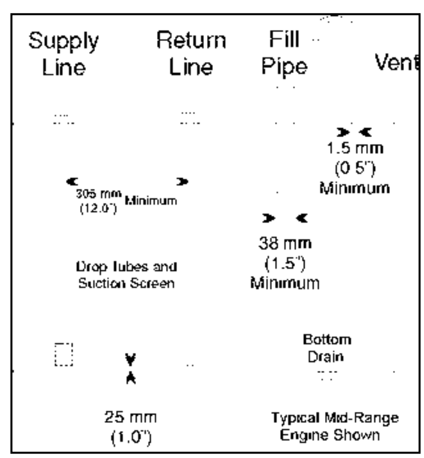


Whenever multiple engines are used, each engine should have separate fuel supply and return lines. Running two or more engines with common fuel lines can result in idle surge and speed stability problems. Pressure pulses in the return line of one engine may affect the operation of other engines that share the common return line. This can be overcome by using a common return line whose cross-sectional area is equal to the sum of the area of each of the individual return lines.



❖ **The fuel tank must be equipped with a vent, and this vent must also be designed to prevent the entry of dirt and water.**

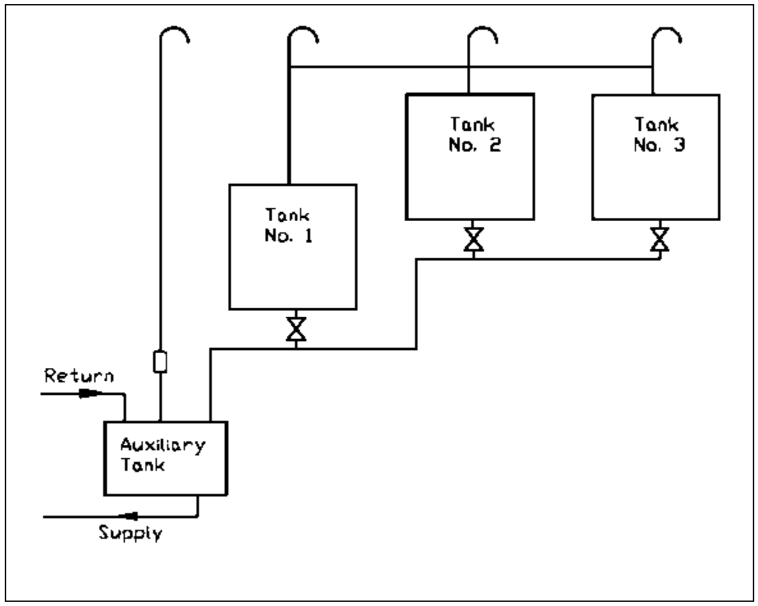
The vent allows the air and gases from the return line to escape from the fuel tank. It also equalizes internal and external pressures on the tank and prevents tank bulging or collapse. The vent line diameter should be at least 1/3 of the fill line diameter with a minimum fuel tank vent line size of 13 mm (0.5 inches).



The vent line should terminate above the deck in a protected location. A gooseneck at the top is recommended to keep dirt and water from entering the fuel tank through the vent line.

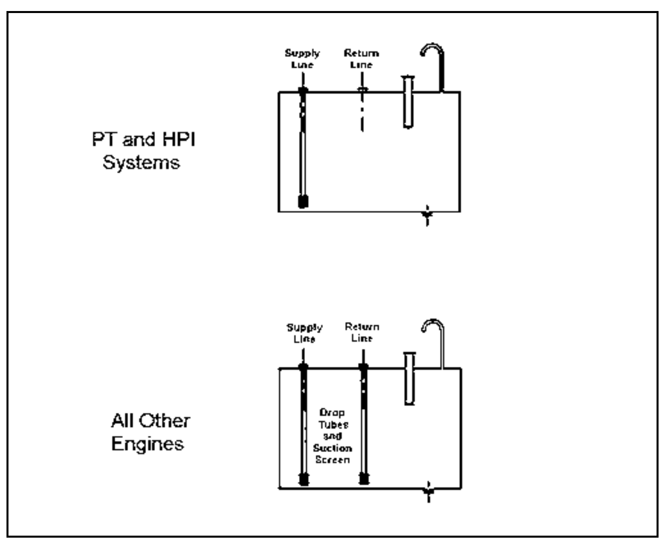
Fuel tanks can be made of terneplate or phosphate coated steel, aluminum or fiberglass. Galvanized or zinc plated steel tanks or piping should never be used in a diesel fuel system.

All auxiliary tanks should have vents routed to a point that is above the highest possible fuel level in the main tanks. This will prevent accidental flooding of the bilges if the auxiliary tank is overfilled.



- **The return fuel line must be routed at least 12" (0.3 m) from the supply line. It must be routed to the top of the tank for engine with PT and HPI fuel systems, and to the bottom of the fuel tank for all other engines.**

On engines with PT and HPI fuel systems, the return fuel must be routed to the top of the tank (either the main or intermediate tank), at least 12 inches (305 mm) from the supply line. This will prevent entrained air in the return line from entering the supply line. It also minimizes the potential to stir up sediment from the bottom of the tank, especially on an older vessel with a Cummins repower.

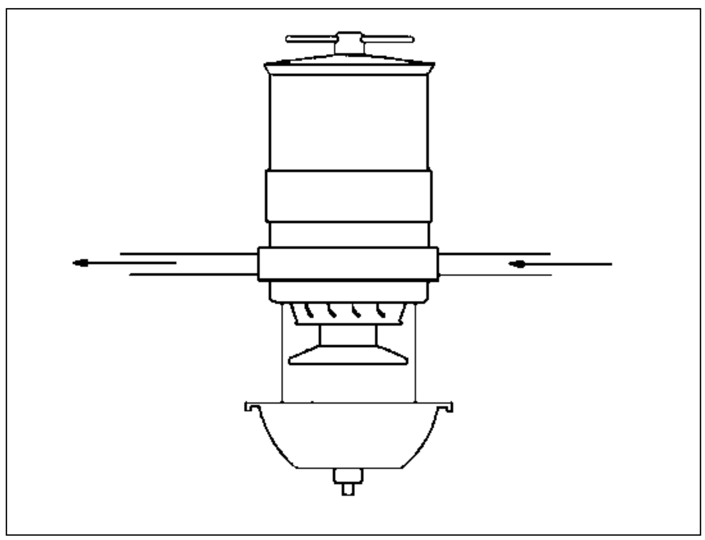


On all other engines, fuel return lines should be installed to the bottom of the fuel tank or with drop tubes in the fuel tank keeping the outlet submerged at all times. Return lines to the top of the fuel tank may allow fuel to drain back into the tank and cause hard starting. The return should be located approximately 1 inch (25mm) above the bottom of the tank to provide space for collection of water and sediment, and at least 12 inches (305 mm) from the supply line.

- **A primary 30-micron fuel filter and water separator must be installed before the engine fuel inlet (all except common rail systems). A primary fuel water separator with a 10 micron rating and a drain valve must be installed between the engine and the fuel tank (common rail fuel systems only).**

Cummins specifies a two-stage filtering setup for all engine installations. The primary filter (the first filter module after the tank) is normally mounted off-engine and is typically customer supplied. The secondary filter (the filter module just before the engine fuel pump) is Cummins-supplied and can be either engine-mounted or remotely mounted off-engine. The primary filter uses a relatively coarse media with a larger capacity compared to the secondary filter, and includes a water separator. Primary filtration of the fuel supply with a customer-supplied 30-micron filter (10-micron for common rail fuel systems) will extend the life of the secondary Cummins-supplied filter, without adding excessive inlet restriction to the system.

All of the fuel pumps used on the engines in this manual are fuel lubricated. Water in the fuel will decrease the lubrication in the pump and possibly cause a failure of the pump. Injectors are also fuel lubricated and can also fail as a result of water in the fuel. Therefore, it is necessary to remove any water from the fuel before it reaches the fuel pump by using a fuel/water separator.

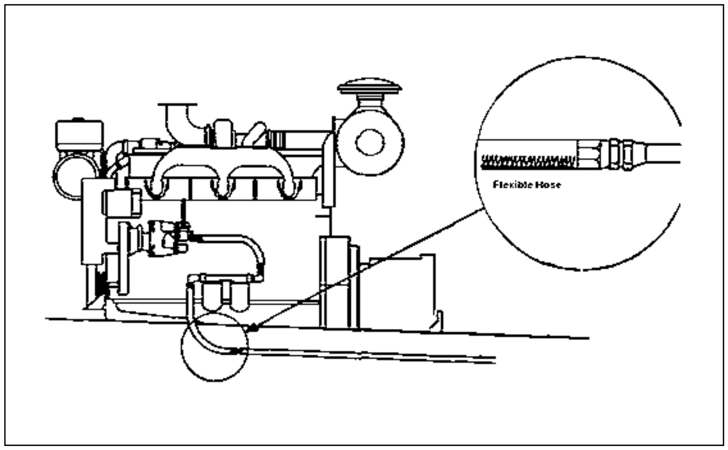


Fuel/water separators that are available from Cummins Engine Company are recommended. If another fuel/water separator is to be used, it must be sized for the engine's fuel supply flow rate. This information is available on the engine performance data sheet.

Fuel Line Plumbing

- **The fuel piping used between the engine and shipboard piping must have a flexible section to allow for relative movement of the engine and hull.**

Engine vibration, thermal growth of a hot engine and flexure of the hull when rolling and pitching in heavy seas could cause a rigid fuel line to crack and fail. Therefore, a section of flexible hose must be used between the engine and hull.



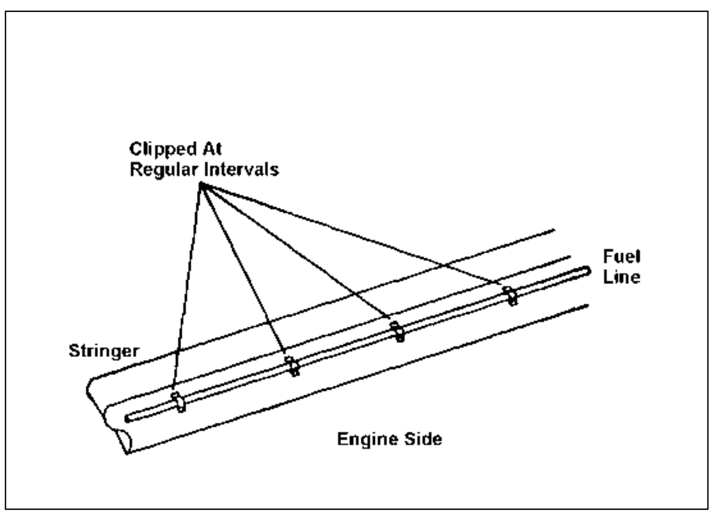
- **Non-Cummins hoses and fittings connected to the engine must comply to SAE J1942/J1527.**

All fuel hoses must meet the flame resistance, burst presssure limits and other requirements of SAE J1942/J1527.

- **The fuel system must not contain any zinc, zinc plated or galvanized components.**

Rigid piping materials suitable for the fuel system are black iron, steel, stainless steel, and flexible hose. The fuel system must not contain any zinc, zinc plated or galvanized components. Copper and copper-nickel lines are not recommended as they tend to work/age harden which will lead to leaks.

The fuel lines should be routed where they are protected from damage. Tubing and hoses must be supported at regular intervals to prevent failure due to excessive load and vibration. Electrical wire ties are not designed to secure fuel tubing and hoses and are not recommended for this purpose.



Duplex Fuel Filters

Some marine agencies require duplex-type fuel filters on marine propulsion engines. This type of system allows the filters to be changed one at a time at sea without shutting off the engine. Duplex fuel filters are offered on some Cummins products.

It is necessary to remote mount these filters when they are required on marine engines. Therefore, you should consult your local Cummins distributor for recommendations on installing these types of systems.

NOTES:

STARTING AND ELECTRICAL SYSTEMS

Marine Installation Requirements

- **The installed battery capacity must not be less than that specified on the General Engine Data Sheet.**
- **The engine must achieve a minimum cranking speed of 150 rpm (tested with no fuel flow to the engine).**
- **The maximum resistance in the starting circuit must not exceed 0.002 ohms.**
- **If the alternator is not supplied with the engine, the installer must assume responsibility for adequate mounting.**
- **All electrical harnesses must be loomed/covered, clamped securely and routed away from heat sources. The wiring must use protective grommets at clamp points.**
- **All powered circuits must include wiring and fuses that comply with governing standards of the intended application.**
- **Unswitched power to the ECM must be wired directly to the battery circuit.**
- **Instrument panels and wiring must be installed according to Cummins installation instructions.**
- **A functioning hour meter must be maintained on the engine.**
- **The air starter supply line size must meet the air starter manufacturer's requirements.**

Marine Installation Recommendations

The starting and electrical system must be designed so that the engine will start readily under the most severe ambient conditions ordinarily encountered. In order to achieve this objective, the installer must exercise good judgment in the selection and application of the electrical system components. These recommendations are offered as a guide to obtain a reliable system.

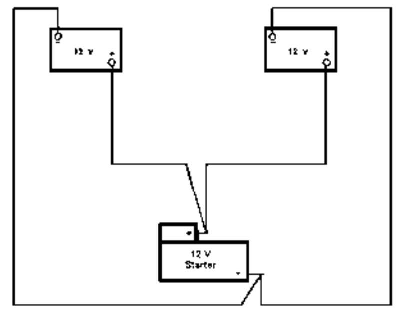
- ❖ **The installed battery capacity must not be less than that specified on the General Engine Data Sheet.**
- ❖ **The engine must achieve a minimum cranking speed of 150 rpm (tested with no fuel flow to the engine).**

There must be enough power available to the starter to ensure quick, reliable starts under any operating conditions. The minimum recommended battery capacity for the engines covered in this manual is listed on the corresponding Engine General Data Sheet. The temperature of the environment in which the vessel operates will greatly affect the power required for starting, so the worst case condition for the vessel should be used.

NOTES:

Battery voltage or current capacity can be increased by connecting batteries in different combinations of series and parallel arrangements.

If the batteries are connected in parallel, the system current will be equal to the sum of the current for the two batteries and the system voltage will be the same as the individual voltages of the batteries.

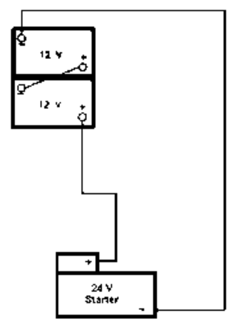


Parallel Circuit

$V = V_1 = V_2$

$I = I_1 + I_2$

Connecting the batteries in series will increase the system voltage, but not the current. The voltage will be equal to the sum of the two battery voltages and the current will be equal to the current of either individual battery.

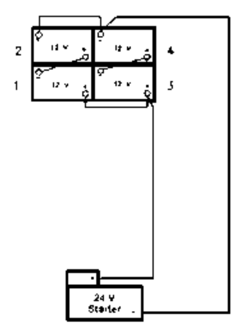


Series Circuit

$V = V_1 + V_2$

$I = I_1 = I_2$

If the batteries are connected in series and parallel, then both the system voltage and current will increase.



Series - Parallel Circuit

$V = V_1 + V_2 = V_3 + V_4$

$I = I_1 + I_3 = I_2 + I_4$

The table below lists typical battery capacities for various combinations.

TYPICAL BATTERY CAPACITIES						
	BATTERY				SYSTEM	
BATTERY SIZE	VOLTS V	CAPACITY CCA	QTY.	WIRING	VOLTS V	CAPACITY CCA
4D-640	12	640	2	Parallel	12	1280
4D-800	12	800	2	Parallel	12	1600
8D-900	12	900	2	Parallel	12	1800
4D-640	12	640	2	Series	24	640
4D-800	12	800	2	Series	24	800
8D-900	12	900	2	Series	24	900
4D-640	12	640	4	Series-Parallel	24	1280
4D-800	12	800	4	Series-Parallel	24	1600
8D-900	12	900	4	Series-Parallel	24	1800

❖ **The maximum resistance in the starting circuit must not exceed 0.002 Ohms.**

If the circuit resistance is too high, the starting motor will not receive an adequate supply of electrical energy and will not provide reliable cranking over the range of conditions encountered in service. The maximum starting circuit resistance for the engines covered in this manual is 0.002 Ohms. The table below lists the maximum length of typical cables in the cranking circuit necessary to meet this requirement.

BATTERY TO CRANKING MOTOR CABLE SIZES					
	MAXIMUM TOTAL LENGTH OF CABLE IN CRANKING CIRCUIT				
MAXIMUM CIRCUIT RESISTANCE	#00	#000	#0000 OR TWO # 0	TWO #00	REMARKS
0.00200 Ohm	6.10 M (20 Feet)	8.23 M (27 Feet)	10.67 M (35 Feet)	13.72 M (45 Feet)	Single Cranking Motor
0.00200 Ohm	6.10 M (20 Feet)	8.23 M (27 Feet)	10.67 M (35 Feet)	13.72 M (45 Feet)	Dual Cranking Motors W/Single Battery Bank

This table lists the cable diameter and cross-sectional area for the sizes listed above.

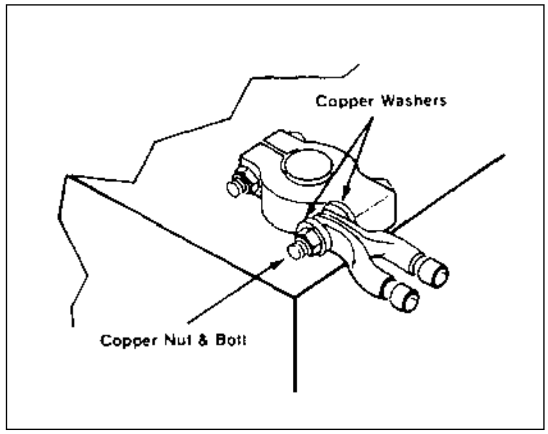
CABLE SIZE (AWG)	CABLE DIAMETER		CABLE AREA (SQ. MM)
	mm	in	
#0	7.8	(.3065)	47.8
#00	8.4	(.3310)	55.4
#000	9.2	(.3625)	66.5
#0000	10.0	(.3938)	78.5

Starting motor circuit resistance will be affected by cable size and length, the number of connections in the system and the possible presence of additional contactors in the wiring arrangement. For assistance in calculating the circuit resistance, contact your local Cummins distributor.

Starter Circuit Wiring

The starter cable terminals should have soldered connections. Rosin flux should be used for soldering electrical connections. Acid flux solders will cause deterioration of the electrical connection.

Connecting two strands of cable, such as two #00 or two #000 should be done carefully in order to assure that both wires have a good connection with the battery. The figure at right shows one method used to connect two cables to a battery. Tinning the stainless steel washers and cable connectors with solder will reduce the chances of problems due to corrosion. The use of a non-conductive grease at the connection will also help prevent corrosion.



The cable to battery connections should use the maximum available contact area of the battery post. Clamps must be positioned squarely on the battery post or stud with clean surfaces and securely fastened. Stacked terminal connections which have only point or line contact will not be satisfactory.

NOTES:

- **If the alternator is not supplied with the engine, the installer must assume responsibility for adequate mounting.**

Since the integrity of customer supplied alternator mounting cannot be assured, Cummins Engine Co. is not responsible for any problems associated with an improperly mounted alternator that was not supplied with the engine. If the customer wishes to supply and mount their own alternator, they should contact the local Cummins distributor for assistance.

Alternator Wiring

Unless special protective devices are used, an alternator system can be damaged by the connection of a charged battery to the alternator in reverse polarity. If a reverse connection is made while attempting to start an engine that has a dead battery or when connecting a newly charged battery, the low resistance path through the rectifier will damage the diodes. It is recommended that one battery lead be shorter than the other so that once the battery is properly set in place it is impossible to misconnect it.

Voltage Range

Most alternators include heavy duty voltage regulators. Generally, the range of regulation will be as follows:

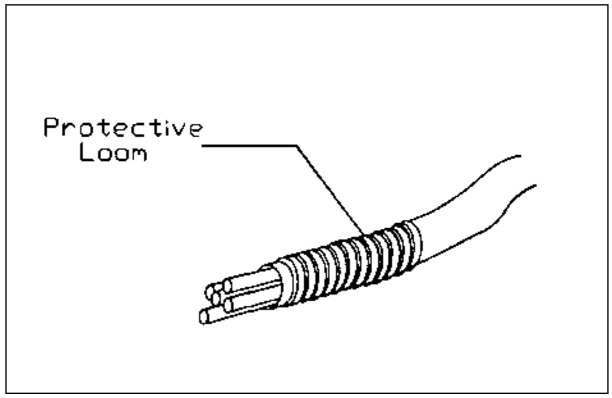
SYSTEM VOLTAGE	LOW	NORMAL	HIGH
12 Volt	13.1	13.7	14.3
24 Volt	26.2	27.4	28.6
32 Volt	34.2	36.5	38.5

Overcharging or undercharging reduces battery life.

System Wiring

- ❖ **All electrical harnesses must be loomed/covered, clamped securely and routed away from heat sources. The wiring must use protective grommets at clamp points.**

Because of operating and environmental conditions, wiring on marine applications need special precautions. Connections should be made with corrosion resistant hardware and be shielded as much as possible. All wiring should be in protective looms, conduit or tape and be routed away from heat sources, such as the exhaust piping, and above bilge water level.

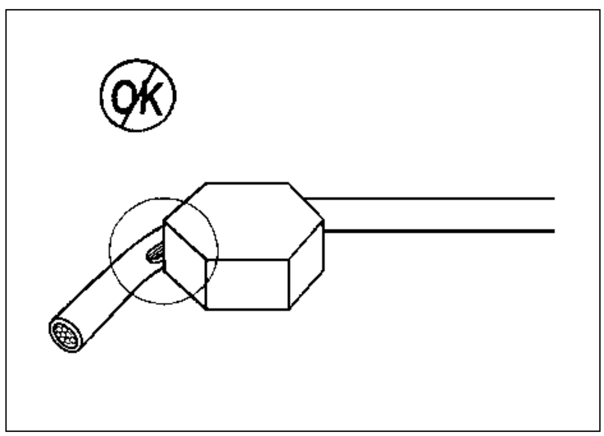


Cummins marine engines are equipped with internally (case) grounded or insulated (floating ground) electrical systems. Cummins schematic wiring diagrams show standard and various optional systems, give recommended cable sizes and other data.

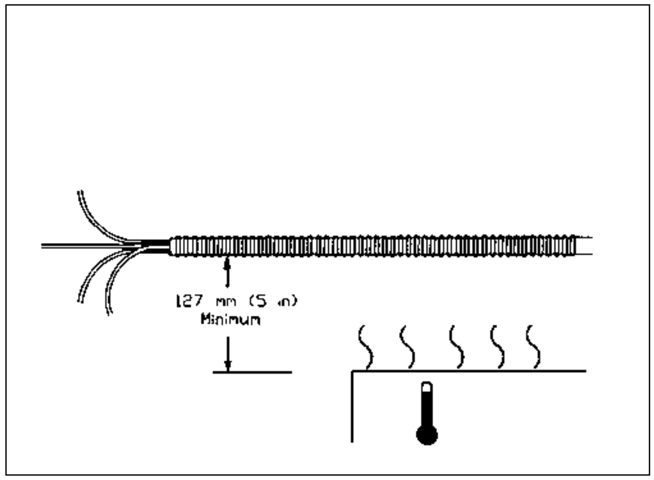
Wire Routing

Proper routing and clipping of electrical wiring is extremely important. Leads should be routed away from heat sources such as the exhaust piping and should be above the bilge water level. Listed below are basic guidelines which should be followed when designing or installing wiring systems. American Boat and Yacht Council (ABYC) guidelines, section E-11 “AC and DC Electrical Systems on Boats” may also be consulted for further details.

1. On any surface likely to see movement from vibration or normal deflections, such as the frame or stringer to engine, wires must not rub against surrounding parts or each other. If they must touch a surface, they should be banded or clipped to it.
2. Under no circumstances should the wires contact sharp edges, screws, bolts or nuts.



3. When clamps are used, the proper size must be installed. An oversized clamp promotes chafing.
4. All wires should be routed so that they are at least 127 mm (5 inches) away from an exhaust pipe, turbocharger, turbocharger crossover tubes or aftercooler assemblies. This is a minimum. The further the wires can be kept from any heat sources, the better.
5. Some type of support should be used at least every 450 mm (18 inches).



Improperly routed wires may quickly rub through due to relative motion or melt due to exposure to high temperatures.

Instrument Panels

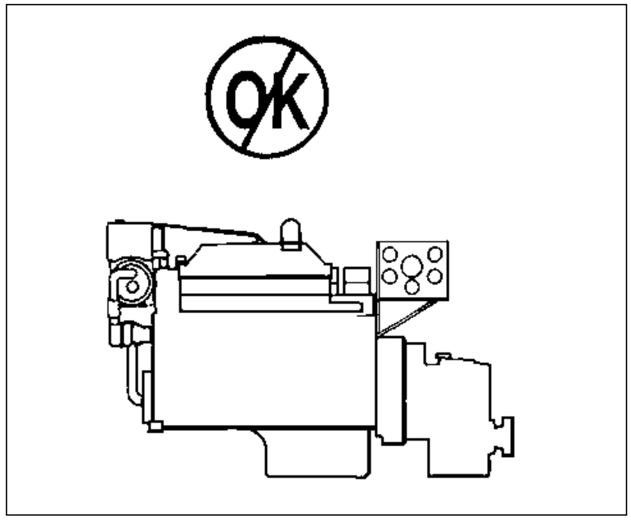
Remote mounted engine room instrument panels are available for Cummins engines. The panels, depending on engine family, may include a tachometer/hour meter, voltmeter, exhaust gas pyrometer, local on-off switch, start switch, circuit breaker and gauges for engine oil pressure, engine water temperature and marine gear oil pressure.

Second station instrument panels are also available for the pilot house or other locations. These panels may include a tachometer, voltmeter, gauges for engine oil pressure, engine water temperature and gear oil pressure. The panel will typically also have alarm lights and a horn which can be used to signal low oil pressure, high water temperature, low battery voltage and/or water in the fuel.

Digital electronic displays are also available for most electronically-controlled engines. These displays typically include the common engine parameters listed above, as well as throttle position, fuel consumption, percent load, fault information, and engine protection alarms.

- ❖ **Instrument panels and wiring must be installed according to Cummins installation instructions.**

Instrument panels should not be mounted on the engine due to engine vibration.



- ❖ **A functioning hour meter must be maintained on the engine.**

All engines must have a means for displaying current engine hours on the engine room instrument panel.

Bonding System

Marine engine installations require special bonding (grounding) of electrical system components to minimize electrolytic corrosion from stray currents and to minimize radio interference. Cummins recommends that ABYC guidelines (section E-11, "AC and DC Electrical Systems on Boats") be consulted for design of the vessel bonding system.

Radio Interference Suppression

Radio frequency interference (RFI) can be created by many types of electrically operated equipment. Proper suppression techniques will improve the reception and extend the operating distances of communication equipment, radio direction finders, fish finders, depth sounders and the electronic gear. Most alternators have capacitors built in to reduce their contribution to RFI and solid state voltage regulators have further reduced the interference levels. Cummins recommends that ABYC guidelines (section E-11, "AC and DC Electrical Systems on Boats") be consulted for good supression practice in vessel design.

Use only approved marine type antennas that are matched to the electronic equipment they serve. Install antennas on the opposite side of the boat from the engine instrument panel and as far forward as possible.

Air Starting Systems

Air starting is available as an engine option for many engines covered in this manual and is acceptable for use on all Cummins engines.

Air Compressor

Cummins recommends the use of a separate motor driven or clutch actuated air compressor. Separate motor driven or clutched air compressors can be sized to the air requirements of the vessel and operate only on demand. Engine driven air compressors are not offered on Cummins marine engines.

Air Piping

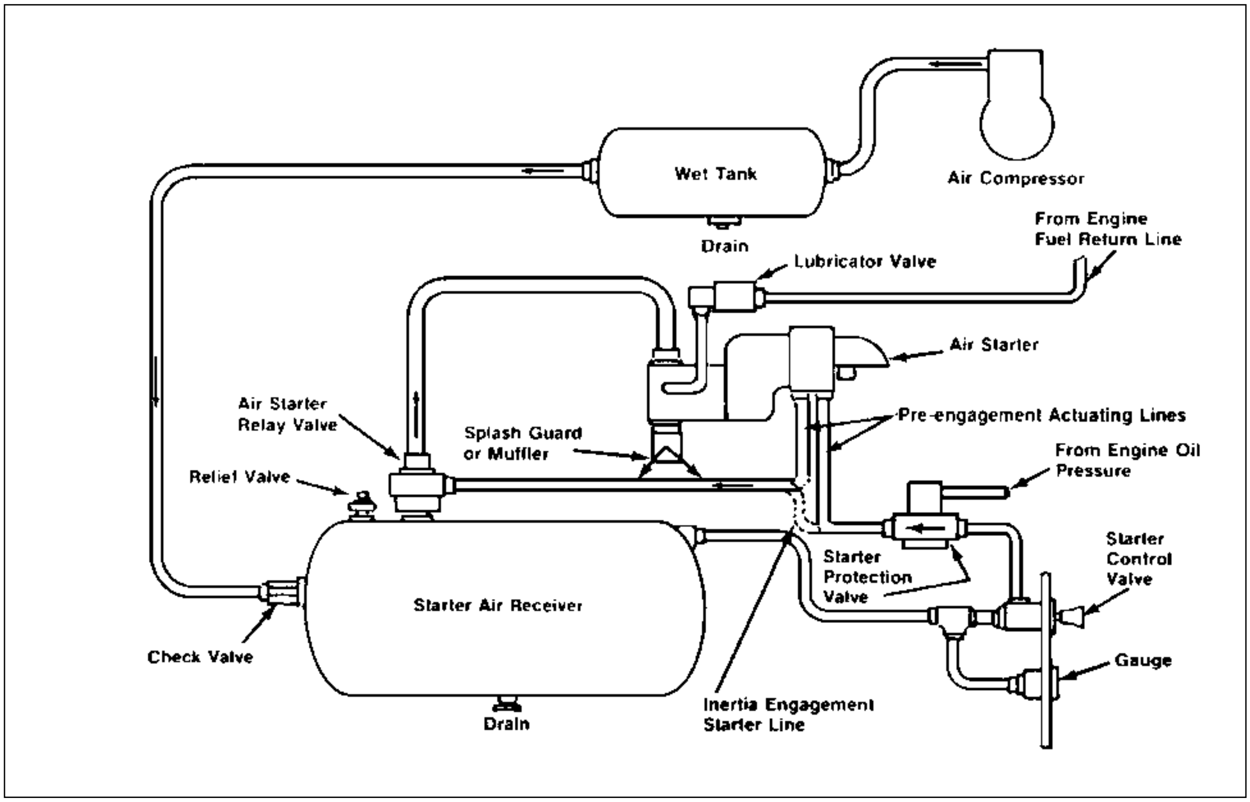
The figure on the following page is a typical piping schematic for an air starting system. The only connection in the bottom of the tank should be the drain required to bleed off condensed moisture, which could cause rust and corrosion if allowed in the cranking motor. Drain valves of the screw-out tapered-seat variety are recommended since others are unreliable and are a common source of air leaks. The inlet check valve is mounted directly on the receiver where it is supported and provides maximum protection to the air supply.

- ❖ **The air starter supply line size must meet the air starter manufacturer's requirements.**

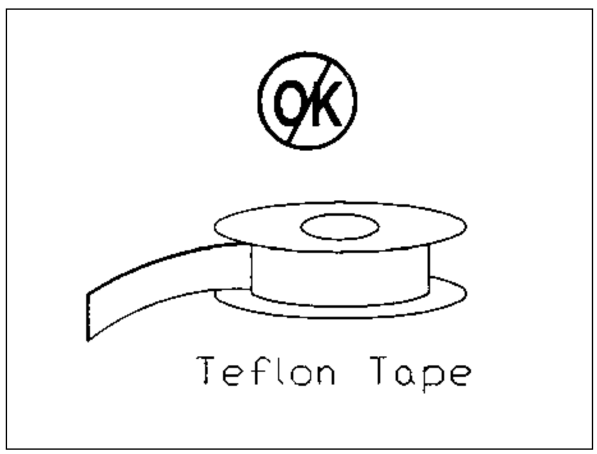
Air starter manufacturers generally recommend the use of 1.5 inch ID minimum hose or pipe for supply lines up to 4.6 meters (15 feet) in length, and 2 inch minimum for supply lines greater than 4.6 meters (15 feet). Also, a 300 mesh strainer (50 micron filtration) on the air supply line is recommended to extend the life of air starters.

- ❖ **The engine must achieve a minimum cranking speed of 150 rpm (tested with no fuel flow to the engine).**

Air starter manufacturers recommend that the dynamic pressure at the starter to be no less than 90 psi for satisfactory performance. Dynamic pressure refers to the pressure measured at the starter while the starter is operating and flowing air. A dynamic pressure of less than 90 psi can lead to a no-crank condition with either a vane or turbine starter. Optimum performance will be achieved with 120 psi dynamic pressure at the starter.



The hose should have J.I.C. fittings with dry seal threads. Any pipe fittings used should also be dry seal type. All connections should be made up with Loctite pipe sealant or equivalent. Teflon tape does not provide enough friction at the pipe threads to prevent loosening; and when carelessly applied, it may get inside the piping and clog valves. It should not be used in air starting systems.



Air Starter Lubricators

Automatic lubricators are recommended for vane type air starters to increase air motor reliability and extend its life; however, they are not required on turbine air starters. The installer must bleed the air out of the lubricator after the initial engine start to prevent a permanent air lock.

Other Considerations for Air Starters

The exhaust port in the starting motor should be protected from dirt and water.

When the starting motor is not furnished with the engine, it should be sized according to the starter manufacturer's recommendations.

All of the air starters available from Cummins have a maximum pressure rating of 10.4 bar (150 psig). It is imperative, therefore, that a pressure regulator be used to prevent application of higher pressures to the starter with vessel air systems delivering more than 150 psi (measured at the starter). Pressure regulator valves are available through Cummins for some engine families, or can be purchased in the aftermarket.

NOTES:

LUBRICATION SYSTEM

Marine Installation Requirements

- **The lubricating filters that are furnished by Cummins Engine Company with every engine must be installed.**
- **All engines must be installed with a Cummins supplied lubricating oil bypass filter or combination filter.**
- **The lubricating oil dipstick must be marked with the high and low oil level when the vessel is in the water and at its normal trim.**
- **All lube oil and fuel hoses and fittings not supplied by Cummins Marine and connected to the engine or marine gear must comply to SAE J1942 and SAE J1527.**
- **The lubricating oil used in the engine must meet the specifications listed in the Operation and Maintenance manual.**
- **Closed crankcase ventilation systems are not permitted, except for Cummins-supplied systems.**
- **Any non-Cummins supplied oil pans must be approved by a Cummins Marine Application Engineer.**
- **All lines must be routed away from heat sources.**
- **Flexible lines must be installed between the engine and shipboard piping to allow for relative motion.**

Marine Installation Recommendations

The lubrication system must provide a continuous supply of clean lubricating oil to the engine at a controlled temperature. Proper installation and maintenance of the lubrication oil system is essential to ensure long engine life and performance.

- **The lubricating filters that are furnished by Cummins Engine Company with every engine must be installed.**
- **All engines must be installed with a Cummins supplied lubricating oil bypass filter or combination filter.**

All engine models are supplied with a full flow lubricating oil filter plus bypass filter, or a combination filter. For engine-mounted options, the engine installation drawing specifies the filter location and space required for element removal. Optional engine mounted filter locations are available for some engine models and information on these may be obtained from the on-line sales e-book.

Engine oil filters that are integral with the engine cannot be removed or modified.

Cummins offers a variety of lubrication filter systems depending on the engine family.

Definitions of Filter Types

Full flow filter - contains a single media, provides relatively coarse filtration, and requires a separate bypass filter.

Bypass filter - contains a single media, provides fine (low micron rating) filtration, and is used in combination with a full flow filter. Takes only a small portion of the total oil flow such that the pressure drop is not excessive.

Combination filter - contains two different media (one coarse and one fine) in the same element, and does not require an external bypass filter. Requires a bypass hose from the filter head to the oil pan.

Venturi combination filter - same as the combination filter but the element and head design is such that it doesn't require a bypass hose.

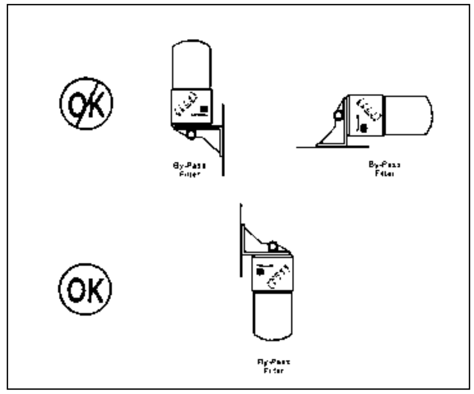
Duplex Lube Filters

Some marine agencies require duplex-type lube filters on marine propulsion engines. This type of system allows the filters to be changed one at a time at sea without shutting off the engine. Duplex lube filters are offered on some Cummins products.

It is necessary to remote mount these filters when they are required on marine engines. Therefore, you should consult your local Cummins distributor for recommendations on these types of systems.

NOTES:

Bypass filters are normally engine mounted. All Cummins bypass filters are spin-on types and must be mounted vertically. If the bypass filter is to be remote mounted, the location of the bypass filter supply and return can be found on the engine installation drawing.

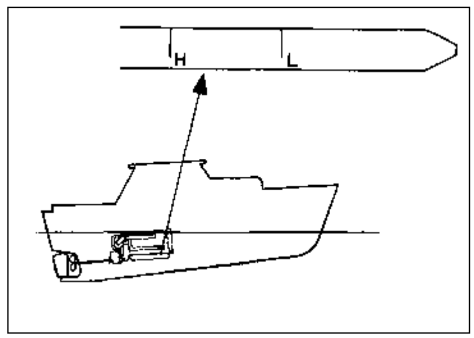


When filled with oil, the bypass lube oil filter has considerable weight and sturdy brackets are required to support it. A location should be selected where it is easily serviced and where neither it nor the connecting lines are subject to damage.

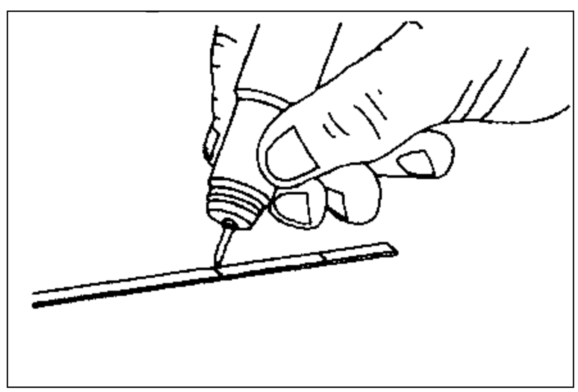
The hose routing for the bypass filter should be as short as possible to provide the least flow resistance.

- **The lubricating oil dipstick must be marked with the high and low oil level when the vessel is in the water and at its normal trim.**

Since the installation angle of a marine engine may vary greatly between vessels, the high and low oil levels on the dipstick will also vary as the engine angle changes.



Dipsticks should be marked by engraving. Stamping or notching will weaken the dipstick and the tip of the dipstick may break off in the oil pan.



The procedure for calibrating marine engine dipsticks is located on the tag attached to the dipstick and in the Operation and Maintenance manual.

- **All lube oil and fuel hoses and fittings not supplied by Cummins Marine and connected to the engine or marine gear must comply to SAE J1942 and SAE J1527.**

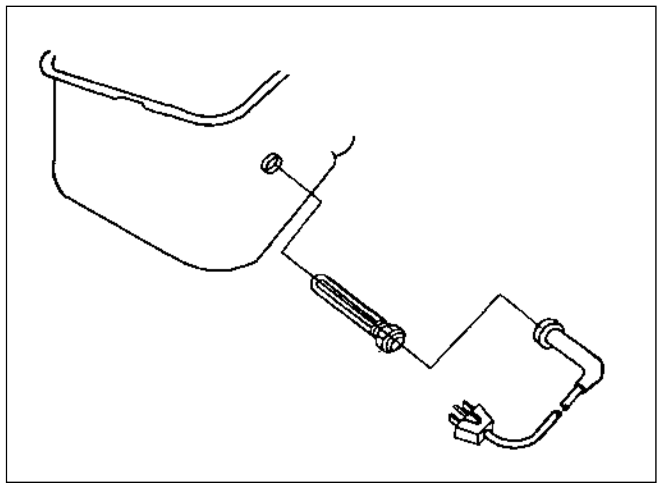
Hoses for bypass oil filters, oil pressure gauge lines or replacement lines for the full-flow filters must meet the requirements of SAE J1942/J1527.

Hoses and hose fittings used must be compatible and should be a product of the same manufacturer. Fittings must conform to SAE J1475. Applicable fittings are listed in SAE J1942-1. Push-on fittings, quick connect couplings, and fittings with a single worm-gear clamp or a single band around the hose are unacceptable.

- **The lubricating oil used in the engine must meet the specifications listed in the Operation and Maintenance manual.**

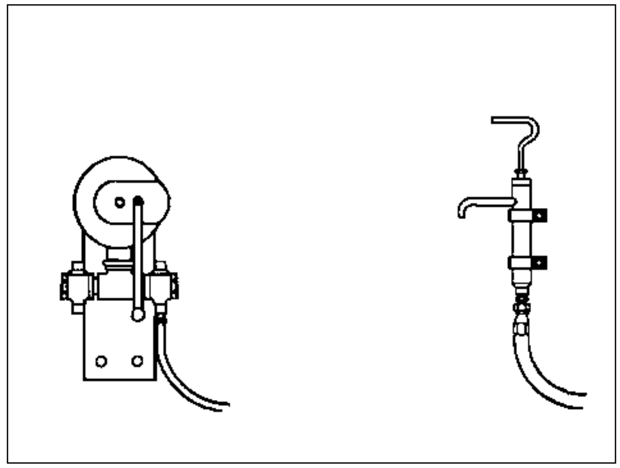
The use of quality engine lubricating oils combined with appropriate oil drain and filter change intervals is a critical factor in maintaining engine performance and durability. Refer to your Operation and Maintenance manual for more information on lubricating oil specifications.

For operation below -18ºC (0ºF), an oil pan immersion heater is recommended to maintain oil temperature and viscosity in an acceptable range for cranking and lubrication.



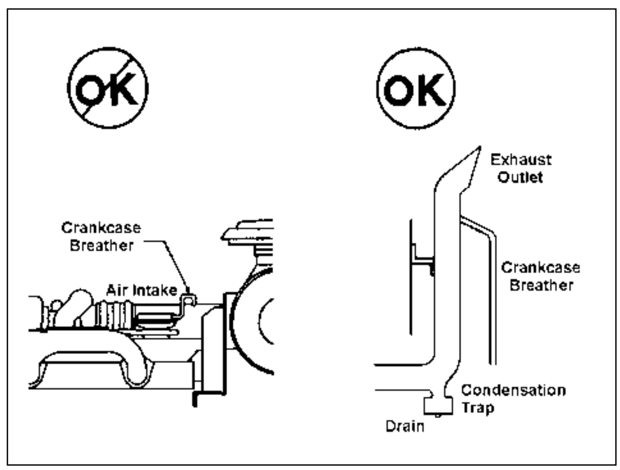
NOTES

The engine oil pan is usually not accessible in a marine application. Lube oil drain hoses or sump pumps are optionally available on all engine models for installations where the oil pan drain plug is difficult to access. Sump pumps can be of the electric or hand-pump variety.



Engine Crankcase Vents

During normal operation a small amount of combustion gas escapes past the piston compression rings into the crankcase. These blow-by gases are vented through the engine breathers. Most of the oil mist and vapor is removed by the breathers and drains back into the engine. However, some oil vapor is carried through the breathers by the blow-by gases. Engines that operate in an open area may allow the gases and oil vapor to escape at the breather.



On boats, the gases and oil vapor should be piped out of the engine room. Vessels with dry exhaust systems can vent the blow-by into the exhaust gas flow after the muffler. The blow-by must not be routed too close to the turbocharger outlet because the higher pressure will prevent blow-by gases from exiting the crankcase. Also, blow-by gases should not be vented to the atmosphere near the engine air intake or directly into air cleaners or the turbocharger inlet. The oil build-up that occurs may plug the air cleaner element and can cause turbocharger failures, loss of power and decrease the effectiveness of the aftercooler.

- **Closed crankcase ventilation systems are not permitted, except for Cummins-supplied systems.**

There are external crankcase vent filtration systems available through your Cummins distributor. The discharge of these units should be vented to the engine room airspace, or piped out of the engine room. The use of closed crankcase ventilation systems, where the crankcase vent is plumbed to the engine inlet, is not approved for use on Cummins engines, except for Cummins factory options available on some light-duty applications. Aftermarket or non-factory-installed closed crankcase systems are not permitted because they can contaminate turbochargers and aftercoolers.

Crankcase vent plumbing should have a continuous upward slope to prevent oil build-up in the vent lines. Drain fittings are required at the bottom of long vertical runs to remove accumulated oil.

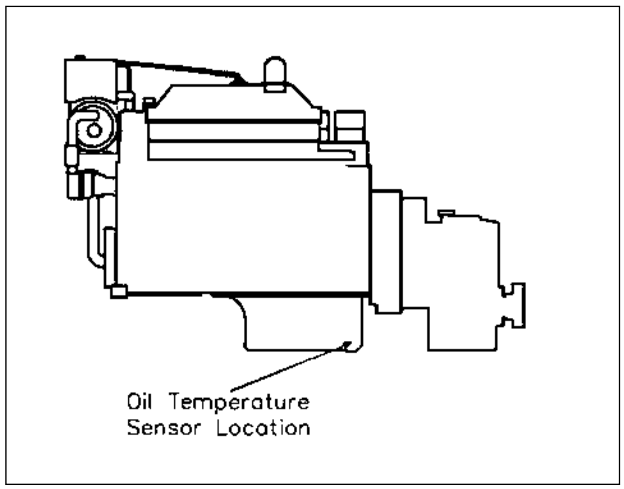
Oil Pressure Gauge

An oil pressure gauge is recommended to indicate lubricating oil pressure during operation. The tapped hole for the oil pressure gauge is specified on the engine installation drawing. Optional locations are available on most engine models. Oil pressures at normal operating temperature are listed on the Engine General Data Sheet and in the Operation and Maintenance manual. The pressure with cold oil may be twice as much as the maximum oil pressure of a warmed-up engine and this should be considered when selecting a gauge.

All Cummins marine single station instrument panels come with oil pressure gauges and sending units. If low oil pressure alarms are to be used, Cummins recommends using the minimum oil pressure listed on the engine data sheet as the alarm set point.

Oil Temperature Gauge

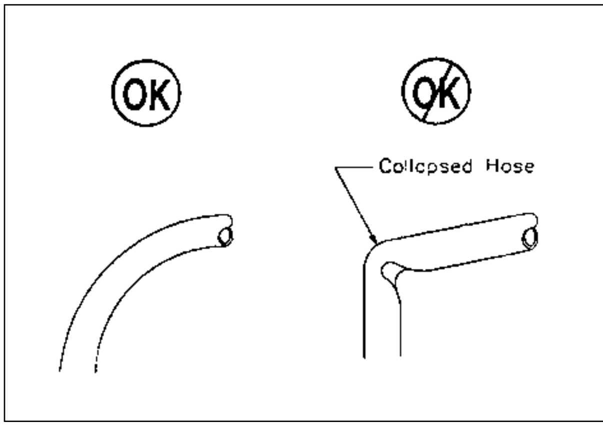
An oil temperature gauge is sometimes used on installations to indicate operating temperatures. The sensing element for the oil temperature gauge should be installed in the oil pan sump at the lowest point possible for the most accurate temperature reading.



Hose Routing

The lines should be supported along their length to prevent chafing against adjacent structures. Electrical wire ties are not designed to secure flexible hoses and are not recommended for this purpose in the lubricating system. Hoses should be shielded from high temperatures when routed near the exhaust system or other hot areas.

When installing hoses, provide enough slack in the hoses to allow for changes in the lengths when the hose is pressurized. Hoses shrink in length by up to 4 percent when in service.

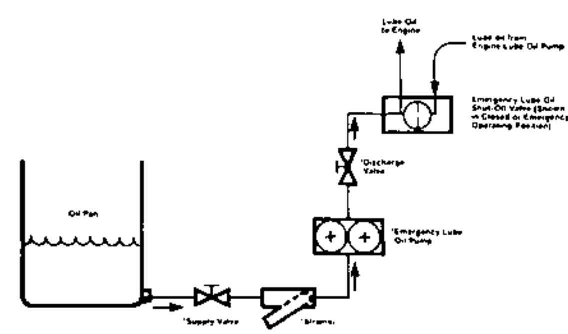


Hoses should be installed without twists or kinks, and all bends should be larger than the minimum bend radius given by the hose manufacturer.

When used as a suction hose or in vacuum service, many hoses require an internal support coil to prevent the hose from collapsing.

Emergency Lubricating Oil System

An emergency lubricating oil system is required by some marine classification societies for vessels in unrestricted service. This system is intended to be used in situations where the engine lube oil system has ceased functioning and the engine is required to run for a short period of time for the safety of the ship and her crew. The emergency lubricating oil system should never be used as a substitute for normal engine repair or maintenance.



Not Supplied by Cummins Engine Co.

Note: Emergency Lubrication Oil Systems can only be used on KV Engines that have the Emergency Lube Oil Shut-Off Valve. Check the Marine Sales Handbook for the Availability of this Option

Table of Contents

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1 Foreword

1.1 The Manual

This manual contains guidance and instructions for the installation and operation of the alternator. This manual does not include instructions for servicing and maintaining the alternator. Contact CGT Customer Service for details.

Before operating the alternator, read this manual and make sure that all personnel who work on the equipment have access to the manual and all additional documentation supplied with it. Misuse and failure to follow the instructions, and the use of non-approved parts, may invalidate the product warranty and lead to potential accidents.

This manual is an essential part of the alternator. Make sure that the manual is available to all users throughout the life of the alternator.

The manual is written for skilled electrical and mechanical technicians and engineers, who have prior knowledge and experience of generating equipment of this type. If in doubt, please seek expert advice or contact your local Cummins Generator Technologies subsidiary.

NOTICE
Information in this manual was correct when published. It may be superseded due to our policy of continuous improvement. Please visit www.stamford-avk.com for latest documentation.

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2 Safety Precautions

2.1 Safety Information and Notices used in this Manual

Danger, Warning and Caution panels are used in this manual to describe the sources of hazards, their consequences and how to avoid injury. Notice panels emphasize important or critical instructions.

⚠ DANGER
Danger indicates a hazardous situation which, if not avoided, WILL result in death or serious injury.

⚠ WARNING
Warning indicates a hazardous situation which, if not avoided, COULD result in death or serious injury.

⚠ CAUTION
Caution indicates a hazardous situation which, if not avoided, COULD result in minor or moderate injury.

NOTICE
Notice refers to a method or practice which can result in product damage, or to draw attention to additional information or explanations.

2.2 General Guidance

NOTICE
These safety precautions are for general guidance and supplement your own safety procedures and all applicable laws and standards.

2.3 Skill Requirements of Personnel

Service and maintenance procedures must only be carried out by experienced and qualified engineers, who are familiar with the procedures and the equipment.

2.4 Risk Assessment

A risk assessment has been performed on this product by Cummins, however a separate risk assessment must be performed by the user/operating company to establish all personnel-related risks. All affected users must be trained on the identified risks. Access to the Power Plant/Generator Set during operation must be restricted to persons who have been trained on these risks.

2.5 Personal Protective Equipment (PPE)

All persons operating, servicing, maintaining or working in or with a power plant or a generator set must wear appropriate Personal Protective Equipment (PPE)

Recommended PPE includes:

- Ear and Eye Protection
- Head and face protection
- Safety footwear
- Overalls that protect the lower arms and legs

Ensure that all persons are fully aware of the emergency procedures in case of accidents.

2.6 Noise

⚠ WARNING
Noise
Noise from a running alternator can cause serious injury by permanent hearing damage.
To prevent injury, wear appropriate personal protection equipment (PPE).

Maximum A-weighted noise emissions may reach 109 dB(A). Contact the supplier for application-specific details.

2.7 Electrical Equipment

⚠ DANGER
Live Electrical Conductors
Live electrical conductors can cause serious injury or death by electric shock and burns.
To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

All electrical equipment can be dangerous if not operated correctly. Always install, service and maintain the alternator in accordance with this manual. Work that requires access to electrical conductors must comply with all applicable local and national electrical safety procedures for the voltages involved and any site specific rules. Always use genuine branded replacement parts.

2.8 Lock Out/Tag Out

⚠ WARNING
Reconnected Energy Source
Accidental reconnection of energy sources during service and maintenance work can cause serious injury or death by electric shock, burns, crushing, severing or trapping.
To prevent injury and before starting service and maintenance work, use appropriate lock out/tag out safety procedures to keep the generator set isolated from energy sources. Do not defeat or bypass the lock out/tag out safety procedures.

2.9 Strong Magnetic Field

⚠ WARNING

Strong Magnetic Field

The strong magnetic field from a permanent magnet generator (PMG) or excitation boost system (EBS), can cause serious injury or death by interference with implanted medical devices.

To prevent injury, do not work near a PMG or EBS if you have an implanted medical device.

2.10 Lifting

⚠ DANGER

Falling Mechanical Parts

Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping.

To prevent injury and before lifting:

- ***Check the capacity, condition and attachment of lifting equipment (crane, hoists and jacks, including attachments to anchor, fix or support the equipment).***
- ***Check the capacity, condition and attachment of accessories for lifting (hooks, slings, shackles and eye bolts for attaching loads to lifting equipment).***
- ***Check the capacity, condition and attachment of lifting fixtures on the load.***
- ***Check the mass, integrity and stability (e.g. unbalanced or shifting center of gravity) of the load.***

⚠ WARNING

Falling Mechanical Parts

Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping.

To prevent injury and before lifting the alternator:

- ***Do not lift the complete generator set by the alternator lifting fixtures.***
- ***Keep the alternator horizontal when lifting.***
- ***Fit drive end and non-drive end transit fittings to single bearing alternators to keep the main rotor in the frame.***

Do not remove the lifting label attached to one of the lifting points.

2.11 Alternator Operating Areas

⚠ WARNING

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- ***Keep away from the air inlet and air outlet when the alternator is running.***
- ***Do not put operator controls near the air inlet and air outlet.***
- ***Do not cause overheating by running the alternator outside rating plate parameters.***
- ***Do not overload the alternator.***
- ***Do not run an alternator with excessive vibration.***
- ***Do not synchronize parallel alternators outside the specified parameters.***

Always wear suitable PPE when working in the hatched areas shown in the diagram or directly in-line with any air inlet/outlet.

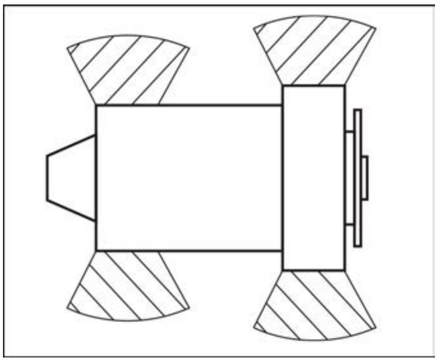

FIGURE 1. HATCHED AREAS

Make sure this consideration is captured in your risk assessment.

2.12 Hazard Warning Labels

⚠ WARNING

Safety Cover Removed

A hazard exposed when a safety cover is removed can cause serious injury or death.

To prevent injury:

- ***Fit the safety labels at the locations shown on the back of the label sheet supplied.***
- ***Observe the safety labels.***
- ***Refer to the service manual before removing covers.***

The generator set manufacturer is responsible for fitting the self-adhesive hazard warning labels supplied with the alternator.

Replace labels that are missing, damaged or painted over.

FIGURE 2. HAZARD WARNING LABELS

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3 Safety Directives and Standards

STAMFORD Alternators meet applicable European safety directives, and national and international standards relevant to alternators. The alternator must be operated within the limits specified in the relevant standards and within the parameters on the alternator rating plate.

Marine alternators meet the requirements of all the major marine classification societies.

This manual includes declaration template examples. Alternators are supplied with a declaration certificate that displays the product description and unique serial number.

3.1 Low Voltage Directive: Declaration of Conformity

EU DECLARATION OF CONFORMITY — Cummins Generator Technologies

This synchronous A.C. generator is designed for incorporation into an electricity generating-set and fulfils all the relevant provisions of the following EU Directive(s) when installed in accordance with the installation instructions contained in the product documentation:

2014/35/EU	Low Voltage Directive
2014/30/EU	The Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction on Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive
2015/863	Delegated Directive amending Annex II of 2011/65/EU

and that the standards and/or technical specifications referenced below have been applied:

EN 61000-6-2:2005	Electromagnetic compatibility (EMC). Generic standards – Part 6-2: Immunity for industrial environments
EN 61000-6-4:2007+A1:2011	Electromagnetic compatibility (EMC). Generic standards – Part 6-4: Emission standard for industrial environments
EN ISO 12100:2010	Safety of machinery – General principles for design – Risk assessment and risk reduction
EN 60034-1:2010	Rotating electrical machines - Part 1: Rating and performance
BS ISO 8528-3:2005	Reciprocating internal combustion engine driven alternating current generating sets - Part 3: Alternating current generators for generating sets
BS 5000-3:2006	Rotating electrical machines of particular types or for particular applications - Part 3: Generators to be driven by reciprocating internal combustion engines - Requirements for resistance to vibration
EN 50581:2012	Technical documentationfor the assessmentof electrical and electronic products with the respect to the restriction of hazardous substances

This declaration has been issued under the sole responsibility of the manufacturer. The object of this Declaration is in conformity with the relevant Union harmonization Legislation.

The name and address of authorised representative, authorised to compile the relevant technical documentation, is the Company Secretary, Cummins Generator Technologies Romania, B-dul Decebal Nr. 116A 200746 Craiova Dolj, Romania.

Signed: K J Simon Date: 6th March 2019	Name, Title and Address: Kevan J Simon Global Technical Director Cummins Generator Technologies Romania B-dul Decebal Nr.116A 200746, Craiova Dolj, ROMANIA

Description	Serial Number
Sheet 1	450-16383-G

Registered in England under Registration No. 441273., Cummins Generator Technologies Ltd. Registered Office: Fountain Court, Lynch Wood, Peterborough, UK, PE2 6FZ

FIGURE 3. DECLARATION OF CONFORMITY - SHEET 1

EU DECLARATION OF CONFORMITY

Cummins Generator Technologies

The A.C. Generator utilizes hazardous material exemptions as detailed in Annex III of EU Directive 2011/65/EU

Products carrying the following descriptions are considered to be out of scope of RoHS Directive 2011/65/EU, intended to be installed in Large Scale Fixed Installations and for installation into a pre-defined and dedicated location, installed and de-installed by professionals:

LVI80*
LVSI80*
DSG 99*
DSG 114*
DSG 125*
DSG 144*

Where "*" represents any combination of letters and characters completing the specific description of the product

Sheet 2 450-16383-G

Registered in England under Registration No. 441273., Cummins Generator Technologies Ltd. Registered Office: Fountain Court, Lynch Wood, Peterborough, UK, PE2 6FZ

FIGURE 4. DECLARATION OF CONFORMITY - SHEET 2

3.2 Machinery Directive: Declaration of Incorporation

2006/42/EC MACHINERY DIRECTIVE
DECLARATION OF INCORPORATION
OF PARTLY COMPLETED MACHINERY

Generator Technologies

Function: Synchronous A.C. generator designed for incorporation into an electricity generating-set.

The partly completed machinery supplied with this declaration:

- Is designed and constructed solely as a non-functional component to be incorporated into a machine requiring completion.
- Is designed to comply with the provisions of the following EU Directives so far as their level of build will allow:

2014/30/EU	The Electromagnetic Compataibility (EMC) Directive
2014/35/EU	Low Voltage Directive
2011/65/EU	Restriction on Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive
2015/863	Delegated Directive amending Annex II of 2011/65/EU

- Must not be put into sevice within the European Community ("EC") until the final machinery into which it is to be incorporated has been declared in conformity with the Machinery Directive and all other applicable EC Directives
- Is designed and constructed to comply with the essential health and safety requirements of the Machinery Directive 2006/42/EC listed on sheet 2 of this Declaration.

The relevant technical documentation is compiled in accordance with the provisions of part B of Annex VII of the Machinery Directive. All relevant information about the partly completed machinery will be provided, in writing, on a reasoned request by the appropriate national authority to its authorized representative. The name and address of authorised representative, authorised to compile the relevant technical documentation, is the Company Secretary, Cummins Generator Technologies Romania, B-dul Decebal Nr. 116A 200746 Craiova Dolj, Romania

The undersigned representing the manufacturer:

Signed: K J Simon Date: 6th March 2019	Name, Title and Address: Kevan J Simon Global Technical Director Cummins Generator Technologies Romania B-dul Decebal Nr.116A 200746, Craiova Dolj, ROMANIA

Description	Serial Number
Sheet 1	450-16388-G

Registered in England under Registration No. 441273., Cummins Generator Technologies Ltd. Registered Office: Fountain Court, Lynch Wood, Peterborough, UK, PE2 6FZ

FIGURE 5. DECLARATION OF INCORPORATION - SHEET 1

2006/42/EC MACHINERY DIRECTIVE
DECLARATION OF INCORPORATION
OF PARTLY COMPLETED MACHINERY

Generator Technologies

ESSENTIAL HEALTH AND SAFETY REQUIREMENTS RELATING TO THE DESIGN AND CONSTRUCTION OF PARTLY COMPLETED MACHINERY

1.1 General Remarks

- 1.1.2 : Principles of safety integration
- 1.1.3 : Materials and products
- 1.1.5 : Design of machinery to facilitate its handling

1.3 Protection Against Mechanical Hazards

- 1.3.1 : Risk of loss of stability
- 1.3.2 : Risk of break-up during operation
- 1.3.3 : Risks due to falling or ejected objects
- 1.3.4 : Risks due to surfaces, edges or angles
- 1.3.7 : Risks related to moving parts
- 1.3.8.1 : Moving transmission parts

1.4 Guarding*

- 1.4.1 : Guards - General requirements*
- 1.4.2.1 : Fixed guards*

1.5 Other Hazards

- 1.5.2 : Static electricity
- 1.5.3 : Energy supply other than electric
- 1.5.4 : Errors of fitting
- 1.5.6 : Fire
- 1.5.13 : Emmisions of hazardous materials and substances

1.7 Information

- 1.7.1 : Information and warnings on the machinery
- 1.7.4 : Instructions

LEGEND

1 . Essential Health and Safety Requirements not shown are not considered applicable for this Partly Completed Machinery or must be fulfilled by the assembler of the Machinery.

2 . Essential Health and Safety Requirements shown are considered applicable for this Partly Completed Machinery and have been fulfilled by the manufacturer to the extent possible, subject to the build requirements of the Machinery assembler, the information contained in the assembly instructions and Cummins bulletins.

3 . * Customers may request Partly Completed Machinery without some or all guarding attached. In these cases section 1.4 Guarding does not apply and the Essential Health and Safety Requirements for guarding must be fulfilled by the assembler of the Machinery

The A.C. Generator utilizes hazardous material exemptions as detailed in Annex III of EU Directive 2011/65/EU.

Products carrying the following descriptions are considered to be out of scope of RoHS Directive 2011/65/EU, intended to be installed in Large Scale Fixed Installations and for installation into a pre-defined and dedicated location, installed and de-installed by professionals:

LVI80*
LVSI80*
DSG 99*
DSG 114*
DSG 125*
DSG 144*

Where "*" represents any combination of letters and characters completing the specific description of the product.

Sheet 2 450-16388-G

Registered in England under Registration No. 441273., Cummins Generator Technologies Ltd. Registered Office: Fountain Court, Lynch Wood, Peterborough, UK, PE2 6FZ

FIGURE 6. DECLARATION OF INCORPORATION - SHEET 2

3.3 Additional Information for EMC Compliance

STAMFORD alternators are designed to meet EMC emissions and immunity standards for industrial environments. Additional equipment may be required when the alternator is installed in residential, commercial and light industrial environments.

The installation ‘earth/ground’ arrangements require the connection of the alternator frame to the site protective earth conductor using a minimum lead length.

Installation, maintenance and servicing must be carried out by adequately trained personnel fully aware of the requirements of the relevant EC directives.

NOTICE
Cummins Generator Technologies is not liable for EMC compliance if unauthorized parts, not of STAMFORD brand, are used for maintenance and servicing.

3.4 Additional Information for CSA Compliance

To comply with Canadian Standards Association (CSA) regulations, all external wiring and components must be rated at the alternator rated voltage shown on the rating plate label.

4 Introduction

4.1 General Description

HC alternators are of brushless rotating field design, available up to 690 V, 50 Hz (1000 RPM, 6 pole and 1500 RPM, 4 pole) or 60 Hz (1200 RPM, 6 pole and 1800 RPM, 4 pole), and built to meet BS5000 Part 3 and international standards.

HC alternators are available self-excited, where excitation power is from the main output windings, or separately-excited, where a permanent magnet generator (PMG) supplies excitation power.

4.2 Alternator Name

TABLE 1. HC ALTERNATOR NAMING FORMAT

Example:	HC	5	-	HC	I	5	3	4	C	2
	Alternator model (HC4, HC5, HC6)			Alternator type (HC = standard, HCK = dedicated, not HC6)	Application (I = industrial, M = marine)	Frame size (4, 5, 6)	Excitation (3 = with PMG, 4 = without PMG)	Number of poles	Core length (A, B, C, ...)	Number of bearings (1 = NDE, 2 = DE & NDE)

4.3 Serial Number Location

A unique serial number is stamped into the upper section of the frame.

4.4 Rating Plate

The fixed rating plate label states the intended operating parameters of the alternator.

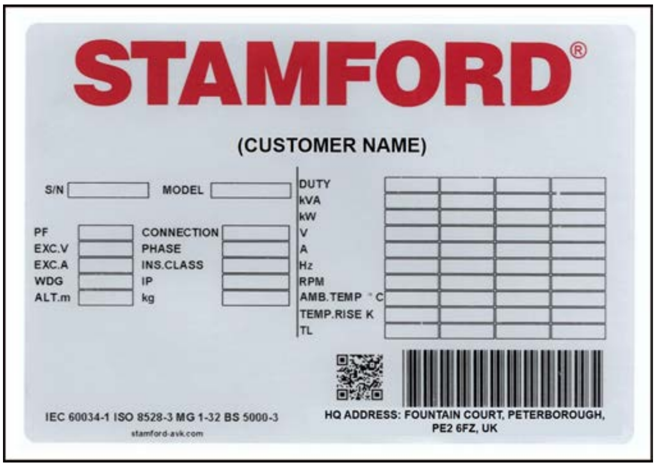

FIGURE 7. GLOBAL STAMFORD AC ALTERNATOR RATING PLATE

4.5 Product Authentication

The STAMFORD high security, anti-counterfeit hologram is located on the Tracking Label. Check that the dots are visible around the STAMFORD logo when viewing the hologram from different angles and the word "GENUINE" appears behind the logo. Use a flashlight to see these security features in low ambient light. Check that the alternator is genuine by entering the unique 7 character hologram code at **www.stamford-avk.com/verify**.

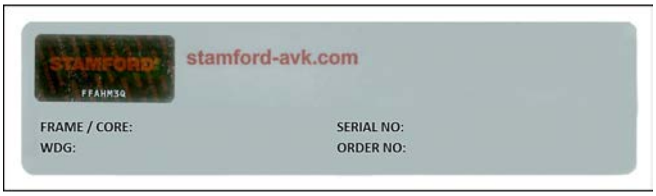

FIGURE 8. TRACKING LABEL

FIGURE 9. DOTS VISIBLE IN LEFT, RIGHT, UPPER AND LOWER VIEWS OF 3D HOLOGRAM

5 Application of the Alternator

It is the customer's responsibility to make sure that the selected alternator is suitable for the final application.

5.1 Environment

The alternators are protected to IP23 as standard. IP23 is not adequate protection for use outdoors without additional measures.

TABLE 2. ENVIRONMENTAL SPECIFICATION

Ambient Temperature	-15 °C to 40 °C (5 °F to 104 °F)
Relative Humidity	< 70%
Altitude	< 1000 m (3280 ft)

The alternator has been designed for the environment shown in the table. The alternator can operate outside these conditions if it is rated accordingly; the nameplate gives details. If the operating environment is changed after purchase, refer to the factory for a revised alternator rating.

5.2 Air Flow

TABLE 3. MINIMUM AIR FLOW AND MAXIMUM PRESSURE DIFFERENCE

Alternator Model and Frequency	Minimum Air flow, m^3/s (ft^3/min)		Maximum intake to outlet pressure difference in mm (in) water gauge
	50 Hz	60 Hz	
HC4	0.8 (1700)	0.99 (2100)	6 (0.25)
HC5	1.04 (2202)	1.31 (2780)	6 (0.25)
HCK5	1.23 (2615)	1.59 (3366)	6 (0.25)
HC6	1.62 (3420)	1.96 (4156)	6 (0.25)

Make sure that the air inlets and outlets are not blocked while the alternator is running.

5.3 Airborne Contaminants

Contaminants such as salt, oil, exhaust fumes, chemicals, dust, and sand will reduce the effectiveness of the insulation and the life of the windings. Consider using air filters and an enclosure to protect the alternator.

5.4 Air Filters

Air filters trap airborne particulates above 5 microns. The filters must be cleaned or replaced regularly, depending on site conditions. Check the filters frequently to establish an appropriate service interval.

Alternators with factory-fitted filters are rated to account for the reduced flow rate of cooling air. If filters are retrofitted, the alternator rating must be reduced by 5%.

Air filters do not remove water. Keep the filters dry with additional protection. Wet filters further restrict airflow, causing the alternator to overheat and leading to premature failure of the insulation.

5.5 Humid Conditions

The water carrying capacity of air depends on temperature. If the air temperature falls below its saturation point, dew may form on the windings, reducing the electrical resistance of the insulation. In humid conditions, additional protection may be required even if the alternator is fitted inside an enclosure. Anti-condensation heaters are supplied on request.

5.6 Anti-Condensation Heaters

⚠ DANGER
Live Electrical Conductors
Live electrical conductors can cause serious injury or death by electric shock and burns.
To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

Power to the anti-condensation heater is supplied from a separate source. Anti-condensation heaters raise the air temperature around the windings to deter condensation forming in humid conditions when the alternator is not operating. Best practice is to energize the heaters automatically when the alternator is off.

5.7 Enclosures

Fit an enclosure to protect the alternator from adverse environmental conditions. Make sure that air entering the alternator is of adequate flowrate, free from moisture and contaminants, and below the maximum ambient temperature on the rating plate.

Make sure there is sufficient access around the alternator for safe maintenance.

5.8 Vibration

The alternators are designed to withstand the vibration levels encountered on generator sets built to meet the requirements of ISO 8528-9 and BS 5000-3. (Where ISO 8528 is taken to be broad band measurements and BS5000 refers to the predominant frequency of any vibrations on the generator set).

NOTICE
Exceeding either of the above specifications will have a detrimental effect on the life of the bearings and other components, and may invalidate the alternator warranty.

NOTICE
The terminal box is designed to support the fitted busbars or terminals, transformers, load cables and auxiliary terminal box. Additional mass could cause excessive vibration and lead to failure of the terminal box enclosure and mounting. Refer to the Installation Manual to connect the load cables to the terminal box. Refer to CGT before fixing any additional mass to the terminal box.

5.8.1 Definition of BS5000–3

Alternators shall be capable of continuously withstanding linear vibration levels with amplitudes of 0.25 mm between 5 Hz and 8 Hz, and velocities of 9.0 mm/s RMS between 8 Hz and 200 Hz, when measured at any point directly on the carcass or main frame of the machine. These limits refer only to the predominant frequency of vibration of any complex waveform.

5.8.2 Definition of ISO 8528-9

ISO 8528-9 refers to a broad band of frequencies; the broad band is taken to be between 10 Hertz and 1000 Hertz. The table below is an extract from ISO 8528-9 (Table C.1, value 1). This simplified table lists the vibration limits by kVA and speed for acceptable operation of standard generator set designs.

5.8.3 Vibration Frequencies

The main vibration frequencies produced by the alternator are as follows:

- 6-pole 1000 RPM 16⅔ Hz
- 6-pole 1200 RPM 20 Hz
- 4-pole 1500 RPM 25 Hz
- 4-pole 1800 RPM 30 Hz

Vibrations induced in the alternator by the engine are complex. It is the responsibility of the generator set designer to ensure that the alignment and stiffness of the bedplate and mountings do not allow vibration to exceed BS5000 part 3 and ISO 8528 part 9 limits.

5.8.4 Linear Vibration Limits

TABLE 4. HC ALTERNATOR LINEAR VIBRATION LEVEL MEASUREMENTS

Engine Speed RPM (min^{-1})	Power Output (kVA)	Vibration Displacement RMS (mm)	Vibration Velocity RMS (mm/s)	Vibration Acceleration RMS (mm/s^2)
1300 ≤ RPM ≤ 2000	250 < S	0.32	20	13
720 ≤ RPM < 1300	250 < S ≤ 1250	0.32	20	13
Note: The broadband is taken as 10 Hz - 1000 Hz.				

5.8.5 Linear Vibration Monitoring

We recommend using vibration analyzing equipment to measure vibration at all of the 12 positions shown below. Check that vibration of the generator set is below the limits stated in the standards. If vibration is above the limits, the generator set builder should investigate the root causes and eliminate them. Best practice is for the generator set builder to take initial readings as a reference and for the user to periodically monitor vibration, according to the recommended service schedule, to detect a deteriorating trend.

5.8.1 Definition of BS5000–3

Alternators shall be capable of continuously withstanding linear vibration levels with amplitudes of 0.25 mm between 5 Hz and 8 Hz, and velocities of 9.0 mm/s RMS between 8 Hz and 200 Hz, when measured at any point directly on the carcass or main frame of the machine. These limits refer only to the predominant frequency of vibration of any complex waveform.

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1300 ≤ RPM ≤ 2000	250 < S	0.32	20	13
720 ≤ RPM < 1300	250 < S ≤ 1250	0.32	20	13
Note: The broadband is taken as 10 Hz - 1000 Hz.				

5.8.5 Linear Vibration Monitoring

We recommend using vibration analyzing equipment to measure vibration at all of the 12 positions shown below. Check that vibration of the generator set is below the limits stated in the standards. If vibration is above the limits, the generator set builder should investigate the root causes and eliminate them. Best practice is for the generator set builder to take initial readings as a reference and for the user to periodically monitor vibration, according to the recommended service schedule, to detect a deteriorating trend.

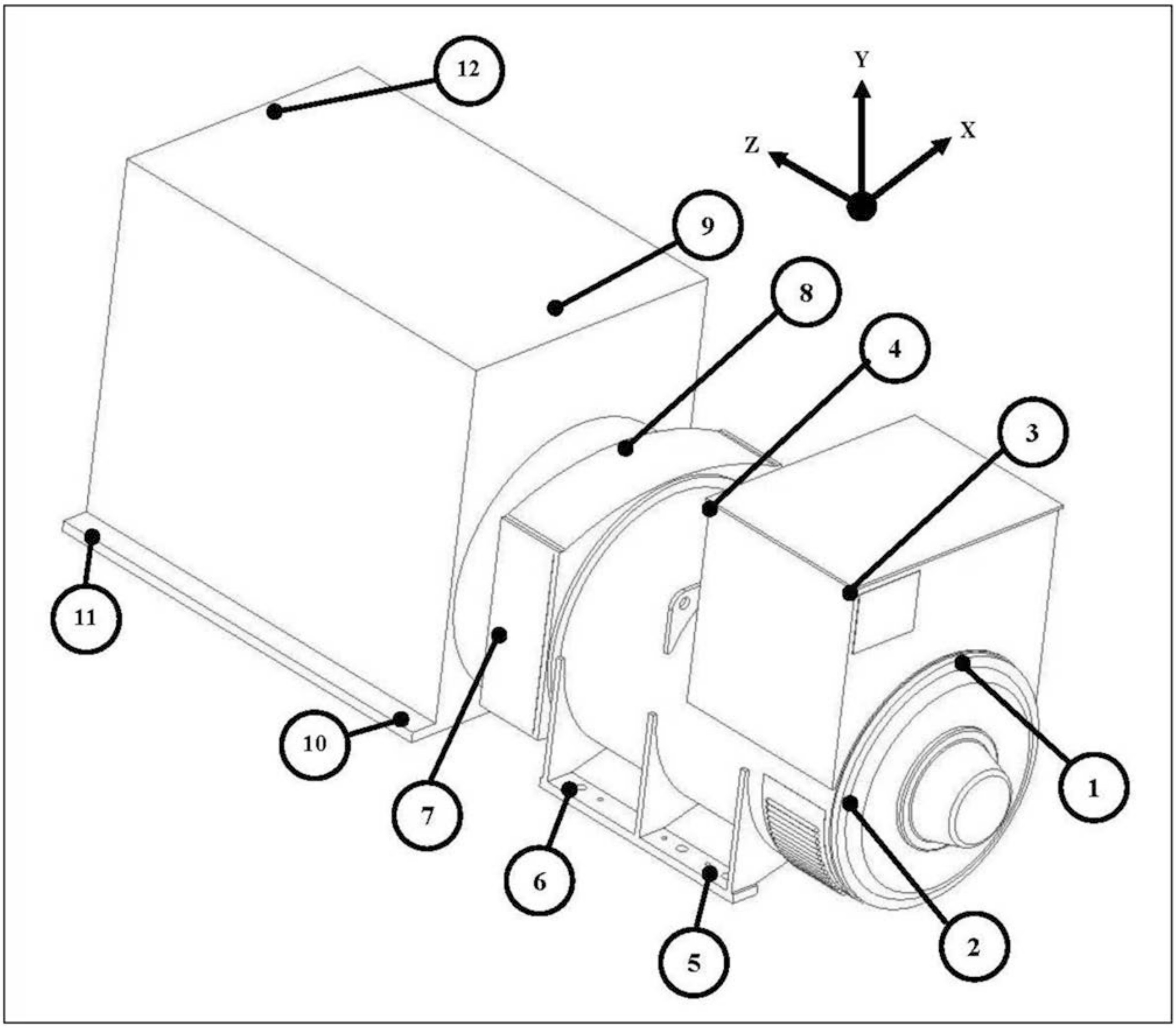

FIGURE 10. VIBRATION MEASUREMENT LOCATIONS

5.8.6 Excessive Vibration

⚠ **WARNING**

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- ***Keep away from the air inlet and air outlet when the alternator is running.***
- ***Do not put operator controls near the air inlet and air outlet.***
- ***Do not cause overheating by running the alternator outside rating plate parameters.***
- ***Do not overload the alternator.***
- ***Do not run an alternator with excessive vibration.***
- ***Do not synchronize parallel alternators outside the specified parameters.***

If the measured vibration of the generator set is not within the limits:

1. Consult with the generator set manufacturer to reduce vibration to an acceptable level.
2. Contact Cummins Generator Technologies to assess the impact on bearing and alternator life expectancy.

5.9 Bearings

5.9.1 Sealed Bearings

Inspect sealed-for-life bearings periodically, according to the recommended service schedule in this manual. Check for signs of wear, fretting or other detrimental features. Damage to seals, grease leakage or discoloration of the bearing races indicate that the bearing may need to be replaced.

5.9.2 Re-greasable Bearings

Each bearing housing is connected by a grease pipe to an external grease nipple. A label gives the grease type and quantity, and frequency for re-greasing. The recommended grease is a high specification synthetic compound that must not be mixed with grease of a different specification. Refer to the Service and Maintenance chapter for detailed instructions.

5.9.3 Bearing Life

Factors that reduce bearing life or lead to bearing failure include:

- Adverse operating conditions and environment
- Stress caused by misalignment of the generator set
- Vibration from the engine that exceeds the limits in BS 5000-3 and ISO 8528-9
- Long periods (including transportation) when the alternator is stationary and subjected to vibration can cause false brinelling wear (flats on the balls and grooves on the races)
- Humid or wet conditions that cause corrosion and deterioration of the grease by emulsification.

5.9.4 Health Monitoring of the Bearings

We recommend that the user checks the bearing condition using vibration monitoring equipment. Best practice is to take initial readings as a reference and periodically monitor the bearings to detect a deteriorating trend. It will then be possible to plan a bearing change at an appropriate generator set or engine service interval.

5.9.5 Bearing 'Service Life' Expectancy

Bearing manufacturers recognize that the service life of bearings depends on factors that are outside their control. Rather than quote a service life, practicable replacement intervals are based on the L10 life of the bearing, the type of grease, and the recommendations of the bearing and grease manufacturers.

For general purpose applications: If the correct maintenance is carried out, vibration levels do not exceed the levels stated in ISO 8528-9 and BS5000-3, and the ambient temperature does not exceed 50 °C, plan to replace the bearings within 30,000 hours of operation.

If in doubt regarding any aspect of bearing life of a STAMFORD alternator, contact the nearest authorized supplier of the alternator or contact Cummins Generator Technologies.

5.9.6 Standby Applications

Run alternators in standby applications at no load for a minimum of 10 minutes every week. For alternators fitted with regreasable bearings, re-grease the bearings every 6 months, regardless of the number of accumulated running hours.

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6 Installation into the Generator Set

6.1 Alternator Dimensions

Dimensions are included in the data sheet specific to the alternator model. Refer to the rating plate to identify the alternator model.

NOTICE
Data sheets are available from www.stamford-avk.com

6.2 Lifting the Alternator

⚠ WARNING
Falling Mechanical Parts ***Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping.*** ***To prevent injury and before lifting the alternator:*** • ***Do not lift the complete generator set by the alternator lifting fixtures.*** • ***Keep the alternator horizontal when lifting.*** • ***Fit drive end and non-drive end transit fittings to single bearing alternators to keep the main rotor in the frame.***

Lift the alternator by hooks or shackles attached to the lifting points (lugs or eyes) provided. A label attached to a lifting point shows the correct lifting arrangement. Use chains of sufficient length, and a spreader bar if necessary, to make sure that the chains are vertical when lifting. Make sure that the capacity of the lifting equipment is sufficient for the alternator mass shown on the label.

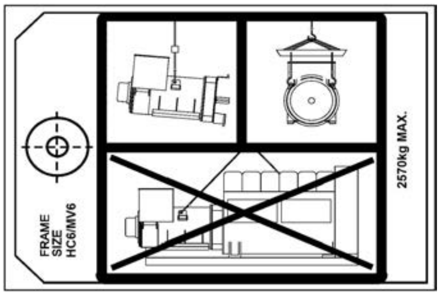

FIGURE 11. LIFTING LABEL

6.3 Storage

If the alternator will not be used immediately, it must be stored in a clean, dry, vibration-free environment. We recommend the use of anti-condensation heaters, when available.

If the alternator can be rotated, turn the rotor a minimum of 6 revolutions every month during storage.

6.3.1 After Storage

After a period of storage, carry out the pre-running checks to determine the condition of the windings. If the windings are damp or the insulation resistance is low, follow one of the drying out procedures (see **Chapter 7 on page 33**).

Before putting the alternator into service, refer to the following table.

TABLE 5. BEARING STORAGE

Bearing Type	Not Rotated during Storage	Rotated during Storage
Sealed Bearing(s)	If stored less than 12 months, put the alternator into service. If stored more than 12 months, replace the bearing(s) then put the alternator into service.	If stored less than 24 months, put the alternator into service. If stored more than 24 months, replace the bearing(s) then put the alternator into service.
Re-greasable Bearing(s)	If stored less than 12 months, put the alternator into service. If stored more than 12 months, replace the bearing(s) then put the alternator into service.	If stored less than 6 months, put the alternator into service. If stored between 6 and 24 months, re-grease the bearing(s) during the first run then put the alternator into service. If stored more than 24 months, replace the bearing(s) then put the alternator into service.

6.3.2 Storage Instruction

When an alternator is stationary, in storage or otherwise, it may be subjected to environmental factors, such as vibration, humidity, temperature and airborne contaminant particles, that could degrade the bearing arrangements.

Contact CGT for advice in advance if the alternator will be stationary for long periods.

6.4 Generator Set Coupling

⚠ WARNING

Moving Mechanical Parts

Moving mechanical parts during generator set coupling can cause serious injury by crushing, severing or trapping.

To prevent injury, keep arms, hands and fingers away from mating surfaces when coupling the generator set.

Efficient operation and long component life depend on minimizing mechanical stresses on and damage to the alternator. When coupled in a generator set, misalignment and vibration interactions with the prime mover engine can cause mechanical stress. In addition, rotating the alternator rotor using a lever against the vanes of the cooling fan will damage the fan. The fan is not designed to withstand such forces.

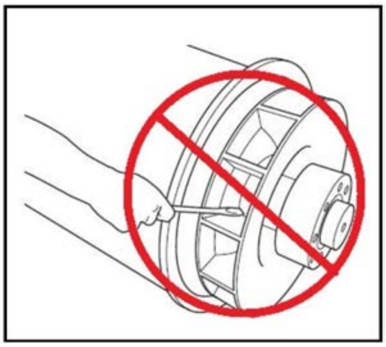

FIGURE 12. DO NOT ROTATE THE ALTERNATOR ROTOR WITH A LEVER

Generator sets need a substantial flat continuous bedplate to suit the installation site floor loading with engine and alternator mounting pads to make a firm base for accurate alignment. The height of all mounting pads must be within 0.25 mm for skid mounting, 3 mm for non-adjustable anti-vibration mounts (AVM) or 10 mm for adjustable height AVMs. Use shims to achieve level. The rotational axes of alternator rotor and engine output shaft must be coaxial (radial alignment) and perpendicular to the same plane (angular alignment). The axial alignment of the alternator and engine coupling must be within 0.5 mm, to allow for thermal expansion without unwanted axial force on the bearings at operating temperature.

Vibration can occur by flexing of the coupling. The alternator is designed for a maximum bending moment not exceeding 140 kgm (1000 lbs ft) for frame sizes 4 and 5, and not exceeding 275 kgm (2000 lbs ft) for frame size 6. Check the maximum bending moment of the engine flange with the engine manufacturer.

Close-coupling of alternator and engine can increase the rigidity of the generator set. Both single and two bearing alternators can be close-coupled. The generator set builder must supply guarding for open-coupled applications.

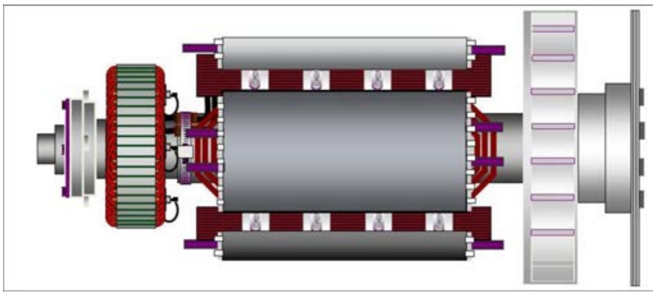

FIGURE 13. SINGLE BEARING ALTERNATOR ROTOR SHOWING COUPLING DISCS BOLTED TO DRIVE END COUPLING HUB AT RIGHT

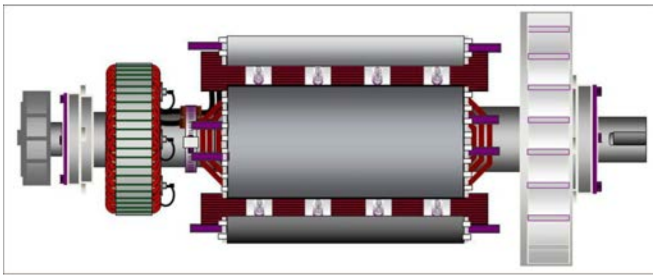

FIGURE 14. TWO BEARING ALTERNATOR ROTOR SHOWING SHAFT WITH KEYWAY FOR FLEXIBLE COUPLING AT RIGHT

To prevent rust during transit and storage, the alternator frame spigot, rotor coupling plates and shaft extension have been treated with a rust preventative coating. Remove this before coupling the generator set.

6.5 Single Bearing

⚠ WARNING

Falling Mechanical Parts

Falling mechanical parts can cause serious injury or death by impact, crushing, severing or trapping.

To prevent injury and before lifting the alternator:

- ***Do not lift the complete generator set by the alternator lifting fixtures.***
- ***Keep the alternator horizontal when lifting.***
- ***Fit drive end and non-drive end transit fittings to single bearing alternators to keep the main rotor in the frame.***

1. Remove the drive end transit bracket that keeps the rotor in place during transport.
2. Remove the air outlet covers from the drive end of the alternator to access the coupling and adaptor bolts.
3. Make sure the coupling discs are concentric with the adaptor.
4. Fit two alignment dowels into flywheel bolt holes 180 degrees apart to help align the disc and the flywheel.
5. Lift and offer the alternator to the engine, barring the engine over by hand to align discs and flywheel.
6. Engage the alignment dowels into coupling disc bolt holes and push the alternator towards the engine until the coupling discs are against the flywheel face.

NOTICE

Do not pull the alternator to the engine using bolts through the flexible discs.

7. Fit the adaptor bolts, using heavy gauge washers under the heads. Tighten the adapter bolts evenly around the adapter.
8. Check the torque of each bolt in a clockwise direction around the bolt circle to ensure all the bolts are tight. Refer to the engine manufacturer’s manual for correct tightening torque.
9. Remove the alignment dowels. Fit the coupling bolts, using heavy gauge washers under the heads.
10. Tighten the bolts to fix the coupling disc to the flywheel in the sequence shown in **Figure 15 on page 27**.
11. Check the torque of each bolt in a clockwise direction around the bolt circle to ensure all the bolts are tight.
12. Remove the rotor support bracket, if supplied.
13. Replace all covers.

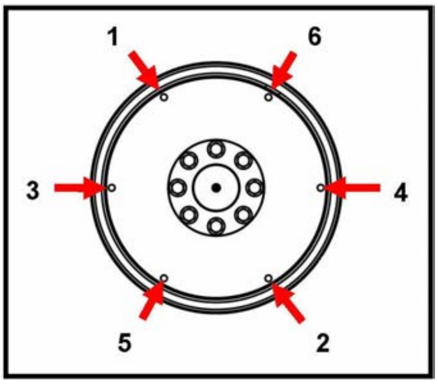

FIGURE 15. FIXING SEQUENCE

6.6 Two Bearing

A flexible coupling, designed to suit the specific engine/alternator combination, is recommended to minimise torsional vibration effects.

If a close coupling adaptor is used the alignment of machined faces must be checked by offering the alternator up to the engine. Shim the alternator feet if necessary.

6.7 Pre-Running Checks

Before starting the generator set, test the insulation resistance of windings and check that all connections are tight and in the correct location. Make sure the alternator air path is clear of obstructions. Replace all covers.

6.8 Direction of Rotation

The fan is designed for clockwise rotation, as viewed from the drive end of the alternator (unless otherwise specified when ordered). If the alternator must run counter-clockwise, please seek advice from Cummins Generator Technologies.

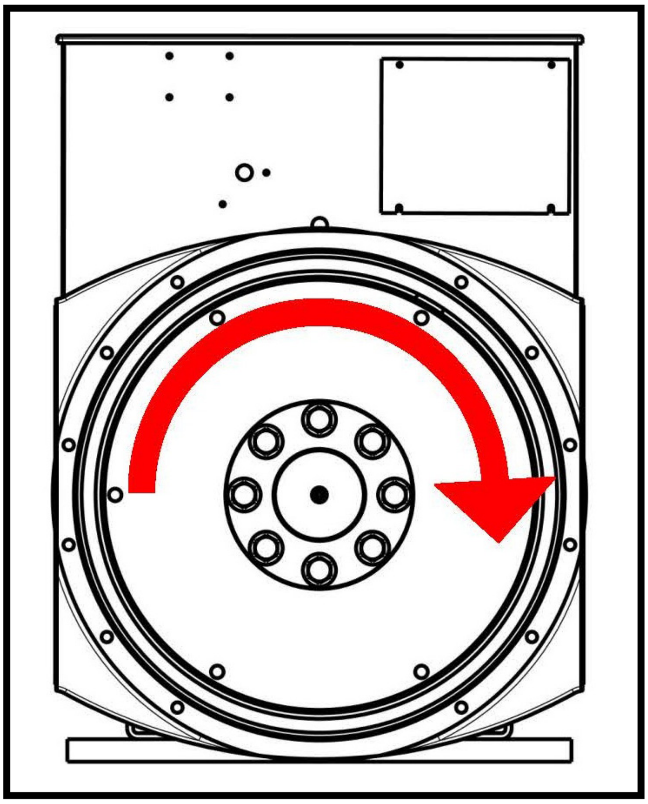

FIGURE 16. DIRECTION OF ROTATION

6.9 Phase Rotation

Main stator output is connected for a phase sequence of U V W when the alternator runs clockwise, as viewed from the drive end. If the phase rotation must be reversed, the customer must re-connect the output cables in the terminal box. Ask Cummins Generator Technologies for a circuit diagram of 'reverse phase connections'.

6.10 Voltage and Frequency

Check that the voltage and frequency shown on the alternator rating plate meet the requirements of the generator set application. Refer to detailed instructions in the AVR manual for adjustments.

6.11 AVR Settings

The AVR is factory set for initial running tests. Check that the AVR settings are compatible with your required output. Refer to detailed instructions in the AVR manual for on- and off-load adjustments.

6.12 Electrical Connections

⚠ WARNING
Incorrect Electrical Installation and System Protection   ***Incorrect electrical installation and system protection can cause serious injury or death by electric shock and burns.***   ***To prevent injury, installers must be qualified and are responsible for meeting appropriate inspectorate and local electricity authority requirements and site safety rules.***

NOTICE

The terminal box is designed to support the fitted busbars or terminals, transformers, load cables and auxiliary terminal box. Additional mass could cause excessive vibration and lead to failure of the terminal box enclosure and mounting. Refer to CGT before fixing any additional mass to the terminal box. Panels must be removed to be drilled or cut, to prevent swarf entering the terminal box or alternator.

Fault current curves and alternator reactance values are available on request from the factory so that the system designer can calculate the necessary fault protection and/or discrimination.

The installer must check that the alternator frame is bonded to the generator set bedplate, and must bond to site earth. If anti-vibration mounts are fitted between the alternator frame and its bedplate, a suitably-rated earth conductor must bridge across the anti-vibration mount.

Refer to wiring diagrams for electrical connection of the load cables. Electrical connections are made in the terminal box, constructed with removable panels to suit site-specific cable entry and glanding. After wiring, inspect the terminal box, remove all debris using a vacuum cleaner if necessary and check that no internal components are damaged or disturbed.

As standard, the alternator neutral is not bonded to the alternator frame. If required, neutral may be connected to the earth terminal in the terminal box, by a conductor of at least one half of the sectional area of a phase lead.

Load cables must be supported appropriately to avoid a tight radius at the point of entry into the terminal box, clamped at the terminal box gland, and allow at least ±25 mm movement by the generator set on its anti-vibration mountings, without causing excessive stress to the cables and alternator load terminals.

6.13 Grid Connection: Voltage Surges and Micro-Interruptions

Take precautions to prevent transient voltages generated by the connected load and/or the distribution system from causing damage to the alternator components.

To identify any possible risk, all aspects of the alternator's proposed application should be considered, especially the following:

- Loads with characteristics that result in large load step changes.
- Load control by switchgear, and power control by any method likely to generate transient voltage spikes.
- Distribution systems susceptible to external influences, such as lightning strikes.
- Applications involving parallel operation to a mains supply, where the risk of a mains disturbance in the form of a micro-interruption could occur.

If the alternator is at risk from voltage surges or micro-interruptions, include adequate protection into the generation system, usually with surge arrestors and suppressors, to meet regulations and installation requirements.

Surge protection must reduce the peak voltage at the alternator of a transient pulse of 5 μs rise time to less than 1.25 x √2 x (2 x rated output voltage + 1000 V). Best practise is to fit protective devices close to the output terminals. Refer to guidance from professional bodies and specialist equipment suppliers for further advice.

6.14 Varying Load

Under certain conditions, load variations can reduce alternator life.

Identify any possible risk, especially the following:

- Large capacitive loads (for example Power Factor Correction equipment) can affect alternator stability and cause pole slip.

- Stepped grid voltage variation (for example Tap Changing).

If the alternator is at risk from varying load, include adequate protection into the generator set system by under-excitation protection.

6.15 Synchronization

⚠ **WARNING**

Ejected Debris

Debris ejected during catastrophic failure can cause serious injury or death by impact, severing or stabbing.

To prevent injury:

- ***Keep away from the air inlet and air outlet when the alternator is running.***
- ***Do not put operator controls near the air inlet and air outlet.***
- ***Do not cause overheating by running the alternator outside rating plate parameters.***
- ***Do not overload the alternator.***
- ***Do not run an alternator with excessive vibration.***
- ***Do not synchronize parallel alternators outside the specified parameters.***

6.15.1 Parallel or Synchronizing Alternators

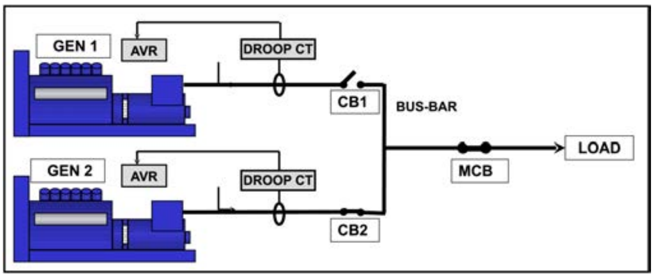

FIGURE 17. PARALLEL OR SYNCHRONIZING ALTERNATORS

The quadrature droop current transformer (Droop CT) gives a signal proportional to reactive current; the AVR adjusts excitation to reduce circulating current and allow each alternator to share reactive load. A factory-fitted droop CT is pre-set for 5% voltage drop at full-load zero power factor. Refer to the supplied AVR manual for droop adjustment.

- The synchronizing switch/breaker (CB1, CB2) must be of a type that will not cause “contact bounce” when it operates.
- The synchronizing switch/breaker must be adequately rated to withstand the continuous full load current of the alternator.
- The switch/breaker must be able to withstanding the rigorous closing cycles during synchronizing and the currents produced if the alternator is paralleled out of synchronizm.
- The closing time of the synchronizing switch/breaker must be under the control of the synchronizer settings.
- The switch/breaker must be capable of operation under fault conditions such as short circuits. Alternator data sheets are available.

NOTICE

The fault level may include a contribution from other alternators as well as from the grid/mains utility.

The method of synchronizing should be either automatic, or by check synchronizing. The use of manual synchronizing is not recommended. The settings on the synchronizing equipment should be such that the alternator will close smoothly. For the synchronizing equipment to achieve this, the phase sequence must match the parameters in the table below.

TABLE 6. SYNCHRONIZING EQUIPMENT PARAMETERS

Voltage Difference	+/- 0.5%
Frequency Difference	0.1 Hz/sec
Phase Angle	+/- 10°
C/B Closing Time	50 ms

The voltage difference when paralleling with the grid/mains utility is +/- 3% .

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7 Service and Maintenance

7.1 Recommended Service Schedule

Refer to Safety Precautions section (**Chapter 2 on page 3**) of this manual before starting any service and maintenance activity.

Refer to Parts Identification section (**Chapter 8 on page 53**) for an exploded view of components and fastener information.

The recommended service schedule shows the recommended service activities in table rows, grouped by alternator subsystem. Columns of the table show the types of service activity, whether the alternator must be running, and the service levels. Service frequency is given in running hours or time interval, whichever is sooner. A cross (X) in the cells where a row intersects the columns shows a service activity type and when it is required. An asterisk (*) shows a service activity done only when necessary.

All service levels in the recommended service schedule can be purchased directly from Cummins Generator Technologies Customer Service Department. For details of your nearest service outlet visit **www.stamford-avk.com**,

1. Proper service and repair are vital to the reliable operation of your alternator and the safety of anyone coming into contact with the alternator.
2. These service activities are intended to maximize the life of the alternator but shall not vary, extend or change the terms of the manufacturer's standard warranty or your obligations in that warranty.
3. Each service interval is a guide only, and developed on the basis that the alternator was installed and is operated in accordance with the manufacturer's guidelines. If the alternator is located and/or operated in adverse or unusual environmental conditions, the service intervals may need to be more frequent. The alternator should be continually monitored between services to identify any potential failure modes, signs of misuse, or excessive wear and tear.

TABLE 7. ALTERNATOR SERVICE SCHEDULE

System	SERVICE ACTIVITY X = required * = if necessary	Alternator running	TYPE: Inspect	Test	Clean	Replace	SERVICE LEVEL: Commission	Post Commission	250 hrs / 0.5 year	Level 1	1000 hrs / 1 year	Level 2	10,000 hrs / 2 years	Level 3	30,000 hrs / 5 years
Alternator	Alternator rating		X				X								
	Bedplate arrangement		X				X								
	Coupling arrangement		X				X					*		X	
	Environmental conditions and cleanliness		X				X	X		X		X		X	
	Ambient temperature (inside & outside)			X			X	X		X		X		X	
	Complete machine - damage, loose parts & earth bonds		X				X	X		X		X		X	
	Guards, screens, warning and safety labels		X				X	X		X		X		X	
	Maintenance access		X				X								
	Electrical nominal operating conditions & excitation	X		X			X	X		X		X		X	
	Vibration*	X		X			X	X		X		X		X	
Windings	Condition of windings		X				X	X		X		X		X	
	Insulation resistance of all windings (PI test for MV/HV)			X			X	*		*		X		X	
	Insulation resistance of rotor, exciter and PMG			X				X		X					
	Temperature sensors	X		X			X	X		X		X		X	
	Customer settings for temperature sensors		X				X								

System	SERVICE ACTIVITY X = required * = if necessary	Alternator running	Inspect	Test	Clean	Replace	Commission	Post Commission / 250 hrs / 0.5 year	Level 1 / 1000 hrs / 1 year	Level 2 / 10,000 hrs / 2 years	Level 3 / 30,000 hrs / 5 years
Bearings	Condition of bearings		X				X				X
	Grease exhaust & trap				X			X	X	X	X
	Grease in re-greasable bearing(s)	X				X		every 4000 to 4500 hours / 6 months			
	Sealed bearing(s)		X					every 4000 to 4500 hours			
	Re-greasable & sealed bearing(s)					X				*	X
	Temperature sensors	X		X			X	X	X	X	X
	Customer settings for temperature sensors		X				X				
Terminal Box	All alternator/customer connections and cabling		X				X	X	X	X	X
Controls & Auxiliaries	Initial AVR & PFC set up	X		X			X				
	AVR & PFC settings	X		X				X	X	X	X
	Customer connection of auxiliaries			X			X		X	X	X
	Function of auxiliaries			X			X	X	X	X	X
	Synchronization settings		X				X				
	Synchronization	X		X			X	X	X	X	X
	Anti condensation heater					X				*	X
Rectifier	Diodes and varistors		X				X	X	X	X	
	Diodes and varistors					X					X
Cooling	Air inlet temperature	X		X			X	X	X	X	X
	Air flow (rate & direction)	X	X				X				
	Condition of fan		X				X	X	X	X	X
	Condition of air filter (where fitted)			X			X	X	X	X	X
	Air filters (where fitted)				X	X			*	*	*

* For stand-alone alternator only.

7.2 Bearings

7.2.1 Introduction

NOTICE
Do not overfill a bearing with grease; the bearing may be damaged.
Do not mix lubricant types. Change gloves to handle different lubricant
Assemble bearings in static- and dust-free conditions while wearing lint free gloves.
Store removed parts and tools in static- and dust-free conditions, to prevent damage or contamination.
A bearing is damaged by the axial force needed to remove it from the rotor shaft. Do not reuse a bearing.
A bearing is damaged if the insertion force is applied through the bearing balls. Do not press fit the outer race by force on the inner race, or vice versa.
Do not try to turn the rotor by levering against the cooling fan vanes. The fan will be damaged.

The alternator rotor is supported by a bearing at the non-drive end (NDE) and by either a bearing or a coupling to the prime mover at the drive end (DE).

- Lubricate each re-greasable bearing according to the recommended service schedule with the correct quantity and type of grease, also shown on a label fitted at the grease nipple.
- Inspect each sealed bearing according to the recommended service schedule. Seek advice from CGT if grease has leaked out of the bearing, notifying the bearing type and quantity leaked.

7.2.2 Safety

⚠ DANGER
Rotating Mechanical Parts
Rotating mechanical parts can cause serious injury or death by crushing, severing or trapping.
To prevent injury and before removing covers over rotating parts, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ WARNING
Hot Surfaces
Skin contact with hot surfaces can cause serious injury by burns.
To prevent injury, wear appropriate personal protection equipment (PPE).

⚠ CAUTION
Grease
Skin contact with grease can cause minor or moderate injury by contact dermatitis.
To prevent injury, wear appropriate personal protection equipment (PPE).

7.2 Bearings

7.2.1 Introduction

NOTICE

Do not overfill a bearing with grease; the bearing may be damaged.

Do not mix lubricant types. Change gloves to handle different lubricant

Assemble bearings in static- and dust-free conditions while wearing lint free gloves.

Store removed parts and tools in static- and dust-free conditions, to prevent damage or contamination.

A bearing is damaged by the axial force needed to remove it from the rotor shaft. Do not reuse a bearing.

A bearing is damaged if the insertion force is applied through the bearing balls. Do not press fit the outer race by force on the inner race, or vice versa.

Do not try to turn the rotor by levering against the cooling fan vanes. The fan will be damaged.

The alternator rotor is supported by a bearing at the non-drive end (NDE) and by either a bearing or a coupling to the prime mover at the drive end (DE).

- Lubricate each re-greasable bearing according to the recommended service schedule with the correct quantity and type of grease, also shown on a label fitted at the grease nipple.
- Inspect each sealed bearing according to the recommended service schedule. Seek advice from CGT if grease has leaked out of the bearing, notifying the bearing type and quantity leaked.

7.2.2 Safety

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To prevent injury and before removing covers over rotating parts, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

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Hot Surfaces

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To prevent injury, wear appropriate personal protection equipment (PPE).

⚠ CAUTION

Grease

Skin contact with grease can cause minor or moderate injury by contact dermatitis.

To prevent injury, wear appropriate personal protection equipment (PPE).

NOTICE
Do not overfill a bearing with grease; the bearing may be damaged. **Do not mix lubricant types. Change gloves to handle different lubricant** **Assemble bearings in static- and dust-free conditions while wearing lint free gloves.** **Store removed parts and tools in static- and dust-free conditions, to prevent damage or contamination.** **A bearing is damaged by the axial force needed to remove it from the rotor shaft. Do not reuse a bearing.** **A bearing is damaged if the insertion force is applied through the bearing balls. Do not press fit the outer race by force on the inner race, or vice versa.** **Do not try to turn the rotor by levering against the cooling fan vanes. The fan will be damaged.**

7.2.3 Re-Grease Bearings

7.2.3.1 Requirements

TABLE 8. RE-GREASING: EQUIPMENT REQUIREMENTS

Requirement	Description
Personal Protective Equipment (PPE)	Wear mandatory site PPE
Consumables	• Lint-free cleaning cloths • Thin disposable gloves
Parts	CGT recommended grease
Tools	Grease gun (calibrated for volume or mass)

7.2.3.2 Re-Grease Method

1. For each bearing, identify the grease nipple, re-greasing label and bearing type.
2. Make sure the new grease is not contaminated. It must be a uniform whitish-beige color and of stiff consistency throughout.
3. Clean the grease gun nozzle and grease nipple.
4. Clean the grease exhaust.
5. Fit the grease gun to the grease nipple and add the correct quantity of grease.
6. Run the alternator for at least 60 minutes, off- or on-load.
7. Clean the grease exhaust.
8. Inspect the color and consistency of the grease expelled from the exhaust and compare with the new grease, which should be whitish-beige and of stiff consistency.
9. Replace the bearing if the expelled grease is severely discolored or absent.

TABLE 9. RE-GREASING: GREASE QUANTITY

Bearing Type	Quantity of Recommended Grease	
	Volume (cm^3)	Mass (g)
Drive End (HC5)	46	41
Non-drive End (HC5)	33	29
Drive End (HC6)	75	66
Non-drive End (HC6)	60	53

7.3 Controls

7.3.1 Introduction

An operating alternator is a harsh environment for control components. Heat and vibration can cause electrical connections to loosen and cables to fail. Routine inspection and test can identify an issue before it becomes a failure that incurs unplanned downtime.

7.3.2 Safety

⚠ DANGER

Live Electrical Conductors

Live electrical conductors can cause serious injury or death by electric shock and burns.

To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ WARNING

Hot Surfaces

Skin contact with hot surfaces can cause serious injury by burns.

To prevent injury, wear appropriate personal protection equipment (PPE).

7.3.3 Connection Test Requirements

TABLE 10. CONNECTION TEST REQUIREMENTS

Requirements	Description
Personal Protective Equipment (PPE)	Wear mandatory site PPE
Consumables	None
Parts	None
Tools	• Insulation test meter • Multimeter • Torque wrench

7.3.4 Inspect and Test

1. Remove the terminal box lid

2. Check the tightness of fasteners securing the load cables.
3. Check that cables are firmly clamped at the terminal box gland, and allow ±25 mm movement by an alternator on anti-vibration mounts.
4. Check that all cables are anchored and unstressed within the terminal box.
5. Check all cables for signs of damage.
6. Check that AVR accessories and current transformers are correctly fitted, and cables pass centrally through current transformers (if fitted).
7. If an anti-condensation heater is fitted:
   a. Isolate the supply and measure the electrical resistance of the heater element(s). Replace the heater element if open circuit.
   b. Connect together both ends of the heater leads.
   c. Apply the test voltage between the winding and earth.
   d. Measure the insulation resistance after 1 minute (IR 1min).
   e. Discharge the test voltage.
   f. If the measured insulation resistance is less than the minimum acceptable level, replace the heater element. See Table 11 on page 39 for values.
8. Test the supply voltage to the anti-condensation heater at the heater connection box. 120 VAC or 240 VAC. (depending on cartridge option and shown on a label) should be present when the alternator is stopped.
9. Check that the AVR and AVR accessories fitted in the terminal box are clean, securely fitted on anti-vibration mounts, and the cable connectors are firmly attached to the terminals.
10. For parallel operation, check that the synchronization control cables are securely connected.
11. Refit and secure the terminal box lid.

TABLE 11. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ANTI-CONDENSATION HEATERS

Component	Test Voltage (V)	Minimum Insulation Resistance at 1 minute (MΩ)	
		New	In-service
Anti-condensation heater	500	10	1

7.4 Cooling System

7.4.1 Introduction

The alternators are designed to meet standards supporting EU Safety Directives, and are rated for the effect of operating temperature on winding insulation.

BS EN 60085 (≡ IEC 60085) Electrical insulation – Thermal Evaluation and Designation classifies insulation by the maximum operating temperature for a reasonable service life. Although chemical contamination and electrical and mechanical stresses also contribute, temperature is the dominant aging factor. Fan cooling maintains a stable operating temperature below the insulation class limit.

If the operating environment differs from the values shown on the rating plate, rated output must be reduced by

- 3% for class H utilization for every 5 °C that the temperature of the ambient air entering the cooling fan exceeds 40 °C, up to a maximum of 60 °C

- 3.5% for class F utilization for every 5 °C that the temperature of the ambient air entering the cooling fan exceeds 40 °C, up to a maximum of 60 °C
- 4.5% for class B utilization for every 5 °C that the temperature of the ambient air entering the cooling fan exceeds 40 °C, up to a maximum of 60 °C
- 3% for every 500 m increase in altitude above 1000 m, up to 4000m, due to the reduced thermal capacity of lower density air, and
- 5% if air filters are fitted, due to restricted air flow.

Note: The values above are cumulative dependant on environmental conditions.

Efficient cooling depends on maintaining the condition of the cooling fan, air filters and gaskets.

7.4.2 Safety

⚠ DANGER

Rotating Mechanical Parts

Rotating mechanical parts can cause serious injury or death by crushing, severing or trapping.

To prevent injury and before removing covers over rotating parts, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ WARNING

Hot Surfaces

Skin contact with hot surfaces can cause serious injury by burns.

To prevent injury, wear appropriate personal protection equipment (PPE).

⚠ CAUTION

Dust

Inhaling dust can cause minor or moderate injury by irritating the lungs. Dust can cause minor or moderate injury by irritating the eyes.

To prevent injury, wear appropriate personal protection equipment (PPE). Ventilate the area to disperse dust.

NOTICE

Do not attempt to rotate the alternator rotor by levering against the vanes of the cooling fan. The fan is not designed to withstand such forces and will be damaged.

NOTICE

Filters are designed to remove dust, not moisture. Wet filter elements can cause reduced air flow and overheating. Do not allow filter elements to get wet.

7.4.3 Cooling System Test Requirements

TABLE 12. COOLING SYSTEM TEST REQUIREMENTS

Requirements	Description
Personal Protective Equipment (PPE)	• Wear mandatory site PPE • Wear eye protection • Wear respiratory protection
Consumables	• Lint-free cleaning cloths • Thin disposable gloves
Parts	• Air filters (if fitted) • Air filter sealing gaskets (if fitted)
Tools	None

7.4.4 Inspect and Clean

NOTICE

A sensor detects the differential pressure caused by blocked filters. If the sensor trips, inspect and clean the air filters more frequently.

1. Remove the fan screen.
2. Inspect the fan for damaged vanes and cracks.
3. Remove air filters (at the fan and terminal box, if fitted) from their frames.
4. Wash and dry the air filters and gaskets to remove contaminant particles.
5. Inspect the filters and gaskets for damage and replace, as necessary.
6. Install the filters and gaskets.
7. Re-install the fan screen.
8. Reinstate the generator set for running.
9. Make sure the air inlets and outlets are not blocked.

7.5 Coupling

7.5.1 Introduction

Efficient operation and long component life rely on minimizing mechanical stresses on the alternator. When coupled in a generator set, misalignment and vibration interactions with the prime mover engine can cause mechanical stress.

The rotational axes of alternator rotor and engine output shaft must be coaxial (radial and angular alignment).

Torsional vibration can cause damage to internal combustion engine shaft-driven systems, if not controlled. The generator set manufacturer is responsible for assessing the effect of torsional vibration on the alternator: Rotor dimensions and inertia, and coupling details are available on request.

7.5.2 Safety

NOTICE

Do not attempt to rotate the alternator rotor by levering against the vanes of the cooling fan. The fan is not designed to withstand such forces and will be damaged.

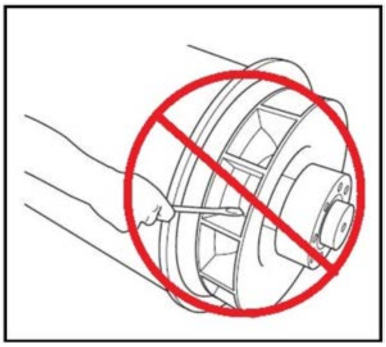

FIGURE 18. DO NOT ROTATE THE ALTERNATOR ROTOR WITH A LEVER

7.5.3 Coupling Test Requirements

TABLE 13. COUPLING TEST REQUIREMENTS

Requirements	Description
Personal Protective Equipment (PPE)	Wear mandatory site PPE
Consumables	None
Parts	None
Tools	• Dial gauge • Torque wrench

7.5.4 Inspect Mounting Points

1. Check the generator set bedplate and mounting pads are in good condition, not cracked
2. Check that rubber in anti-vibration mounts has not perished
3. Check vibration monitoring historical records for a trend of increasing vibration

7.5.4.1 Single Bearing Coupling

1. Remove the DE adapter screen and cover to access the coupling.
2. Check that the coupling discs are not damaged, cracked or distorted, and the coupling disc holes are not elongated. If any are damaged, replace the complete set of discs.
3. Check tightness of bolts fixing the coupling discs to the engine flywheel. Tighten in the sequence shown for alternator coupling in the Installation chapter, to the torque recommended by the engine manufacturer.
4. Replace the DE adapter screen and drip proof cover.

7.6 Rectifier System

7.6.1 Introduction

The rectifier converts alternating current (AC) induced in the exciter rotor windings into direct current (DC) to magnetize the main rotor poles. The rectifier comprises two semicircular annular positive and negative plates, each with three diodes. In addition to connecting to the main rotor, the DC output of the rectifier also connects to a varistor. The varistor protects the rectifier from voltage spikes and surge voltages that may be present on the rotor under various loading conditions of the alternator.

Diodes provide a low resistance to current in one direction only: Positive current will flow from anode to cathode, or another way of viewing it is that negative current will flow from cathode to anode.

The exciter rotor windings are connected to 3 diode anodes to form the positive plate and to 3 diode cathodes to form the negative plate to give full wave rectification from AC to DC. The rectifier is mounted on, and rotates with, the exciter rotor at the non-drive end (NDE).

7.6.2 Safety

⚠ DANGER
Live Electrical Conductors
Live electrical conductors can cause serious injury or death by electric shock and burns.
To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ DANGER
Rotating Mechanical Parts
Rotating mechanical parts can cause serious injury or death by crushing, severing or trapping.
To prevent injury and before removing covers over rotating parts, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

7.6.3 Test and Replace Rectifier System Component Requirements

TABLE 14. RECIFIER SYSTEM TEST AND REPLACE REQUIREMENTS

Requirements	Description
Personal Protective Equipment (PPE)	Wear appropriate PPE
Consumables	• Loctite 241 thread locking adhesive • Dow Corning silicone heat sink compound type 340 or similar
Parts	• Full set of three anode lead diodes and three cathode lead diodes (all from the same manufacturer) • One metal-oxide varistor
Tools	• Insulation tester • Multimeter • Torque wrench

7.6.4 Test and Replace Varistor

1. Inspect the varistor, (if fitted).
2. Record varistor as faulty if there are signs of overheating (discoloration, blisters, melting) or disintegration.
3. Disconnect one varistor lead. Store fastener and washers.
4. Measure the resistance across the varistor. Good varistors have a resistance greater than 100 MΩ.
5. Record the varistor as faulty if the resistance is short circuit or open circuit in either direction. (Some multimeters will read O.L. at high resistance levels. Please be aware of the limits of your tools.)
6. If the varistor is faulty, replace it and replace all diodes.
7. Reconnect and check that all leads are secure, washers fitted and fasteners tight.

7.6.5 Test and Replace Diodes

NOTICE
Do not tighten a diode above the stated torque. The diode will be damaged.

1. Disconnect the lead of one diode where it joins the windings at the insulated terminal post. Store fastener and washers.
2. Measure the voltage drop across the diode in the forward direction, using the diode test function of a multimeter.
3. Measure the resistance across the diode in the reverse direction, using the 1000 VDC test voltage of an insulation tester.
4. Diode is faulty if the voltage drop in the forward direction is outside the range 0.3 to 0.9 VDC, or the resistance is below 20 MΩ in the reverse direction.
5. Repeat the tests for the five remaining diodes.

6. If any diode is faulty, replace the full set of six diodes (same type, same manufacturer):
   a. Remove diode(s).
   b. Apply a small amount of heat sink compound **only** to the base of the replacement diode(s), not the threads.
   c. Check polarity of diode(s).
   d. Screw each replacement diode into a threaded hole in the rectifier plate.
   e. Apply 2.6 to 3.1 Nm (23 to 27.4 in-lb) torque to give good mechanical, electrical and thermal contact.
   f. Replace the varistor.
7. Reconnect and check that all leads are secure, washers fitted and fasteners tight.

7.7 Temperature Sensors

7.7.1 Introduction

The alternators are designed to meet standards supporting EU Safety Directives, and recommended operating temperatures. Temperature sensors (where fitted) detect abnormal overheating of the main stator windings and bearing(s). Sensors are of two types: Resistance Temperature Detector (RTD) sensors, with three wires, and Positive Temperature Coefficient (PTC) thermistors, with two wires, which are connected to a terminal block in the auxiliary or main terminal box. The resistance of Platinum (PT100) RTD sensors increases linearly with temperature.

TABLE 15. RESISTANCE (Ω) OF PT100 SENSOR BETWEEN 40 TO 180 °C

Temperature (°C)		+1 °C	+2 °C	+3 °C	+4 °C	+5 °C	+6 °C	+7 °C	+8 °C	+9 °C
40.00	115.54	115.93	116.31	116.70	117.08	117.47	117.86	118.24	118.63	119.01
50.00	119.40	119.78	120.17	120.55	120.94	121.32	121.71	122.09	122.47	122.86
60.00	123.24	123.63	124.01	124.39	124.78	125.16	125.54	125.93	126.31	126.69
70.00	127.08	127.46	127.84	128.22	128.61	128.99	129.37	129.75	130.13	130.52
80.00	130.90	131.28	131.66	132.04	132.42	132.80	133.18	133.57	133.95	134.33
90.00	134.71	135.09	135.47	135.85	136.23	136.61	136.99	137.37	137.75	138.13
100.00	138.51	138.88	139.26	139.64	140.02	140.40	140.78	141.16	141.54	141.91
110.00	142.29	142.67	143.05	143.43	143.80	144.18	144.56	144.94	145.31	145.69
120.00	146.07	146.44	146.82	147.20	147.57	147.95	148.33	148.70	149.08	149.46
130.00	149.83	150.21	150.58	150.96	151.33	151.71	152.08	152.46	152.83	153.21
140.00	153.58	153.96	154.33	154.71	155.08	155.46	155.83	156.20	156.58	156.95
150.00	157.33	157.70	158.07	158.45	158.82	159.19	159.56	159.94	160.31	160.68
160.00	161.05	161.43	161.80	162.17	162.54	162.91	163.29	163.66	164.03	164.40
170.00	164.77	165.14	165.51	165.89	166.26	166.63	167.00	167.37	167.74	168.11
180.00	168.48									

PTC thermistors are characterised by a sudden increase in resistance at a reference “switching” temperature. Customer-supplied external equipment may be connected to monitor the sensors and generate signals to raise an alarm and to shutdown the generator set.

BS EN 60085 (≡ IEC 60085) Electrical insulation – Thermal Evaluation and Designation classifies insulation of windings by the maximum operating temperature for a reasonable service life. To avoid damage to windings, signals should be set, appropriate to the insulation class shown on the alternator rating plate.

TABLE 16. ALARM AND SHUTDOWN TEMPERATURE SETTINGS FOR WINDINGS

Windings Insulation	Max. Continuous Temperature (°C)	Alarm Temperature (°C)	Shutdown Temperature (°C)
Class B	130	120	140
Class F	155	145	165
Class H	180	170	190

To detect overheating of bearings, control signals should be set according to the following table.

TABLE 17. ALARM AND SHUTDOWN TEMPERATURE SETTINGS FOR BEARINGS

Bearings	Alarm Temperature (°C)	Shutdown Temperature (°C)
Drive End Bearing	45 + maximum ambient	50 + maximum ambient
Non-drive End Bearing	40 + maximum ambient	45 + maximum ambient

7.7.2 Safety

⚠ DANGER

Live Electrical Conductors

Live electrical conductors can cause serious injury or death by electric shock and burns.

To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ WARNING

Hot Surfaces

Skin contact with hot surfaces can cause serious injury by burns.

To prevent injury, wear appropriate personal protection equipment (PPE).

7.7.3 Test RTD Temperature Sensors

1. Remove the auxiliary terminal box lid.
2. Identify the sensor leads at the terminal block and where each sensor is fitted
3. Measure the resistance between the white and each red wire of one sensor
4. Calculate the sensor temperature from the measured resistance
5. Compare calculated temperature with temperature indicated by external monitoring equipment (if available)
6. Compare alarm and shutdown signal settings (if available) with recommended settings
7. Repeat steps 3 to 7 for each sensor
8. Refit the auxiliary terminal box lid.
9. Contact Cummins Customer Service Help Desk to replace faulty sensors. Main stator RTD are not replaceable. Bearing RTD are replaceable.

7.7.4 Test PTC Temperature Sensors

1. Remove the auxiliary terminal box lid.
2. Identify the sensor leads at the terminal block and where each sensor is fitted.
3. Measure the resistance between the two wires.
4. Sensor is faulty if resistance shows open circuit (infinity Ω) or short circuit (zero Ω).
5. Repeat steps 3 to 5 for each sensor.
6. Stop the alternator and inspect the change in resistance as the stator winding cools.
7. Sensor is faulty if resistance does not change or change is not smooth.
8. Repeat steps 6 and 7 for each sensor.
9. Refit the auxiliary terminal box lid.
10. Contact Cummins Customer Service Help Desk to replace faulty sensors.

7.8 Windings

7.8.1 High Voltage Test

NOTICE
Windings have been tested at high voltage during manufacture. Repeated high voltage tests may degrade the insulation and reduce operating life. If a further test is required at installation for customer acceptance, it must be done at a reduced voltage, V = 0.8 x (2 x Rated Voltage + 1000). Once in service, any further tests for maintenance purposes must be done after passing visual checks and insulation resistance tests, and at a reduced voltage, V = (1.5 x Rated Voltage).

7.8.2 Introduction

NOTICE
Disconnect all control wiring and customer load leads from alternator winding connections before conducting these tests.

NOTICE
The Automatic Voltage Regulator (AVR) contains electronic components which would be damaged by high voltage applied during insulation resistance tests. The AVR must be disconnected before doing any insulation resistance test. Temperature sensors must be grounded to earth before doing any insulation resistance test. **Damp or dirty windings have a lower electrical resistance and could be damaged by insulation resistance tests at high voltage. If in doubt, test the resistance at low voltage (500 V) first.**

Alternator performance depends on good electrical insulation of the windings. Electrical, mechanical and thermal stresses, and chemical and environmental contamination, cause the insulation to degrade. Various diagnostic tests indicate the condition of insulation by charging or discharging a test voltage on isolated windings, measuring current flow, and calculating the electrical resistance by Ohm's law.

When a DC test voltage is first applied, three currents can flow:

- **Capacitive Current:** To charge the winding to the test voltage (decays to zero in seconds),

- **Polarizing Current:** To align the insulation molecules to the applied electric field (decays to near-zero in ten minutes), and
- **Leakage Current:** Discharge to earth where the insulation resistance is lowered by moisture and contamination (increases to a constant in seconds).

For an insulation resistance test, a single measurement is made one minute after a DC test voltage is applied, when capacitive current has ended. For the polarization index test, a second measurement is made after ten minutes. An acceptable result is where the second insulation resistance measurement is at least double the first, because the polarization current has decayed. In poor insulation, where leakage current dominates, the two values are similar. A dedicated Insulation Tester takes accurate, reliable measurements and may automate some tests.

7.8.3 Safety

⚠ DANGER
Live Electrical Conductors   ***Live electrical conductors can cause serious injury or death by electric shock and burns.***   ***To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.***

⚠ WARNING
Live Electrical Conductors   ***Live electrical conductors at the winding terminals after an insulation resistance test can cause serious injury or death by electric shock or burns.***   ***To prevent injury, discharge the windings by shorting to earth through an earthing rod for at least 5 minutes.***

7.8.4 Requirements

TABLE 18. WINDING TEST REQUIREMENTS

Requirement	Description
Personal Protective Equipment (PPE)	Wear mandatory site PPE.
Consumables	None
Parts	None
Tools	• Insulation test meter • Multimeter • Milliohm meter or microohm meter • Clamp ammeter • Infrared thermometer • Earth rod

7.8.5 Test the Electrical Resistance of Windings

1. Stop the alternator.
2. Verify the electrical resistance of the exciter field (stator) winding:
   a. Disconnect the exciter field leads F1 and F2 from the AVR.
   b. Measure and record the electrical resistance between F1 and F2 leads with a multimeter.

   c. Reconnect the exciter field leads F1 and F2.
   d. Make sure the fasteners are secure.

3. Verify the electrical resistance of the exciter armature (rotor) winding:
   a. Mark the leads attached to diodes on one of the two rectifier plates.
   b. Disconnect all exciter rotor leads from all diodes at the rectifier.
   c. Measure and record the electrical resistance between pairs of marked leads (between phase windings). A specialist micro ohmmeter must be used.
   d. Reconnect all exciter rotor leads to the diodes.
   e. Make sure the fasteners are secure.
4. Verify the electrical resistance of the main field (rotor) winding:
   a. Disconnect the two main rotor DC leads from the rectifier plates.
   b. Measure and record the electrical resistance between the main rotor leads. A specialist micro ohmmeter must be used.
   c. Reconnect the two main rotor DC leads to the rectifier plates.
   d. Make sure the fasteners are secure.
5. Verify the electrical resistance of the main armature (stator) winding:
   a. Disconnect the leads of the main stator from the output terminals.
   b. Measure and record the electrical resistance between U1 and U2 leads and between U5 and U6 (if present). A specialist micro ohmmeter must be used.
   c. Measure and record the electrical resistance between V1 and V2 leads and between V5 and V6 (if present). A specialist micro ohmmeter must be used.
   d. Measure and record the electrical resistance between W1 and W2 leads and between W5 and W6 (if present). A specialist micro ohmmeter must be used.
   e. Reconnect the leads to the output terminals, as before.
   f. Make sure the fasteners are secure.
6. Verify the electrical resistance of the PMG armature (stator) winding, if fitted:
   a. Disconnect the three PMG output leads P2, P3 and P4 from the AVR.
   b. Measure and record the electrical resistance between pairs of the PMG output leads, with a multimeter.
   c. Reconnect the three PMG output leads P2, P3 and P4 to the AVR.
   d. Make sure the fasteners are secure.
7. Refer to the Technical Data (**Chapter 9 on page 61**) to verify the measured resistances of all windings agree with the reference values.

7.8.6 Test the Insulation Resistance of Windings

NOTICE
The alternator must not be put into service until the minimum insulation resistance is achieved.

TABLE 19. TEST VOLTAGE AND MINIMUM ACCEPTABLE INSULATION RESISTANCE FOR NEW AND IN-SERVICE ALTERNATORS

Part	Test Voltage (V)	Minimum Insulation Resistance at 1 Minute (MΩ)	
		New	In-Service
Main Stator	500	10	5
PMG Stator	500	5	3
Exciter Stator	500	10	5
Exciter Rotor, Rectifier & Main Rotor Combined	500	10	5

1. Inspect the windings for mechanical damage or discoloration from overheating. Clean the insulation if there is hygroscopic dust and dirt contamination.
2. For main stators:
   a. Disconnect the neutral to earth conductor (if fitted).
   b. Connect together the three leads of all phase windings (if possible).
   c. Apply the test voltage from the table between any phase lead and earth.
   d. Measure the insulation resistance after 1 minute (IR_{1min}).
   e. Discharge the test voltage with an earth rod for five minutes.
   f. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
   g. Reconnect neutral to earth conductor (if fitted).
3. For PMG and exciter stators, and combined exciter and main rotors:
   a. Connect together both ends of the winding (if possible).
   b. Apply the test voltage from the table between the winding and earth.
   c. Measure the insulation resistance after 1 minute (IR_{1min}).
   d. Discharge the test voltage with an earth rod for five minutes.
   e. If the measured insulation resistance is less than the minimum acceptable value, dry the insulation, then repeat the method.
   f. Repeat the method for each winding.
   g. Remove the connections made for testing.

7.8.7 Dry the Insulation

Use the methods below to dry the insulation of the main stator windings. To prevent damage as water vapor is expelled from the insulation, make sure the winding temperature does not increase faster than 5 ºC per hour or exceed 90 ºC.

Plot the insulation resistance graph to show when drying is complete.

7.8.7.1 Dry with Ambient Air

In many cases, the alternator can be dried sufficiently using its own cooling system. Disconnect the cables from the X+ (F1) and XX- (F2) terminals of the AVR so there is no excitation voltage supply to the exciter stator. Run the generator set in this de-excited state. Air must flow freely through the alternator to remove the moisture. Operate the anti-condensation heater (if fitted) to assist the drying effect of the air flow.

After drying is complete, re-connect the cables between the exciter stator and AVR. If the generator set is not put into service immediately, turn on the anti-condensation heater (if fitted) and retest the insulation resistance before use.

7.8.7.2 Dry with Hot Air

Direct the hot air from one or two 1 to 3 kW electrical fan heaters into the alternator air inlet. Make sure each heat source at least 300 mm away from the windings to avoid scorching or over-heating damage to the insulation. Air must flow freely through the alternator to remove the moisture.

After drying, remove the fan heaters and re-commission as appropriate.

If the generator set is not put into service immediately, turn on the anti-condensation heaters (where fitted) and retest the insulation resistance before use.

7.8.7.3 Plot IR Graph

Whichever method is used to dry out the alternator, measure the insulation resistance and temperature (if sensors fitted) of the main stator windings every 15 to 30 minutes. Plot a graph of insulation resistance, IR (y axis) against time, t (x axis).

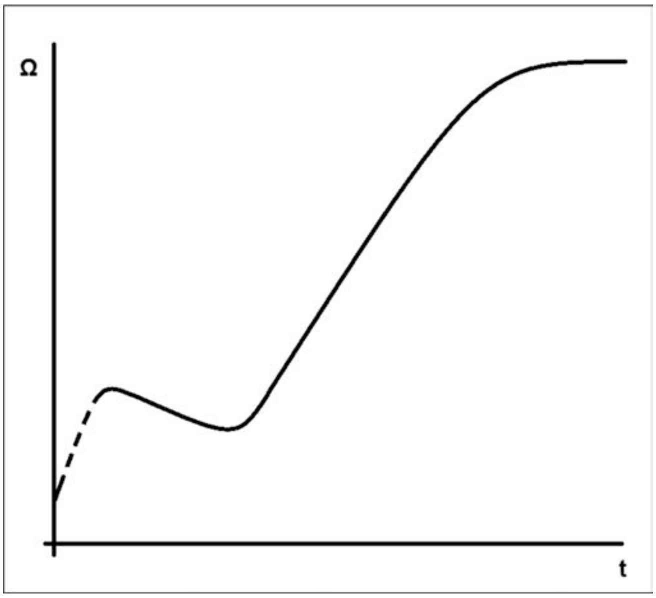

FIGURE 19. INSULATION RESISTANCE GRAPH

A typical curve shows an initial increase in resistance, a fall and then a gradual rise to a steady state; if the windings are only slightly damp the dotted portion of the curve may not appear. Continue drying for another hour after steady state is reached.

NOTICE
The alternator must not be put into service until the minimum insulation resistance is achieved.

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8 Parts Identification

8.1 HC4 Single Bearing Alternator

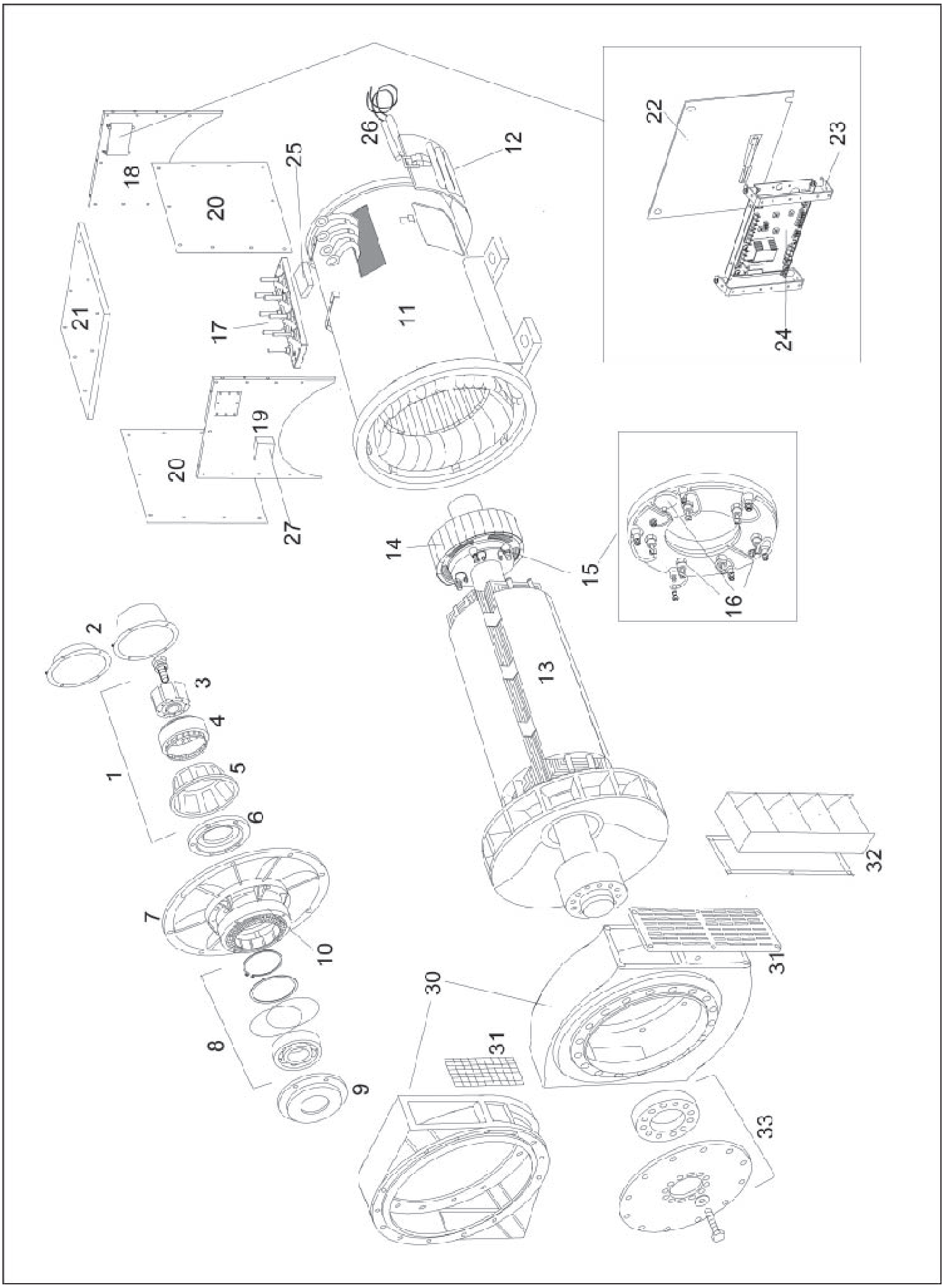

FIGURE 20. HC4 SINGLE BEARING ALTERNATOR

8.2 HC4 Two Bearing Alternator

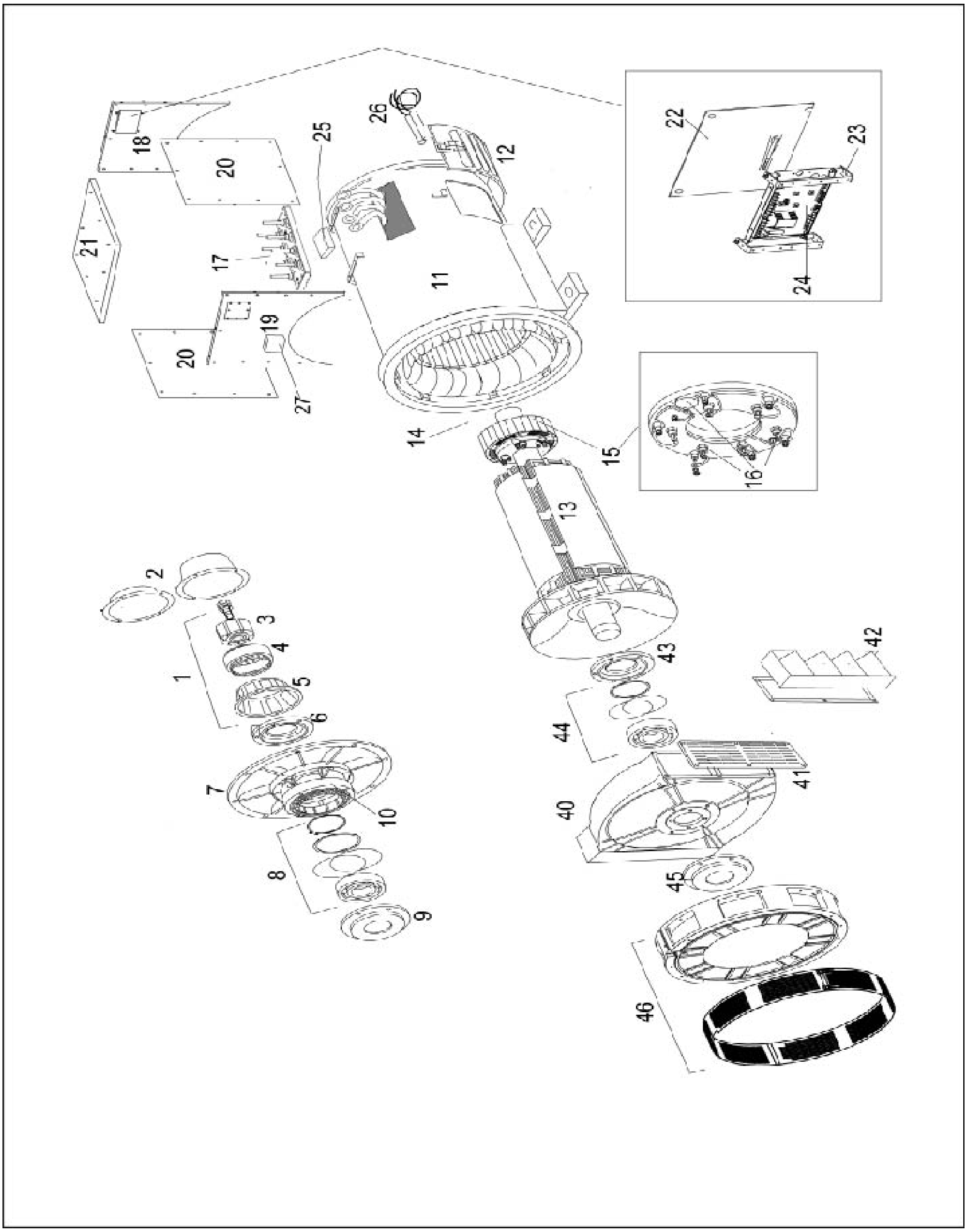

FIGURE 21. HC4 TWO BEARING ALTERNATOR

8.3 HC5 Single Bearing Alternator

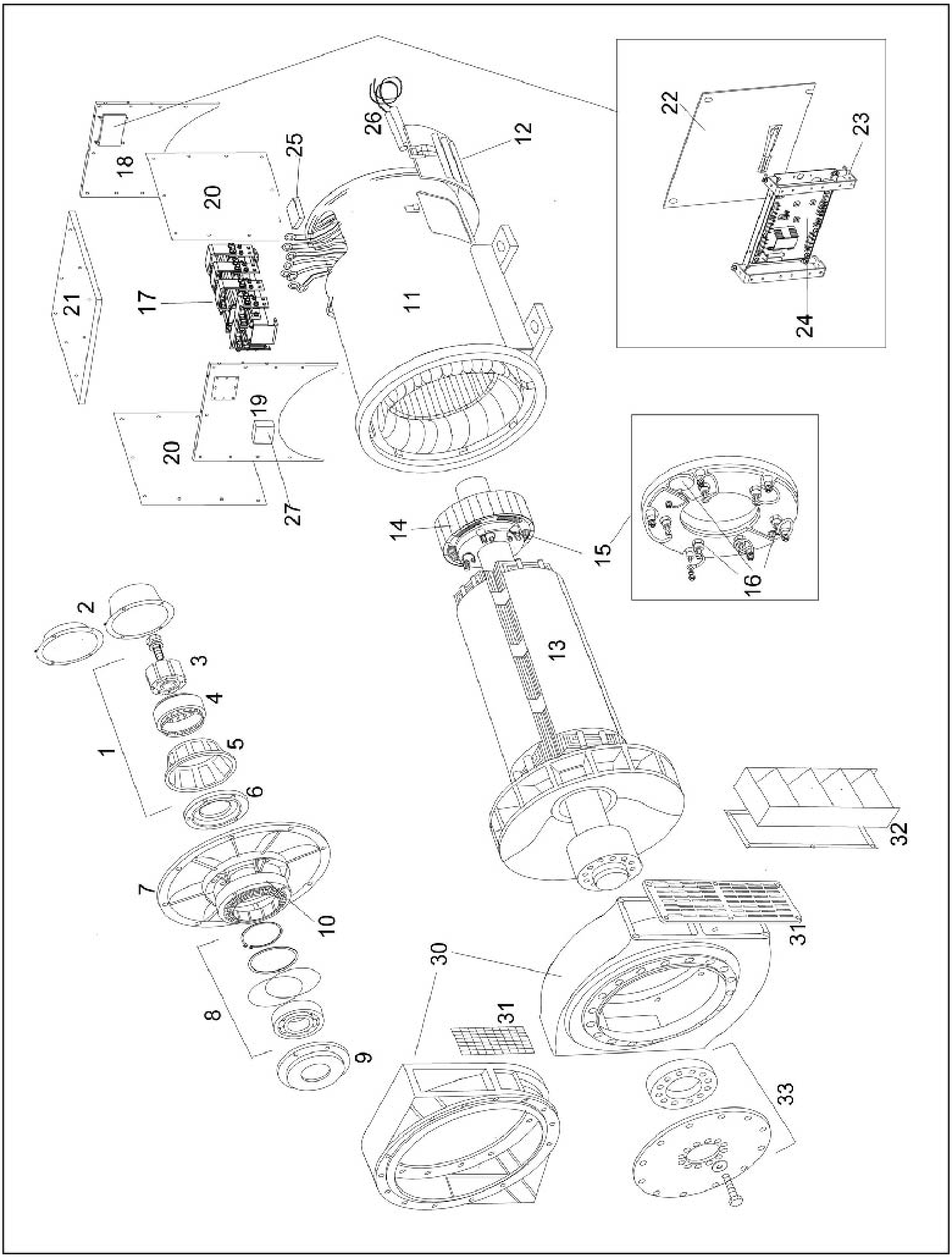

FIGURE 22. HC5 SINGLE BEARING ALTERNATOR

8.4 HC5 Two Bearing Alternator

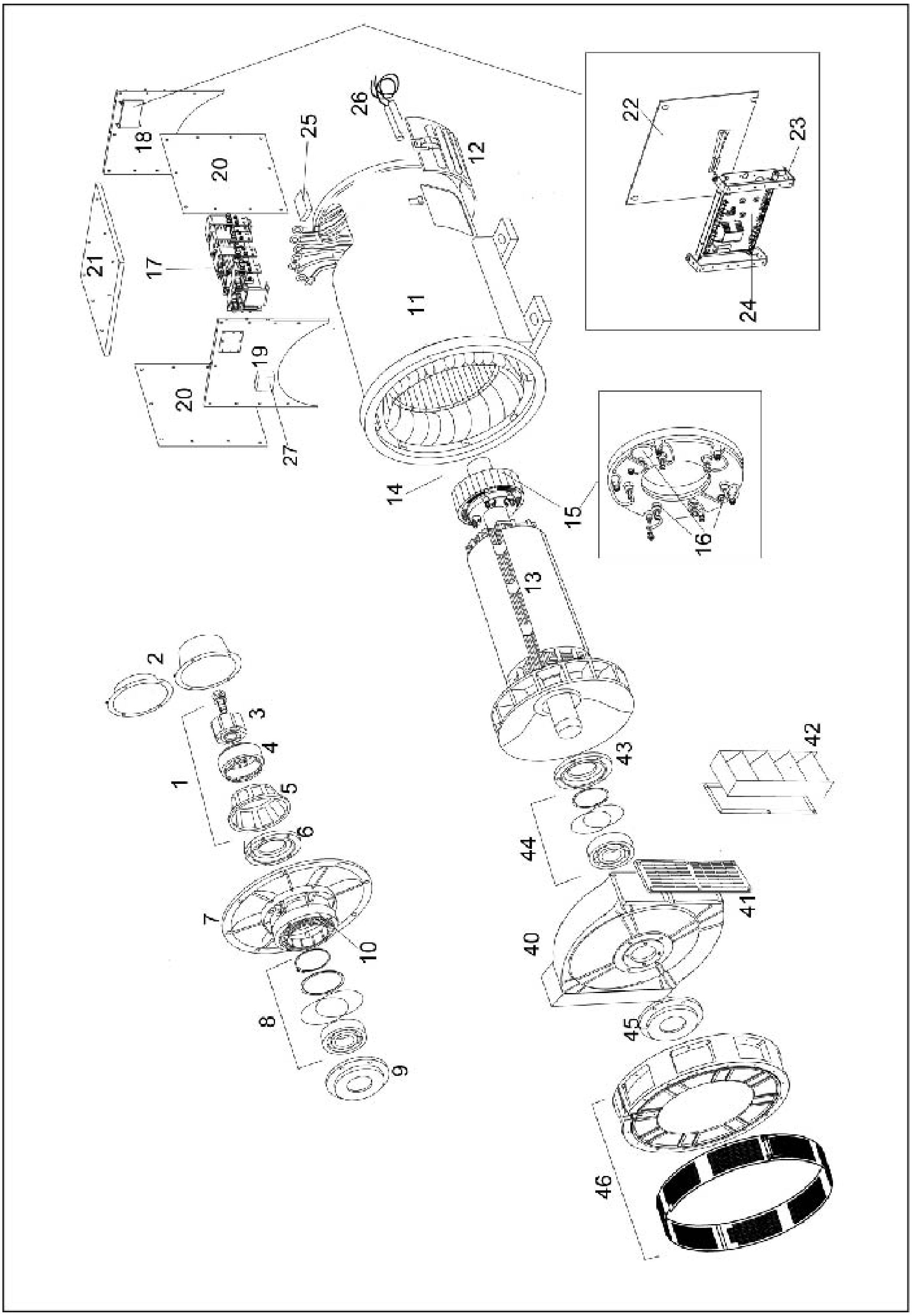

FIGURE 23. HC5 TWO BEARING ALTERNATOR

8.5 HC6 Single Bearing Alternator

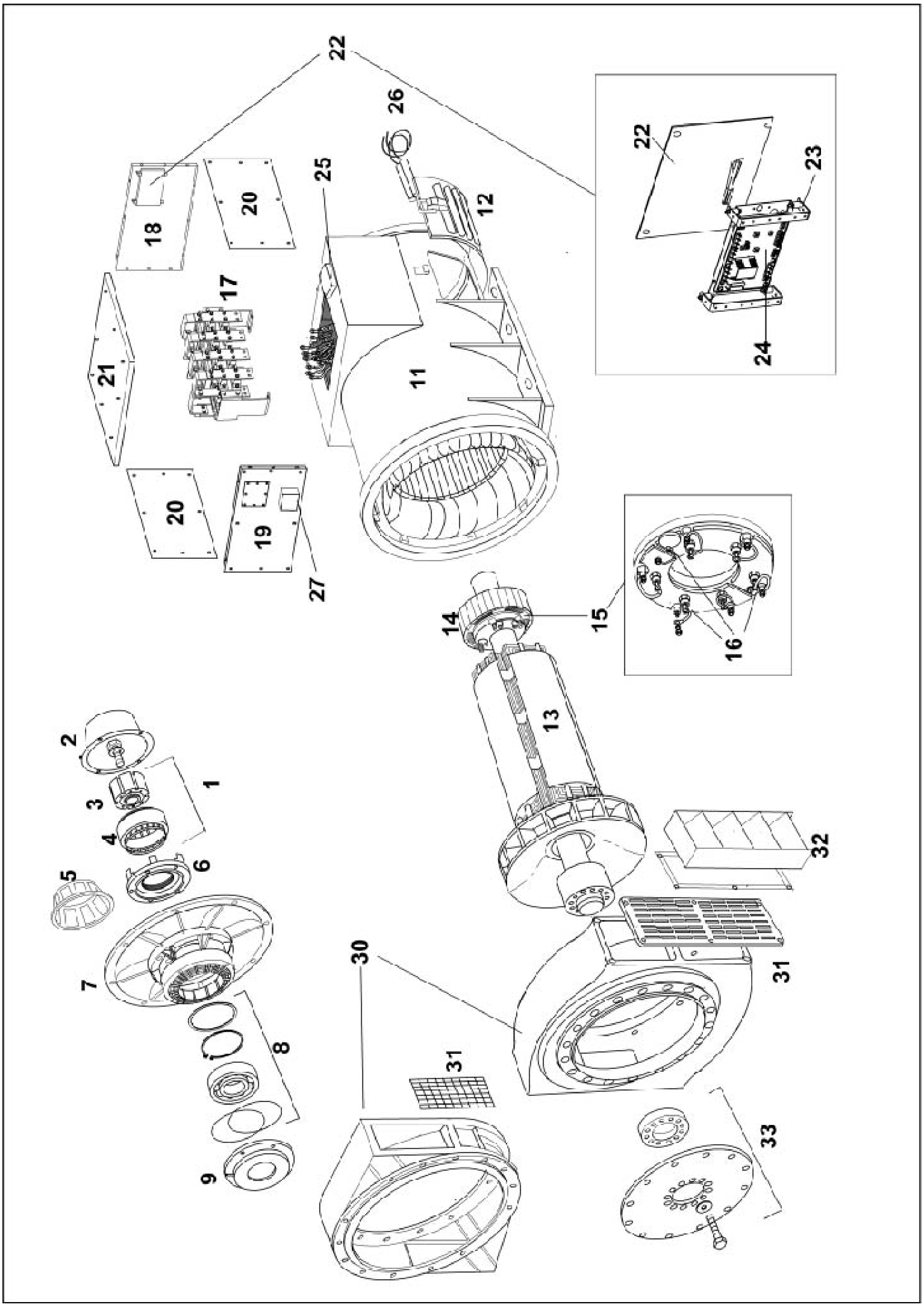

FIGURE 24. HC6 SINGLE BEARING ALTERNATOR

8.6 HC6 Two Bearing Alternator

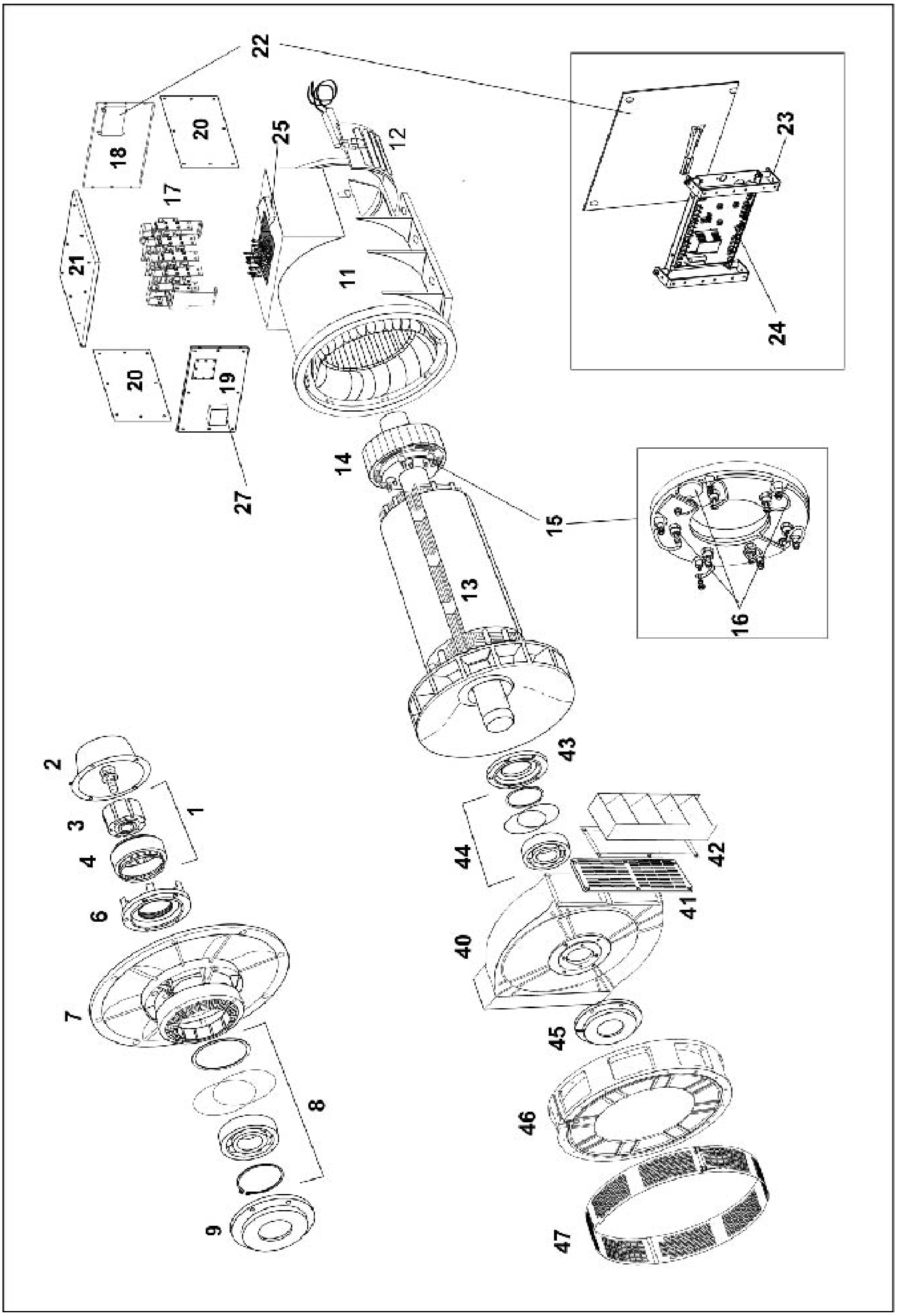

FIGURE 25. HC6 TWO BEARING ALTERNATOR

8.7 HC Parts and Fasteners

TABLE 20. HC PARTS AND FASTENERS

Reference	Component	Fastener	Quantity	Torque (Nm)
1	Complete PMG parts	-	-	-
2	PMG Cover/non-PMG Cover	M6 x 16	4	10
3	PMG Rotor	M10 x 100	1	50
4	PMG Stator	M6 x 45	4	10
5	PMG Crown (if fitted)	-	-	-
6	NDE Bearing Cap	M10 x 30	4	50
7	NDE Bracket	M12 x 40	8	50
8	Complete NDE Bearing parts	-	-	-
9	NDE Bearing Cartridge	M10 x 50	4	50
10	Exciter Stator	M8	6	26
11	Main Frame	-	-	-
12	Air Inlet Cover	Split pin	-	-
13	Main Rotor	-	-	-
14	Exciter Rotor	-	-	-
15	Rectifier Assembly	M6 x 65	4	10
16	Diode/Varistor	-	-	2.6 - 3.1
17	Main Terminals	M12 x 40	8	50
18	Terminal Box End Panel NDE	M10 x 35	4	50
19	Terminal Box End Panel DE	M10 x 25	2	50
20	Terminal Box Side Panel	M6 x 12	20	6
21	Terminal Box Lid	M6 x 12	8	6
22	AVR Cover Plate	M5 x 12	4	5
23	AVR Mounting Bracket	M5 x 12	6	5
24	AVR	M5 x 30	4	5
25	Auxilliary Terminal Board	M6 x 25	8	10
26	Anti-condensation Heater	M6	2	n/c
27	Heater terminal Box	M4 x 12	2	5
30	DE Adapter (1 bearing)	M12 x 40	8	95
31	DE Air Outlet Screen (1 bearing)	M5 x 12	12	5
32	DE Louvres (1 bearing)	M5 x 16	12	5
33	DE Coupling Hub and Coupling Discs (1 bearing)	M20 x 55	8	479
40	DE Bracket (2 bearing)	M12 x 40	8	95

Reference	Component	Fastener	Quantity	Torque (Nm)
41	DE Air Outlet Screen (2 bearing)	M5 x 12	12	5
42	DE Louvres (2 bearing)	M5 x 16	12	5
43	DE Bearing Cartridge (2 bearing)	M10 x 50	4	50
44	Complete DE Bearing parts (2 bearing)	-	-	-
45	DE Bearing Cap (2 bearing)	M10 x 30	4	50
46	DE Adapter (2 bearing)	M12 x 40	8	95
47	DE Adapter Screen (2 bearing)	M5 x 12	12	5

Reference	Component	Fastener	Quantity	Torque (Nm)
41	DE Air Outlet Screen (2 bearing)	M5 x 12	12	5
42	DE Louvres (2 bearing)	M5 x 16	12	5
43	DE Bearing Cartridge (2 bearing)	M10 x 50	4	50
44	Complete DE Bearing parts (2 bearing)	-	-	-
45	DE Bearing Cap (2 bearing)	M10 x 30	4	50
46	DE Adapter (2 bearing)	M12 x 40	8	95
47	DE Adapter Screen (2 bearing)	M5 x 12	12	5

9 Technical Data

NOTICE

Compare measurements with the technical data sheet and the test certificate supplied with the alternator.

9.1 HC Winding Resistances

TABLE 21. HC WINDING RESISTANCES

Alternator	Resistance of Windings at 22 °C (Measured Values Should Be within 10%)								
	Main Stator (lead - lead) (Ohms)					Exciter Stator (Ohms)	Exciter Rotor, L-L (Ohms)	Main Rotor (Ohms)	PMG Stator, L-L (Ohms)
	311 (U1-U2) (V1-V2) (W1-W2) (U5-U6) (V5-V6) (W5-W6)	17 (U1-U2) (V1-V2) (W1-W2) (U5-U6) (V5-V6) (W5-W6)	14 (U1-U2) (V1-V2) (W1-W2) (U5-U6) (V5-V6) (W5-W6)	25 (U1-U2) (V1-V2) (W1-W2) (U5-U6) (V5-V6) (W5-W6)	27 (U1-U2) (V1-V2) (W1-W2) (U5-U6) (V5-V6) (W5-W6)				
HC434C	0.0083	0.0115	0.0055	0.0020	0.0154	18	0.136	0.92	3.8
HC434D	0.0062	0.0100	0.0045	0.0160	0.0130	18	0.136	1.05	3.8
HC434E	0.0045	0.0075	n/a	0.0140	0.0100	18	0.136	1.19	3.8
HC434F	0.0037	0.0055	n/a	0.0105	0.0075	18	0.136	1.37	3.8
HC444C	0.0083	0.0115	0.0055	0.0020	0.0154	18	0.136	0.92	n/a
HC444D	0.0062	0.0100	0.0045	0.0160	0.0130	18	0.136	1.05	n/a
HC444E	0.0045	0.0075	n/a	0.0140	0.0100	18	0.136	1.19	n/a
HC444F	0.0037	0.0055	n/a	0.0105	0.0075	18	0.136	1.37	n/a
HC534C	0.0033	0.0053	0.0026	0.0100	0.0065	17	0.184	1.55	3.8
HC534D	0.0025	0.0040	0.0021	0.0075	0.0005	17	0.184	1.77	3.8
HC534E	0.0022	0.0034	0.0013	n/a	0.0044	17	0.184	1.96	3.8
HC534F	0.0019	0.0025	0.0013	0.0050	0.0041	17	0.184	2.46	3.8
HC544C	0.0033	0.0053	0.0026	0.0100	0.0065	17	0.184	1.55	n/a
HC544D	0.0025	0.0040	0.0021	0.0075	0.0005	17	0.184	1.77	n/a
HC544E	0.0022	0.0034	0.0013	n/a	0.0044	17	0.184	1.96	n/a
HC544F	0.0019	0.0025	0.0013	0.0050	0.0041	17	0.184	2.46	n/a
HC634G	0.0017	n/a	n/a	n/a	n/a	17	0.158	1.75	3.8
HC634H	0.0013	n/a	n/a	n/a	n/a	17	0.158	1.88	3.8
HC634J	0.0011	n/a	n/a	n/a	n/a	17	0.158	2.09	3.8
HC634K	0.0009	n/a	n/a	n/a	n/a	17	0.158	2.36	3.8

Alternator	Resistance of Windings at 22 °C (Measured Values Should Be within 10%)								
	Main Stator (lead - lead) (Ohms)					Exciter Stator (Ohms)	Exciter Rotor, L-L (Ohms)	Main Rotor (Ohms)	PMG Stator, L-L (Ohms)
	312 (U1-U2) (V1-V2) (W1-W2)	07 (U1-U2) (V1-V2) (W1-W2)	13 (U1-U2) (V1-V2) (W1-W2)	26 (U1-U2) (V1-V2) (W1-W2)	28 (U1-U2) (V1-V2) (W1-W2)				
HC434F	n/a	n/a	0.0060	n/a	n/a	18	0.136	1.37	3.8
HC444F	n/a	n/a	0.0060	n/a	n/a	18	0.136	1.37	n/a
HC534E	n/a	n/a	n/a	0.0130	n/a	17	0.184	1.96	3.8
HC544E	n/a	n/a	n/a	0.0130	n/a	17	0.184	1.96	n/a
HC634G	0.0034	0.0055	0.0002	0.0090	0.0075	17	0.158	1.75	3.8
HC634H	0.0025	0.0036	0.0019	0.0080	n/a	17	0.158	1.88	3.8
HC634J	0.0022	0.0030	0.0015	0.0060	n/a	17	0.158	2.09	3.8
HC634K	0.0017	0.0026	0.0010	0.0045	0.0030	17	0.158	2.36	3.8
HC636G	0.0090	0.0102	n/a	n/a	n/a	17	0.200	1.12	8.22
HC636H	0.0063	0.0102	n/a	n/a	n/a	17	0.200	1.33	8.22
HC636J	0.0049	0.0070	n/a	n/a	n/a	17	0.200	1.50	8.22
HC636K	0.0039	0.0060	n/a	n/a	n/a	17	0.200	1.75	8.22

10 Service Parts

We recommend the use of genuine STAMFORD service parts supplied from an authorized service outlet. For details of your nearest service outlet visit **www.stamford-avk.com**.

10.1 Parts Orders

When ordering parts the machine serial number or machine identity number and type should be quoted, together with the part description. The machine serial number can be found on the name plate or frame.

10.2 Customer Service

Cummins Generator Technologies' service engineers are experienced professionals, trained extensively to deliver the best support possible. Our global service offers:

- On-site a.c. alternator commissioning
- On-site bearing maintenance & bearing condition monitoring
- On-site insulation integrity checks
- On-site AVR & accessories set-up

For details of your nearest service outlet visit **www.stamford-avk.com**.

10.3 Recommended Service Parts

In critical applications a set of these service spares should be held with the alternator.

TABLE 22. HC4 SERVICE PARTS

Part	Number
Rectifier Service Kit **(3 forward & 3 reverse diodes with varistors)**	RSK-5001
MX321 AVR (if fitted)	E000-23212/1P
MX341 AVR (if fitted)	E000-23412/1P
AS440 AVR (if fitted)	E000-24403/1P
DM110 AVR (if fitted)	E000-23800
Sealed Bearing DE Kit	45-0319
Sealed Bearing NDE Kit	45-0320

TABLE 23. HC5 SERVICE PARTS

Part	Number
Rectifier Service Kit (3 forward & 3 reverse diodes with varistors)	RSK-5001
MX321 AVR (if fitted)	E000-23212/1P
MX341 AVR (if fitted)	E000-23412/1P
AS440 AVR (if fitted)	E000-24403/1P
DM110 AVR (if fitted)	E000-23800
HC5 1 Bearing	
Sealed Bearing NDE Kit	45-0320
Re-greasable Bearing NDE Kit	45-1099
HC5 2 Bearing	
Sealed Bearing DE Kit	45-0321
Sealed Bearing NDE Kit	45-0320
Re-greasable Bearing DE Kit	45-1100
Re-greasable Bearing NDE Kit	45-1099

TABLE 24. HC6 SERVICE PARTS

Part	Number
Rectifier Service Kit (3 forward & 3 reverse diodes with varistors)	RSK-6001
MX321 AVR (if fitted)	E000-23212/1P
MX341 AVR (if fitted)	E000-23412/1P
AS440 AVR (if fitted)	E000-24403/1P
DM110 AVR (if fitted)	E000-23800
HC6 1 Bearing	
Sealed Bearing NDE Kit	45-0340
Re-greasable Bearing NDE Kit	45-1099
HC6 2 Bearing	
Sealed Bearing DE Kit	45-0339
Sealed Bearing NDE Kit	45-0340
Re-greasable Bearing DE Kit	45-0342
Re-greasable Bearing NDE Kit	45-0343

10.4 Klüber Asonic GHY72 Grease

All bearings trials and calculated life expectancy are based on the use of Klüber Asonic GHY72.

11 End of Life Disposal

Companies specializing in reclaiming material from scrap products can reclaim most of the iron, steel and copper from the alternator. For more details, please contact Customer Service.

11.1 Recyclable material

Mechanically separate the base materials, iron, copper and steel, removing paint, polyester resin, and insulation tape and/or plastics residues from all components. Dispose of this ‘waste material’

The iron, steel and copper can now be recycled.

11.2 Items requiring specialist treatment

Remove electrical cable, electronic accessories and plastic materials from the alternator. These components need special treatment to remove the waste from the reclaimable material.

Forward the reclaimed materials for recycling.

11.3 Waste material

Dispose of waste material from both of the above processes via a specialist disposal company.

Table of Contents

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1 Description

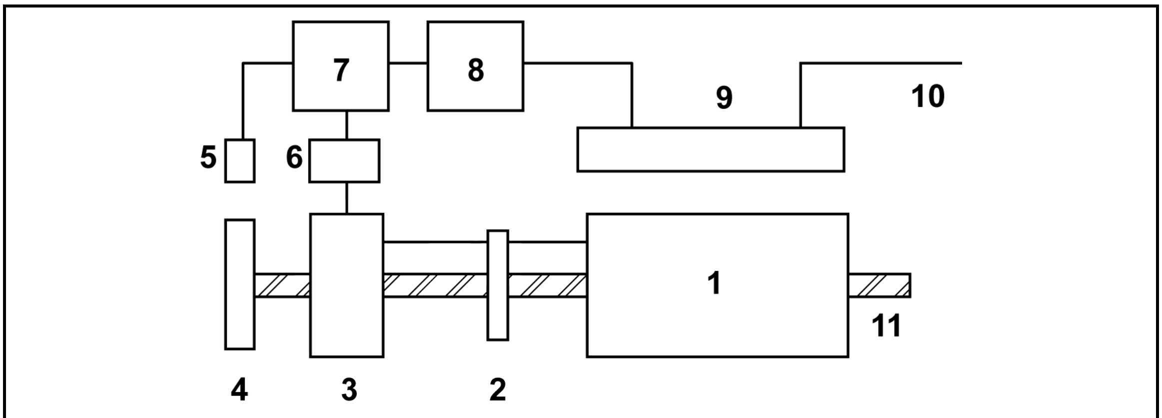
1.1 Separately-Excited AVR Controlled Alternators

1.1.1 Permanent Magnet Generator (PMG) excited - AVR controlled alternators

⚠ WARNING

Strong Magnetic Field
The strong magnetic field from a permanent magnet generator (PMG) can cause serious injury or death by interference with implanted medical devices.
To prevent injury, do not work near a PMG if you have an implanted medical device.

The AVR provides closed loop control by sensing the alternator output voltage at the main stator windings and adjusting the exciter stator field strength. Voltage induced in the exciter rotor, rectified by the rotating diodes, magnetises the rotating main field which induces voltage in the main stator windings. A separately-excited AVR is independently powered from a separate permanent magnet generator (PMG), mounted on the main alternator rotor shaft. Voltage is induced in the stator of the PMG by a rotor of permanent magnets.



No.	Description	No.	Description	No.	Description
1	Main field (rotor)	5	PMG armature (stator)	9	Main armature (stator)
2	Rotating diodes	6	Exciter field (stator)	10	Output
3	Exciter armature (rotor)	7	AVR	11	Rotor shaft
4	PMG field (rotor)	8	Isolating transformer (if fitted)		

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2 Specification

2.1 MX321 Technical Specification

- **Sensing Input**
    - Voltage: 190 VAC to 264 VAC maximum, 2 or 3 phase
    - Frequency: 50 Hz to 60 Hz nominal
- **Power Input**
    - Voltage: 170 VAC to 220 VAC maximum, 3 phase, 3 wire
    - Current: 3 A per phase
    - Frequency: 100 Hz to 120 Hz nominal
- **Power Output**
    - Voltage: maximum 120 VDC
    - Current:
        - continuous 3.7 A[1]
        - transient 6 A for 10 seconds
    - Resistance: 15 Ω minimum
- **Regulation**
    - +/- 0.5% RMS[2]
- **Thermal Drift**
    - 0.02% per 1 °C change in AVR ambient temperature[3]
- **Soft Start Ramp Time**
    - 0.4 s to 4 s
- **Typical Response**
    - AVR response in 10 ms
    - Field current to 90% in 80 ms
    - Machine Volts to 97% in 300 ms
- **External Voltage Adjustment**
    - +/-10% with 5 kΩ, 1 W trimmer[4]
- **Under-Frequency Protection**
    - Set point 95% Hz[5]
    - Slope 100% to 300% down to 30 Hz

[1] De-rate linearly from 3.7 A at 50 °C to 2.7 A at 70 °C
[2] With 4% engine governing. The stated voltage regulation may not be maintained in the presence of certain transmitted radio signals. Any change in regulation will fall within the limits in Criteria B of BS EN 61000-6-2: 2001
[3] After 10 minutes
[4] Applies to Mod status E onwards. Alternator de-rate may apply. Check with factory
[5] Factory set, semi-sealed, jumper selectable

    - Maximum dwell 20% V/s recovery
- **Unit Power Dissipation**
    - 18 W maximum
- **Analogue Input**
    - Maximum input: +/- 5 VDC[6]
    - Sensitivity: 1V for 5% Alternator Volts (adjustable)
    - Input resistance 1 kΩ
- **Quadrature Droop Input**
    - 10 Ω burden
    - Maximum sensitivity: 0.22 A for 5% droop, zero power factor
    - Maximum input: 0.33 A
- **Current Limit Input**
    - 10 Ω burden
    - Sensitivity range 0.5 A to 1 A
- **Over-Voltage Detection**
    - Set point: 300 VDC.
    - Time delay: 1 s (fixed)
    - Circuit breaker trip coil voltage: 10 VDC to 30 VDC
    - Circuit breaker trip coil resistance: 20 Ω to 60 Ω
- **Over-Excitation Protection**
    - Set point: 75 VDC.
    - Time delay: 8 s to 15 s (fixed)
- **Environmental**
    - Vibration:
        - 20 Hz to 100 Hz: 50 mm/sec
        - 100 Hz to 2 kHz: 3.3 g
    - Operating temperature: -40 °C to +70 °C
    - Relative Humidity 0 °C to 70 °C: 95%[7]
    - Storage temperature: -55 °C to +80 °C

[6] Any device connected to the analogue input must be fully floating (galvanically isolated from ground), with an insulation strength of 500 VAC

[7] Non condensing.

3 Controls

⚠ DANGER

Live Electrical Conductors

Live electrical conductors can cause serious injury or death by electric shock and burns.

To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ DANGER

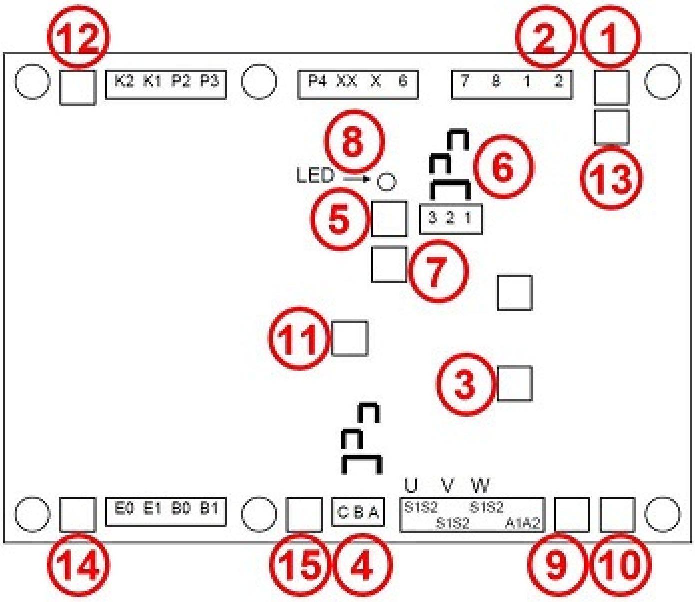
Live Electrical Conductors

Live electrical conductors at output, AVR and AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.

To prevent injury, take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.

NOTICE

Refer to alternator wiring diagram for connection details.



Ref.	Control	Function	Turn potentiometer CLOCKWISE to
1	AVR [VOLTS]	Adjust alternator output voltage	increase voltage
2	**Link : Hand trimmer** 1-2 : No trimmer None : Trimmer fitted	Adjust alternator output voltage	increase voltage
3	AVR [STAB]	Adjust stability to prevent voltage hunting	increase damping effect
4	**Link : Power** A-B : > 550 kW B-C : 90-550 kW A-C : < 90 kW	Select stability response for alternator size	N/A
5	AVR [UFRO]	Adjust under-frequency roll-off knee point	reduce UFRO frequency
6	**Link : Frequency** None : 6 pole 50 Hz 1-2 : 6 pole 60 Hz 2-3 : 4 pole 50 Hz 1-3 : 4 pole 60 Hz	Select alternator frequency for UFRO	N/A
7	AVR [DIP]	Adjust under-frequency voltage dip rate	increase rate
8	Light Emitting Diode	LED lights in UFRO, O/VOLTS or O/EXC condition	N/A
9	AVR [DROOP]	Adjust alternator droop to 5% at zero power factor	increase droop
10	AVR [TRIM]	Adjust analog input sensitivity	increase sensitivity
11	AVR [DWELL]	Adjust voltage recovery	increase recovery time
12	AVR [RAMP]	Adjust soft start voltage ramp	increase ramp time
13	AVR [I LIMIT]	Adjust current limit protection	increase current limit
14	AVR [OVER V]	Adjust over-voltage protection	increase trip voltage
15	AVR [EXC]	Adjust over-excitation protection	increase trip excitation voltage

FIGURE 1. MX321 AVR CONTROLS

3.2 Initial AVR Setup

NOTICE

The AVR must be setup only by authorised, trained service engineers. Do not exceed the designed safe operating voltage, shown on the alternator rating plate.

The AVR controls are set at the factory for initial running tests. Check that the AVR settings are compatible with your required output. Do not adjust controls that have been sealed. To set up a replacement AVR, follow these steps:

1. Stop and isolate the generator set.
2. Install and connect the AVR.
3. Turn the **AVR [VOLTS]** volts control Section 3.3 on page 7 fully counter-clockwise.
4. Turn the hand trimmer (if fitted) to 50%, the midway position.
5. Turn the **AVR [STAB]** stability control Section 3.4 on page 8 to 50%, the midway position.
6. Connect a suitable voltmeter (0 to 300 VAC range) between one output phase and neutral.
7. Start the generator set with no load.
8. Adjust speed to nominal frequency (50 to 53 Hz or 60 to 63 Hz).
9. If the LDE is lit, adjust the **AVR [UFRO]** control Section 3.5 on page 9.
10. Carefully turn **AVR [VOLTS]** control clockwise until the voltmeter shows rated voltage.
11. If voltage is unstable, adjust the **AVR [STAB]** stability control.
12. Re-adjust the **AVR [VOLTS]** control, as needed.

3.3 Adjust the AVR [VOLTS] Voltage Control

NOTICE

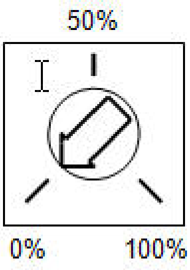
Do not exceed the designed safe operating voltage, shown on the alternator rating plate.

NOTICE

Hand trimmer terminals may be above earth potential. Do not ground any of the hand trimmer terminals. Grounding hand trimmer terminals could cause equipment damage.

To set the output voltage AVR [VOLTS] control on the AVR:

1. Check the alternator nameplate to confirm the designed safe operating voltage.
2. Set the **AVR [VOLTS]** control to 0%, the fully counter-clockwise position.



3. Check that the remote hand trimmer is fitted or terminals 1 and 2 are linked.

NOTICE
If a remote hand trimmer is connected, set it to 50%, the midway position.

4. Turn the **AVR [STAB]** control to 50%, the midway position.
5. Start the alternator and set at the correct operating speed.
6. If the red Light Emitting Diode (LED) is illuminated, refer to the Under Frequency Roll Off **AVR [UFRO]** adjustment.
7. Adjust the **AVR [VOLTS]** control slowly clockwise to increase the output voltage.

NOTICE
If the voltage is unstable set the AVR stability before proceeding Section 3.4 on page 8.

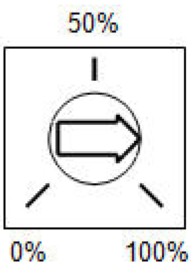
8. Adjust the output voltage to the desired nominal value (VAC).
9. If instability is present at rated voltage, refer to the **AVR [STAB]** adjustment, then adjust **AVR [VOLTS]** again, if necessary.
10. If a remote hand trimmer is connected, check its operation.

NOTICE
0% to 100% rotation corresponds to 90% to 110% VAC

The **AVR [VOLTS]** control is now set.

3.4 Adjust the AVR [STAB] Stability Control

1. Check the nameplate to confirm the power rating of the alternator.
2. Check that the jumper link or rotary switch selection (depending on AVR type) matches the alternator power rating for optimal stability response.
3. Set the **AVR [STAB]** control to approximately 75% position.



4. Start the alternator and set at the correct operating speed.

5. Verify that the alternator voltage is within safe limits.

NOTICE
If the voltage is unstable go immediately to step 5.

6. Adjust the **AVR [STAB]** control slowly counter-clockwise until the output voltage becomes unstable.
7. Adjust the **AVR [STAB]** control slowly clockwise until the voltage is stable.
8. Adjust the **AVR [STAB]** control a further 5% clockwise.

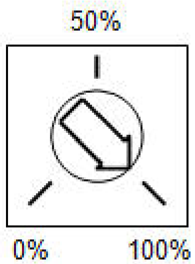
NOTICE
Readjust the voltage level if necessary (see Section 3.3 on page 7).

The **AVR [STAB]** control is now set.

3.5 Adjust the AVR [UFRO] Under-Frequency Roll-Off Control

Below an adjustable frequency threshold ('knee' point), the AVR under-speed protection operates to reduce ('roll-off') the excitation voltage in proportion to alternator frequency. The AVR LED lights when UFRO operates.

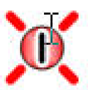
1. Check the nameplate to confirm the frequency of the alternator.
2. Check that the jumper link or rotary switch selection (depending on AVR type) matches the alternator frequency.
3. Set the **AVR [UFRO]** control to 100%, the fully clockwise position.



4. Start the alternator and set at the correct operating speed.
5. Verify that the alternator voltage is correct and stable.

NOTICE
If the voltage is high / low / unstable, use method Section 3.3 on page 7 or Section 3.4 on page 8 before proceeding.

6. Reduce the alternator speed to approximately 95% of correct operating speed. i.e. 47.5 Hz for 50 Hz operation, 57.0 Hz for 60 Hz operation.
7. Adjust the **AVR [UFRO]** control slowly counter-clockwise until the AVR LED lights.



8. Adjust the **AVR [UFRO]** control slowly clockwise until the AVR LED is just OFF.

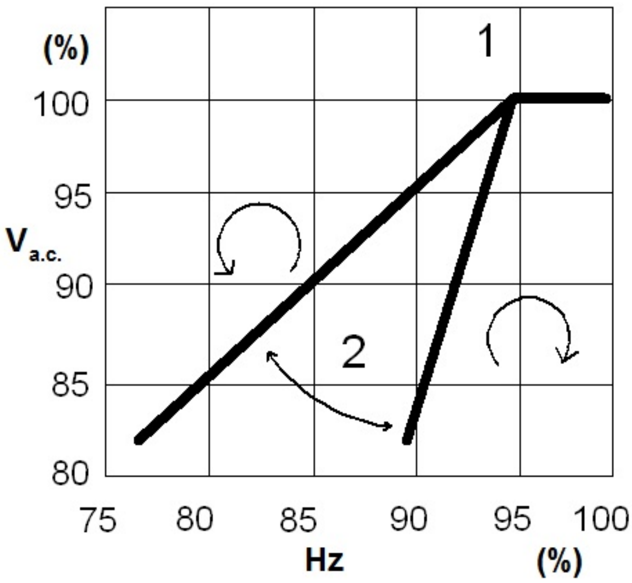
NOTICE
Do not go past the point at which the LED is just OFF.

9. Adjust the alternator speed back to 100% nominal. The LED should be off.

The **AVR [UFRO]** control is now set.

3.6 Adjust the AVR [DIP] Dip Control

Some generator set prime movers, for example turbocharged engines, have limited capacity to tolerate sudden load increases. The rotational speed, and therefore the frequency of the alternator output, falls below the UFRO setting. The AVR reduces the excitation voltage - and hence the output power - in proportion to the frequency, to allow the prime mover to recover. The **AVR [DIP]** control adjusts the proportion.



1	Under-frequency roll-off setting, AVR [UFRO] control
2	Adjust drop in voltage with frequency, AVR [DIP] control

FIGURE 2. EFFECT OF AVR [DIP] CONTROL

1. For the minimum effect (1% fall in frequency gives 1% voltage drop), turn the **AVR [DIP]** control fully counter-clockwise.
2. For the maximum effect (1% fall in frequency gives 3% voltage drop), turn the **AVR [DIP]** control fully clockwise.

3.7 Adjust the AVR [DROOP] Voltage Droop Control for Parallel Operation

A correctly fitted and adjusted droop current transformer (CT) allows the alternator to share reactive current for stable parallel operation.

1. Mount the Droop CT to the correct phase lead of the main output windings of the alternator.
2. Connect the two secondary leads marked S1 and S2 from the CT to the terminals S1 and S2 of the AVR.
3. Turn the **AVR [DROOP]** control to the midway position.
4. Start the alternator(s) and set at the correct operating speed and voltage.
5. Parallel the alternator(s) according to installation rules and procedures.
6. Set the **AVR [DROOP]** control to produce the required balance between individual alternator output currents. Set the AVR droop off-load and then check the currents when the output load is applied, on-load.
7. If the individual alternator output currents rise (or fall) in an uncontrolled way, isolate and stop the alternators then check that:
   - The droop transformer is fitted to the correct phase and in the correct polarity (see the machine wiring diagrams).
   - The droop transformer secondary S1 and S2 leads are connected to the AVR terminals S1 and S2.
   - The droop transformer is the correct rating.

3.8 Adjust the AVR [TRIM] Trim Control

NOTICE
AVR analog inputs must be fully floating (galvanically isolated from ground), with an insulation strength of 500 V a.c. to avoid equipment damage.

An analog input (-5 VDC to +5 VDC) modifies the AVR excitation voltage, by adding to, or subtracting from, the sensed alternator voltage. A Stamford Power Factor Controller (PFC3) can provide such an input. The **AVR [TRIM]** control adjusts the effect.

1. Connect the analog input from the PFC3, or similar, to terminals A1 and A2 of the AVR. Terminal A1 is connected to AVR zero volts. Positive voltage connected to A2 increases AVR excitation, negative voltage connected to A2 decreases AVR excitation.
2. Turn the **AVR [TRIM]** control to the desired position. The analog signal has no effect on excitation when the **AVR [TRIM]** control is fully counter-clockwise, and maximum effect when fully clockwise.

3.9 Adjust the AVR [OVER V] Over-Voltage Control

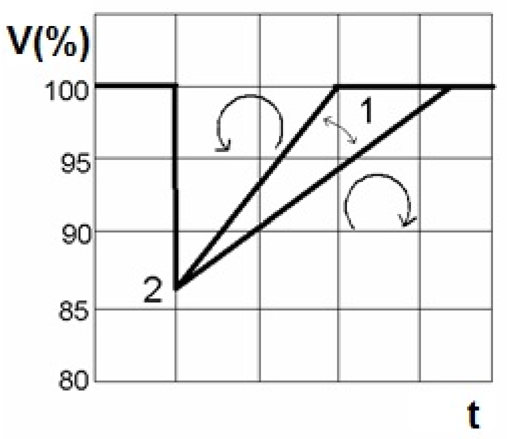
NOTICE
The AVR [OVER V] control is set and sealed at the factory to protect the alternator from over-voltage. Incorrect AVR [OVER V] control setting could damage the alternator.

The AVR protects the alternator by removing excitation if it senses that the alternator output voltage exceeds a threshold set by the **AVR [OVER V]** control.

1. If the alternator output voltage exceeds the over-voltage setting, the red LED on the AVR turns on.
2. After a short time, the AVR removes the excitation voltage and the red LED flashes (which can also indicate an over-excitation trip or UFRO operation).
3. Stop the alternator to reset the over-voltage condition.

3.10 Adjust the AVR [DWELL] Dwell Control

Some generator set prime movers, for example turbocharged engines, have limited capacity to tolerate sudden load increases. The AVR introduces a time delay before increasing the excitation voltage after an under-frequency condition, to allow the prime mover to recover. The **AVR [DWELL]** control adjusts the proportion.



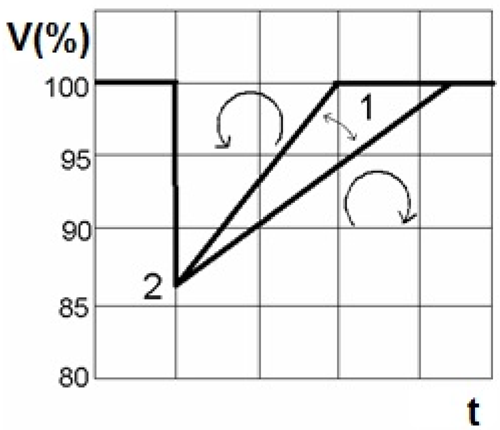
1	Adjustable rate of excitation voltage rise, AVR [DWELL] control
2	Prime mover starts to recover from under-frequency condition

FIGURE 3. EFFECT OF AVR [DWELL] CONTROL

1. For the minimum effect (excitation voltage follows speed according to UFRO V/Hz ramp), turn the **AVR [DWELL]** control fully counter-clockwise.
2. For the maximum effect (excitation voltage lags speed increase by several seconds), turn the **AVR [DWELL]** control fully clockwise.

3.11 Adjust the AVR [RAMP] Dwell Control

The AVR includes a soft start circuit to control the rate of excitation voltage rise, as the alternator starts and runs up to speed. The **AVR [RAMP]** control adjusts the rate.



1	Adjustable rate of excitation voltage rise, AVR [RAMP] control
2	Alternator starts

FIGURE 4. EFFECT OF AVR [DWELL] CONTROL

1. For the minimum effect (excitation voltage reaches 100% in about 0.5s), turn the **AVR [RAMP]** control fully counter-clockwise.
2. For the maximum effect (excitation voltage reaches 100% in about 4.0s), turn the **AVR [RAMP]** control fully clockwise.

3.12 Adjust the AVR [EXC] Over-Excitation Control

NOTICE
The AVR [EXC] control is set and sealed at the factory to protect the alternator from over-excitation, usually caused by overload. Incorrect AVR [EXC] control setting could damage the alternator rotor components.

The AVR protects the alternator by removing excitation if it senses that the excitation voltage exceeds a threshold set by the **AVR [EXC]** control.

1. If the excitation voltage exceeds the over-excitation trip setting, the red LED on the AVR turns on.
2. After a short time, the AVR removes the excitation voltage and the red LED flashes (which can also indicate an over-voltage trip or UFRO operation).
3. Stop the alternator to reset the over-excitation condition.

3.13 Current Limiting Transformers

Alternator main output current can be electronically limited by connecting additional current transformers to the MX321 AVR. In any situation where the output current attempts to rises above a preset threshold (set on AVR) then the AVR will reduce the terminal voltage to restore the set current level. For unbalanced loads, operation is based on the highest of the three phase currents.

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4 Accessories

4.1 Alternator Protection Module

4.1.2 Description

The STAMFORD Alternator Protection Module (APM) is a three-phase over-voltage/under-voltage detector. The APM detects if any phase-to-neutral voltage exceeds an adjustable upper threshold or falls below a fixed lower threshold, and switches an internal relay if the fault persists for more than a few cycles (to avoid nuisance activation).

The changeover contact of the relay can be wired to a protective circuit to open a main circuit breaker, remove alternator excitation or stop the engine, for example. The APM is an inexpensive alternative to current monitoring short circuit protection, which requires three or more current transformers.

The APM operates for these faults:

- phase-to-neutral, by detecting under-voltage on the affected phase
- line-to-line, by detecting under-voltage on the affected phases or over-voltage on the third
- three-phase short circuit, by detecting under-voltage (separate no-voltage protection may also be triggered).

Key features include:

- Robust and reliable solid-state electronics
- Built-in relay to operate a protective circuit
- Short circuit protection without current transformers
- Simple connection to the alternator.

4.1.3 Specification

- **Input**
  - Voltage: 100 VAC to 360 VAC, 50 Hz to 60 Hz, 1 phase or 3 phase + neutral (APM 220 VAC version)
  - Voltage: 175 VAC to 625 VAC, 50 Hz to 60 Hz, 3 phase + neutral (APM 380 VAC version)
- **Output**
  - Single pole changeover relay rating: 5 A @ 30 VDC, 5 A @ 240 VAC
  - Power dissipation: 6 W maximum
  - Pulse[8] length: 200 ms minimum
  - Pulse frequency: 3.2 s typical
- **Preset Range**
  - Under-voltage threshold: 110 VAC ± 10% (APM 220 VAC version)
  - Under-voltage threshold: 190 VAC ± 10% (APM 380 VAC version)
  - Over-voltage threshold: 245 VAC to 360 VAC, adjustable (APM 220 VAC version)
  - Over-voltage threshold: 420 VAC to 625 VAC, adjustable (APM 380 VAC version)
- **Environmental**
  - Vibration: 30 mm/s @ 20 Hz to 100 Hz, 2 g @ 100 Hz to 2 kHz
  - Relative humidity: 95%[9]
  - Storage temperature: -55 °C to +80 °C
  - Operating temperature: -40 °C to +70 °C.

4.1.4 Controls

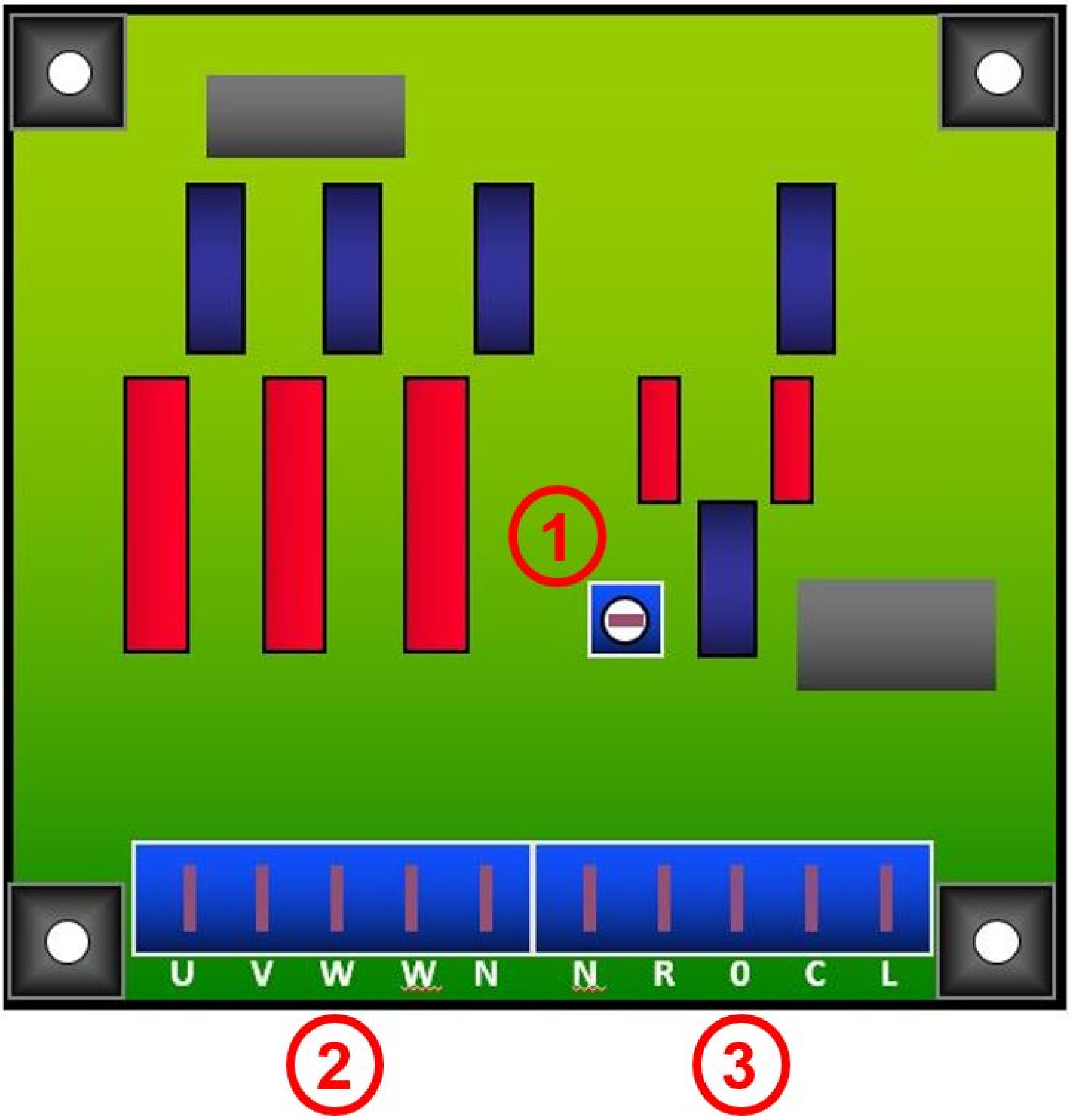
⚠ DANGER
Live Electrical Conductors **Live electrical conductors can cause serious injury or death by electric shock and burns.** **To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.**

⚠ DANGER
Live Electrical Conductors **Live electrical conductors at output, AVR and AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.** **To prevent injury, take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.**

[8] Pulsed output prevents overloading
[9] Non-condensing

NOTICE

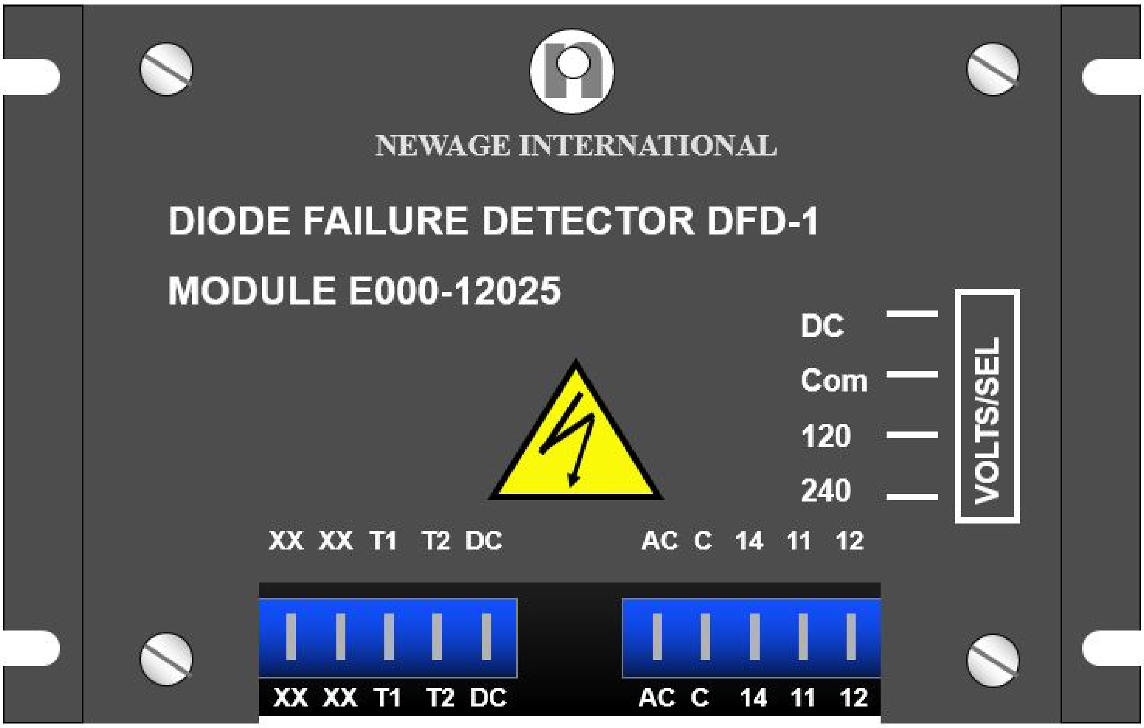
Refer to alternator wiring diagram for connection details. Mount the APM on a switchboard or bedplate, not in the alternator terminal box.



Ref.	Control	Function	Turn potentiometer CLOCKWISE to
1	THRESHOLD	Adjust over-voltage threshold	increase voltage to operate relay
2	**Sensing Input** U, V, W, N	Connect to alternator output	N/A
3	**Output relay contacts** L, W : :	Connect to external control system	N/A

FIGURE 5. ALTERNATOR PROTECTION MODULE CONTROLS

4.2 Diode Failure Detector



4.2.2 Description

The STAMFORD Diode Failure Detector (DFD) senses ripple current in the exciter output caused by diode failure in short or open circuit, and switches an internal relay if it persists for 7 seconds.

The changeover contacts of the relay can be wired to provide a warning indication of diode failure or initiate an automatic shutdown.

Where the DFD triggers a warning, monitor the exciter field current or voltage and reduce load as necessary, so that the generator set can continue to run until a planned controlled shutdown to replace the diode.

Key features include:

- Robust and reliable solid-state electronics
- Built-in test function
- Selectable power supply
- Simple connection to the alternator.

4.2.3 Specification

- **Sensing Input**
  - Voltage: 0 VDC to 150 VDC

    Input resistance: 100 kΩ

    Sensitivity: 50 V peak
- **Power Supply**
  - Voltage: 12 VDC to 28 VDC
  - Voltage: 100 VAC to 140 VAC

- Voltage: 200 VAC to 280 VAC
- Current: 0.2 A maximum

- **Output**
  - Single pole changeover relay rating: 5 A @ 30 VDC, 5 A @ 240 VAC
  - Isolation: 2 kV
  - Volt-free contacts
- **Time Delays**
  - Response time: 7 s (approximately)
- **Environmental**
  - Vibration: 30 mm/s @ 20 Hz to 100 Hz, 2 g @ 100 Hz to 2 kHz
  - Relative humidity: 95%[10]
  - Storage temperature: -55 °C to +80 °C
  - Operating temperature: -40 °C to +70 °C.

4.2.4 Controls

⚠ DANGER

Live Electrical Conductors
Live electrical conductors can cause serious injury or death by electric shock and burns.
To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

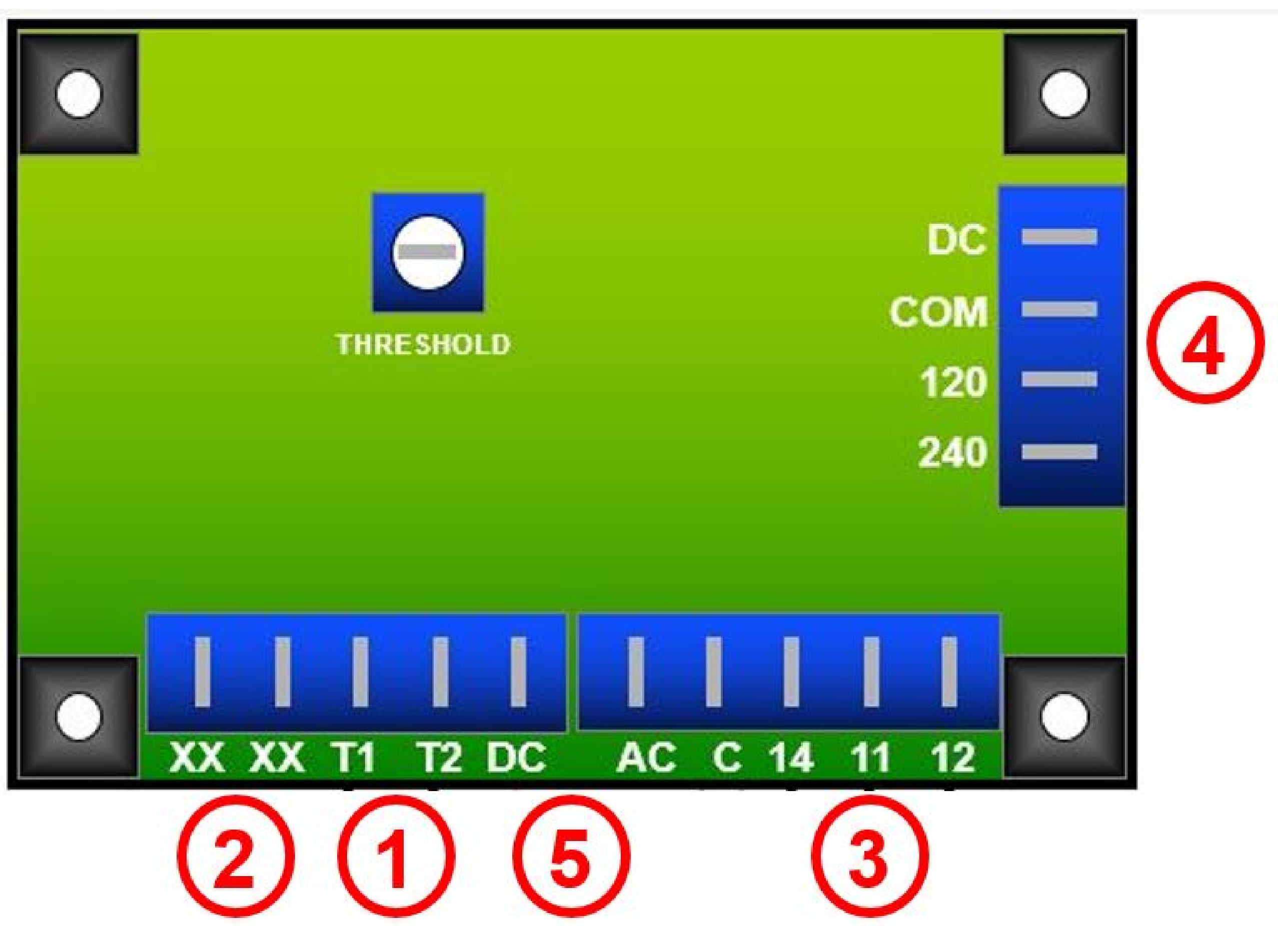
⚠ DANGER

Live Electrical Conductors
Live electrical conductors at output, AVR and AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.
To prevent injury, take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.

NOTICE

Refer to alternator wiring diagram for connection details. Mount the DFD on a switchboard or bedplate, not in the alternator terminal box.

[10] Non-condensing



Ref.	Control	Function
1	**Link : Test** T1-T2	Test DFD function
2	**Sensing Input** XX, XX	Connect F2 in series between exciter stator and AVR
3	**Output relay contacts** 11-14 : Normally-open 11-12 : Normally-closed	Connect to external warning or shutdown system
4	**Link : Supply voltage** COM-DC : 12 VDC to 28 VDC COM-120 : 100 VAC to 140 VAC COM-240 : 200 VAC to 280 VAC	Select VDC or VAC supply voltage
5	**Power Supply** DC : VDC positive (VDC supply)[11] C : VDC negative (VDC supply) AC : P2 from PMG (VAC supply) C : P3 from PMG (VAC supply)	Connect VDC **or** VAC power supply

FIGURE 6. DIODE FAILURE DETECTOR CONTROLS

[11] disconnect to reset DFD

4.3 Dual AVR Unit

4.3.1 Description

The STAMFORD dual AVR unit (DAU) has two MX321 AVRs arranged for manual switching. If an AVR fails, regulation can be switched to the other AVR, so that the generator set can continue to run until a planned controlled shutdown to replace the faulty AVR. The supplied 6 pole changeover switch can be panel-mounted or substituted by another of equivalent rating and preferred design.

Both AVRs are wired to terminals at a terminal block, grouped for easy connection; to the alternator, to optional current transformers for paralleling and/or short circuit protection, and to hand trimmers.

Key features include:

- Robust and reliable solid-state electronics
- Built-in changeover switch
- Simple connection to the alternator.

4.3.2 Specification

- **Sensing Input**
  - Paralleling: quadrature droop current transformer (CT) in W phase[12]
  - Short circuit protection: current transformer in U, V and W phases
- **Manual Switch**
  - 6 pole changeover switch contact rating: 5 A @ 240 VAC
  - Power dissipation: 6 W maximum
- **Environmental**
  - Vibration: 30 mm/s @ 20 Hz to 100 Hz, 2 g @ 100 Hz to 2 kHz
  - Relative humidity: 95%[13]
  - Storage temperature: -55 °C to +80 °C
  - Operating temperature: -40 °C to +70 °C.

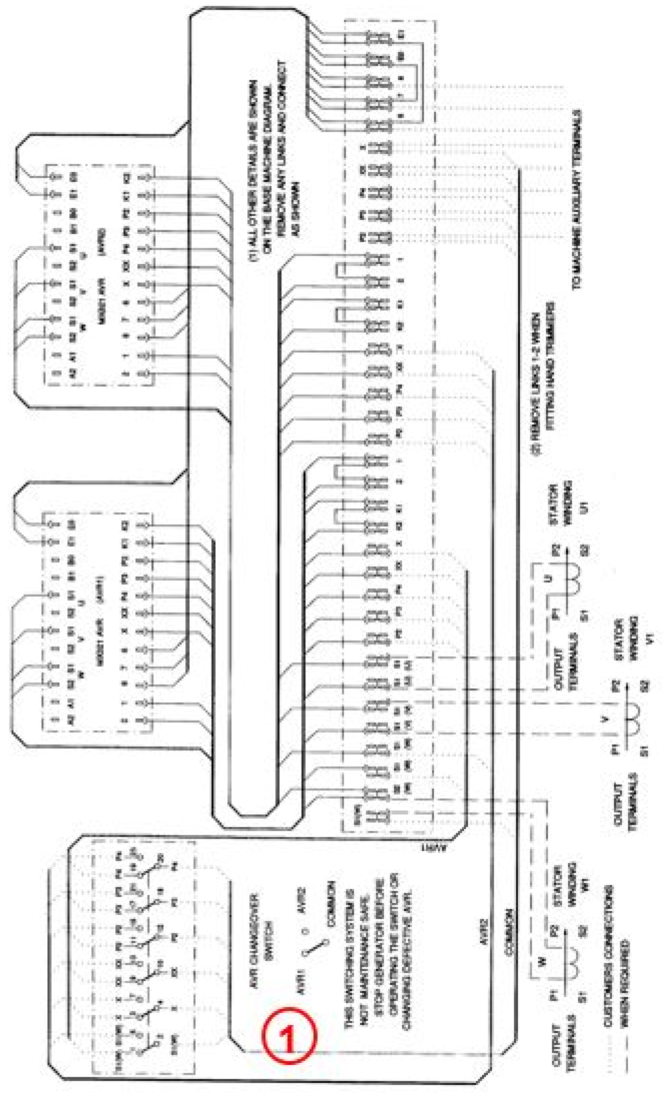
4.3.3 Controls

⚠ DANGER
Live Electrical Conductors **Live electrical conductors can cause serious injury or death by electric shock and burns.** **To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.**

⚠ DANGER
Live Electrical Conductors **Live electrical conductors at output, AVR and AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.** **To prevent injury, take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.**

[12] same CT can be used for short circuit protection.
[13] Non-condensing

NOTICE
Refer to alternator wiring diagram for connection details. Mount the DAU on a switchboard or bedplate.



Ref.	Control	Function
1	AVR Select Switch	AVR1 : alternator regulated by AVR1. See **Chapter 3** to set up AVR1. AVR2 : alternator regulated by AVR2. See **Chapter 3** to set up AVR2.

FIGURE 7. DUAL AVR UNIT CONTROLS

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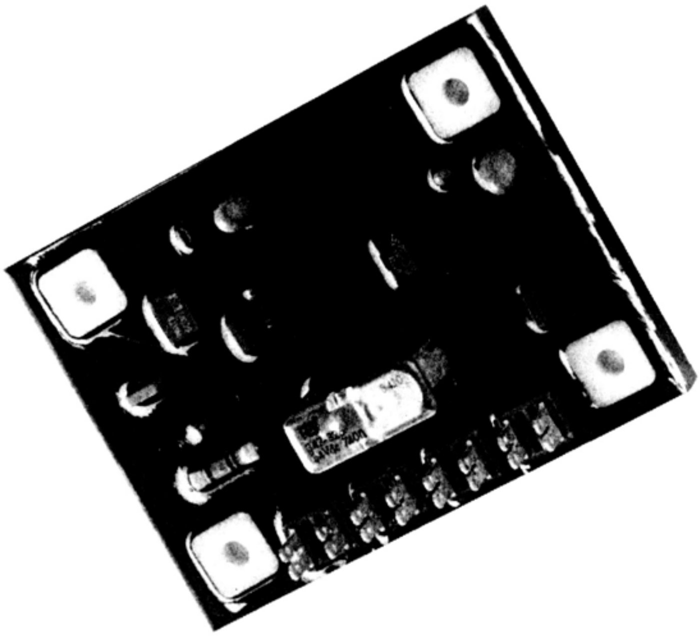
4.4 Excitation Loss Module



4.4.2 Description

A loss of alternator excitation during parallel operation will result in heavy circulating currents, pole-slipping (loss of synchronization), and torque/current surges and oscillation. The STAMFORD Excitation Loss Module (ELM) monitors the alternator AVR output and signals any sustained interruption to an integral relay to initiate an indication/alarm.

The ELM has been specially designed for use with all Stamford AVRs. It is powered independently from the engine battery at 12 VDC or 24 VDC. It operates by detecting the absence of the characteristic 'rectifier ripple' in the exciter field voltage. An optical isolator ensures complete electrical isolation between the exciter field circuit and the engine battery system. Any loss of AVR output is recognised immediately by the monitoring circuit, and if the interruption persists for more than about a second the module output energises an integral relay. The changeover contacts can either provide remote indication of the excitation failure or operate any other relay-fed protective device. The system incorporates a time delay to prevent spurious tripping on transients and an eight-second engine-start lock-out that can be overridden.

Key features include:

- Robust and reliable solid-state electronics
- Independently-powered from the engine battery
- Power supply is completely isolated from exciter field
- Engine-start lock-out time delay.

4.4.3 Specification

- **Sensing Input**
  - Voltage: 0 VDC to 150 VDC

    Input resistance: 100 kΩ

    Sensitivity: 50 V peak

- **Power Input**
  - Voltage: 10 VDC to 14 VDC (ELM 12V version)
  - Voltage: 20 VDC to 28 VDC (ELM 24V version)
  - Current: 25 mA max. in standby (both versions)
  - Relay on: 150 mA maximum (ELM 12V version)
  - Relay on: 60 mA maximum (ELM 24V version)
- **Output**
  - Single pole changeover relay rating: 5 A @ 30 VDC, 5 A @ 240 VAC
  - Power dissipation: 3 W maximum
- **Time Delays**
  - Response time: 1.5 s to 2 s
  - Power up delay: 8 s to 15 s
- **Environmental**
  - Vibration: 30 mm/s @ 20 Hz to 100 Hz, 2 g @ 100 Hz to 2 kHz
  - Relative humidity: 95%[14]
  - Storage temperature: -55 °C to +80 °C
  - Operating temperature: -40 °C to +70 °C.

4.4.4 Controls

⚠ DANGER

Live Electrical Conductors
Live electrical conductors can cause serious injury or death by electric shock and burns.
To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

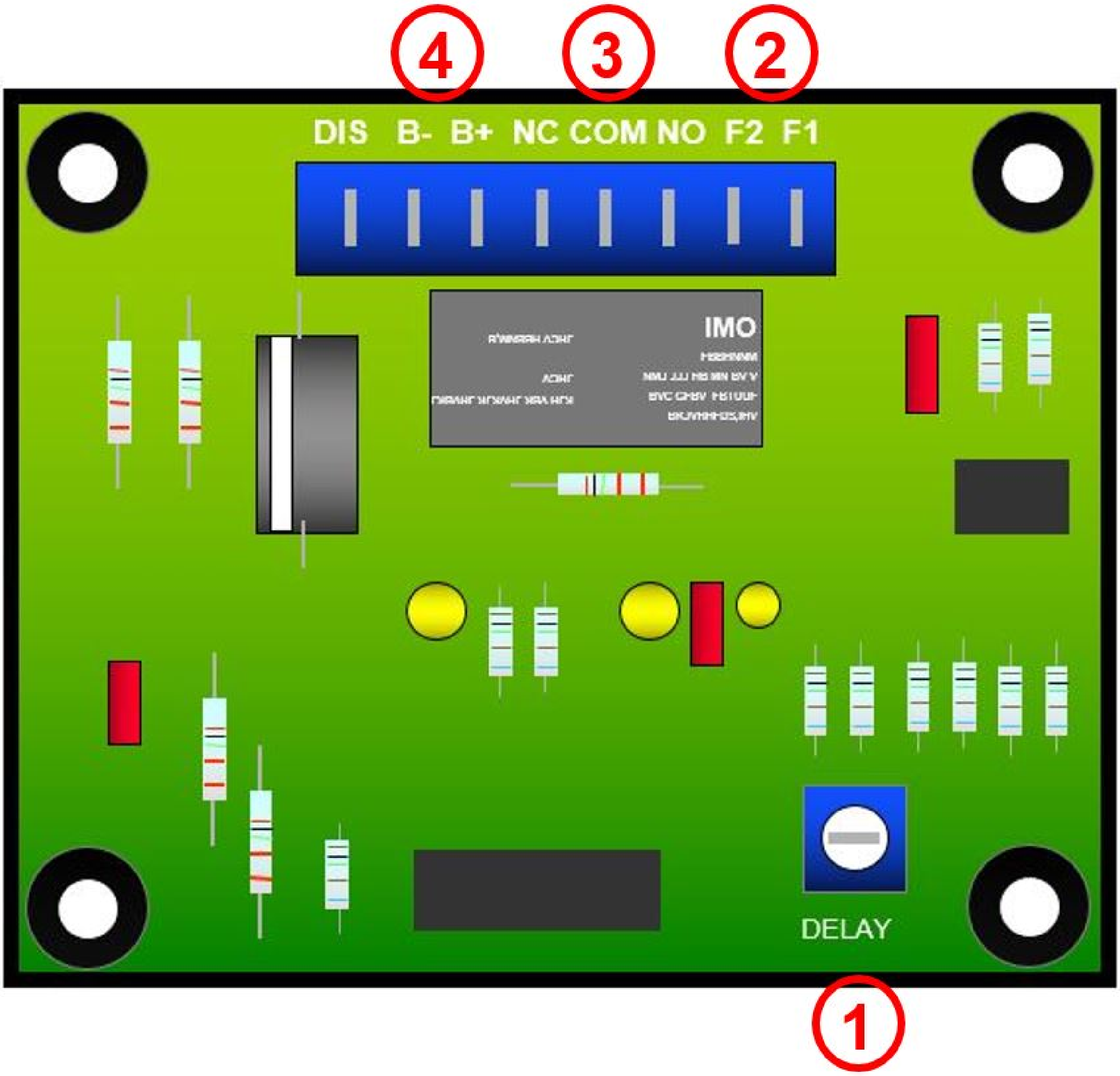
⚠ DANGER

Live Electrical Conductors
Live electrical conductors at output, AVR and AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.
To prevent injury, take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.

NOTICE

Refer to alternator wiring diagram for connection details. Mount the ELM on a switchboard or bedplate, not in the alternator terminal box.

[14] Non-condensing



Ref.	Control	Function	Turn potentiometer CLOCKWISE to
1	DELAY	Adjust time delay	increase delay to operate relay
2	**Sensing Input** F1, F2	Connect to exciter stator	N/A
3	**Output relay contacts** COM-NO : Normally-open COM-NC : Normally-closed	Connect to external control system	N/A
4	**Power Input** B- : Battery negative B+: Battery positive	Connect to engine battery	N/A

FIGURE 8. EXCITATION LOSS MODULE CONTROLS

4.5 Frequency Detection Module

4.5.1 Description

The STAMFORD Frequency Detection Module (FDM) is used with a separately-excited alternator, deriving an alternator frequency (rotational speed) signal from the Permanent Magnet Generator (PMG).

The FDM operates a relay if the frequency falls below an adjustable preset under-frequency threshold. Changeover contacts can be used for engine control to disengage a starter motor, for example.

The FDM operates a relay if the frequency rises above an adjustable preset over-frequency threshold. Changeover contacts can be used for engine control to initiate an over-speed shutdown.

Key features include:

- Robust and reliable solid-state electronics
- Independently powered from the engine battery
- Simple connection to the alternator.

4.5.2 Specification

- **Sensing Input**
  - Voltage: 20 VAC to 300 VAC
  - Frequency: 100 Hz @ 1500 RPM
  - Optical isolation: 2 kV
- **Power Input**
  - Voltage: 10 VDC to 16 VDC (FDM 12VDC version)
  - Voltage: 20 VDC to 32 VDC (FDM 24VDC version)
  - Current: 200 mA maximum (FDM 12VDC version)
  - Current: 100 mA maximum (FDM 24VDC version)
- **Output**
  - Single pole changeover relay rating: 5 A @ 30 VDC, 5 A @ 240 VAC
  - Optical isolation: 2 kV
- **Preset Range**
  - Under-frequency: 300 RPM to 1800 RPM
  - Over-frequency: 1500 RPM to 2500 RPM
- **Environmental**
  - Vibration: 30 mm/s @ 20 Hz to 100 Hz, 2 g @ 100 Hz to 2 kHz
  - Relative humidity: 95%[15]
  - Storage temperature: -55 °C to +80 °C
  - Operating temperature: -40 °C to +70 °C.

[15] Non-condensing

4.5.3 Controls

⚠ DANGER

Live Electrical Conductors

Live electrical conductors can cause serious injury or death by electric shock and burns.

To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ DANGER

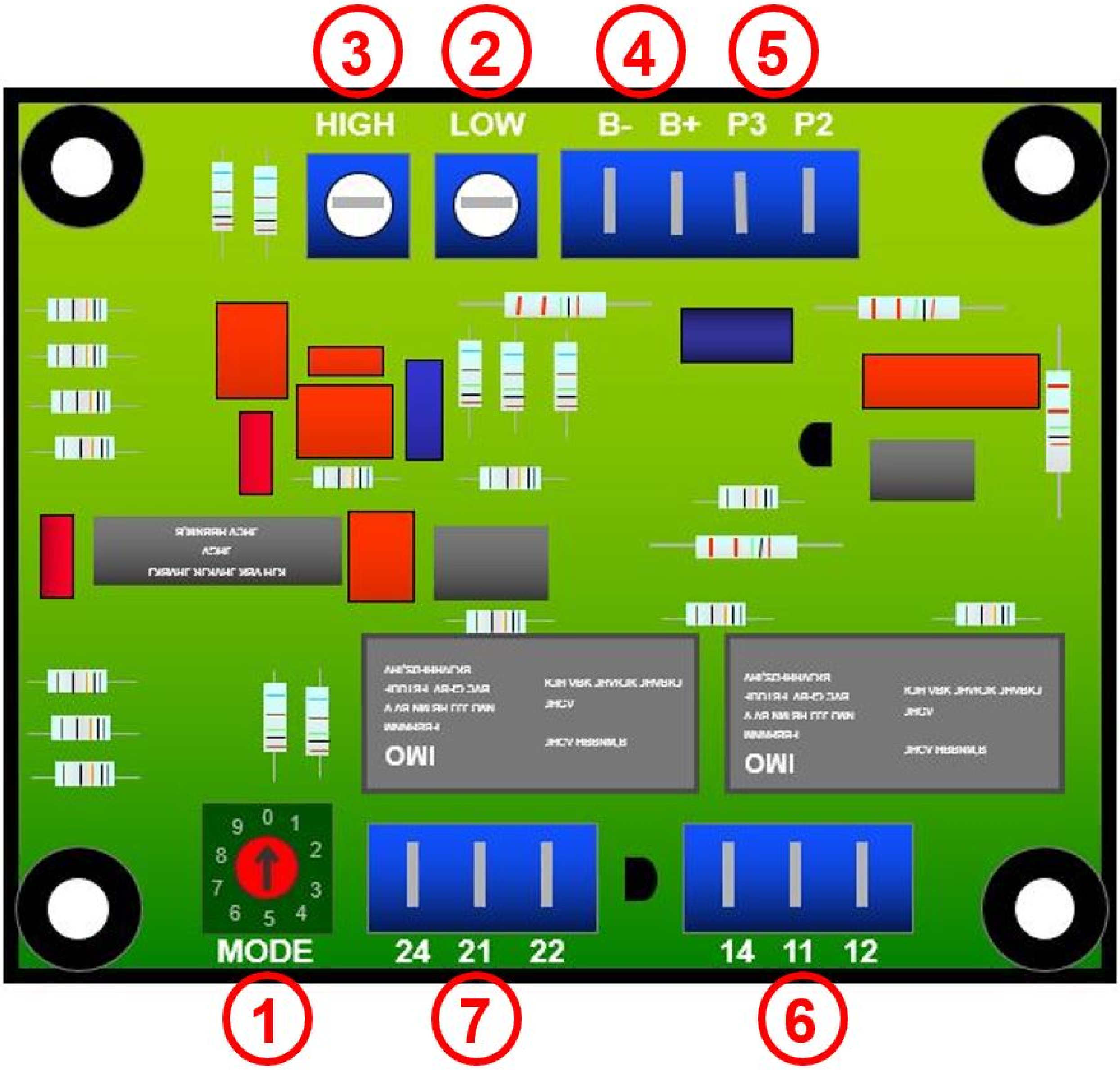
Live Electrical Conductors

Live electrical conductors at output, AVR and AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.

To prevent injury, take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.

NOTICE

Refer to alternator wiring diagram for connection details. Mount the FDM on a switchboard or bedplate, not in the alternator terminal box.



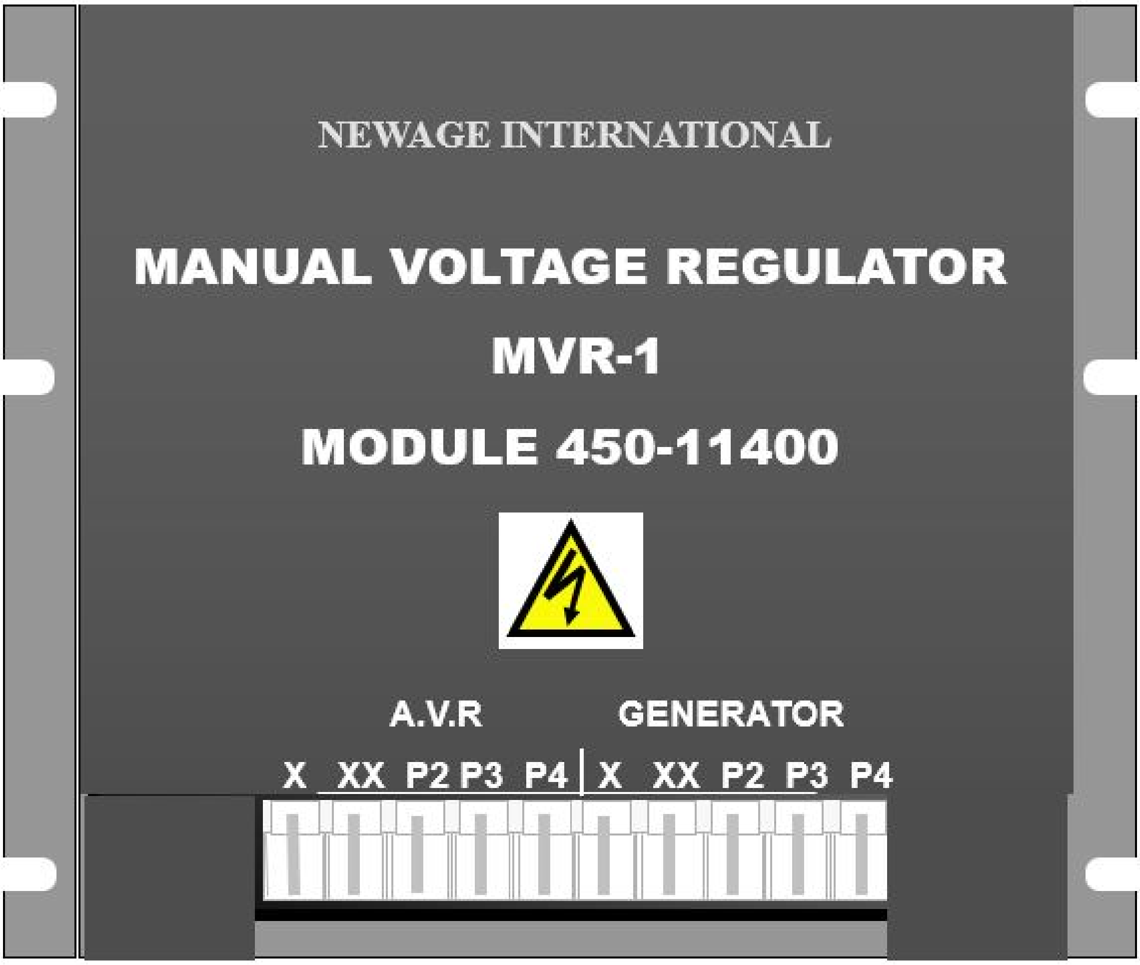
Ref.	Control	Function	Turn potentiometer CLOCKWISE to
1	MODE	Select under-frequency relay mode 0 = relay energised at rest 1 = relay de-energised at rest	N/A
2	LOW	Adjust under-frequency threshold	increase frequency to operate relay
3	HIGH	Adjust over-frequency threshold	increase frequency to operate relay
4	**Power Input** B- : Battery negative B+: Battery positive	Connect to engine battery	N/A
5	**Sensing Input** P2, P3	Connect to PMG	N/A
6	**Output relay contacts** 11-14 : Normally-open 11-12 : Normally-closed	Connect to under-frequency external control system	N/A

-

7	**Output relay contacts** 21-24 : Normally-open 21-22 : Normally-closed	Connect to over-frequency external control system	N/A

FIGURE 9. FREQUENCY DETECTION MODULE CONTROLS

4.6 Manual Voltage Regulator



4.6.2 Description

The STAMFORD Manual Voltage Regulator (MVR) automatically controls alternator current output to a manually-set constant, independent of alternator voltage or frequency.

A manually-controlled excitation system can be useful if the AVR fails. Although not practicable for stand-alone operation, a manually-controlled alternator can operate in parallel with another alternator whose AVR is healthy. Manual control can also provide a controlled level of short-circuit current for:

- drying-out windings or setting protective devices
- frequency starting of relatively large motors (where an electrically-connected alternator and motor are run up together from rest)
- dynamometer loading of motors or engines, and
- control of static loads (e.g. variable-intensity lighting).

An MVR is used with a separately-excited AVR, and powered from the same permanent-magnet generator (PMG). PMG-powered systems offer reliable build-up and sustained short-circuit current for flexibility and operational stability.

Key features include:

- Robust and reliable solid-state electronics
- Manually-set automatic field current control
- Dependable power supply from PMG.

The MVR has three switch-selectable modes:

- Auto, with the AVR maintaining a pre-set alternator output voltage
- Off, with zero exciter stator current
- Manual, with a manually-set exciter stator current, automatically maintained.

A mode can be changed while the alternator is running without damage to MVR or AVR, but the effects on the alternator and any connected load must be monitored. An external lamp or relay can be connected across two of the AVR terminals to show when the MVR is in Auto mode.

4.6.3 Specification

- **Power Input from PMG**
  - Voltage: 150 VAC to 220 VAC, three phase
  - Frequency: 67 Hz to 120 Hz (depending on alternator speed)
- **Regulated Output**
  - 0.25 A to 2.0 A, minimum 20 Ω
- **Power Dissipation**
  - 6 W maximum
  - Power up delay: 8 s to 15 s
- **Environmental**
  - Vibration: 30 mm/s @ 20 Hz to 100 Hz, 2 g @ 100 Hz to 2 kHz
  - Relative humidity: 95%[16]
  - Storage temperature: -55 °C to +80 °C
  - Operating temperature: -40 °C to +70 °C.

4.6.4 Controls

⚠ DANGER
Live Electrical Conductors **Live electrical conductors can cause serious injury or death by electric shock and burns.** **To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.**

[16] Non-condensing

⚠ DANGER

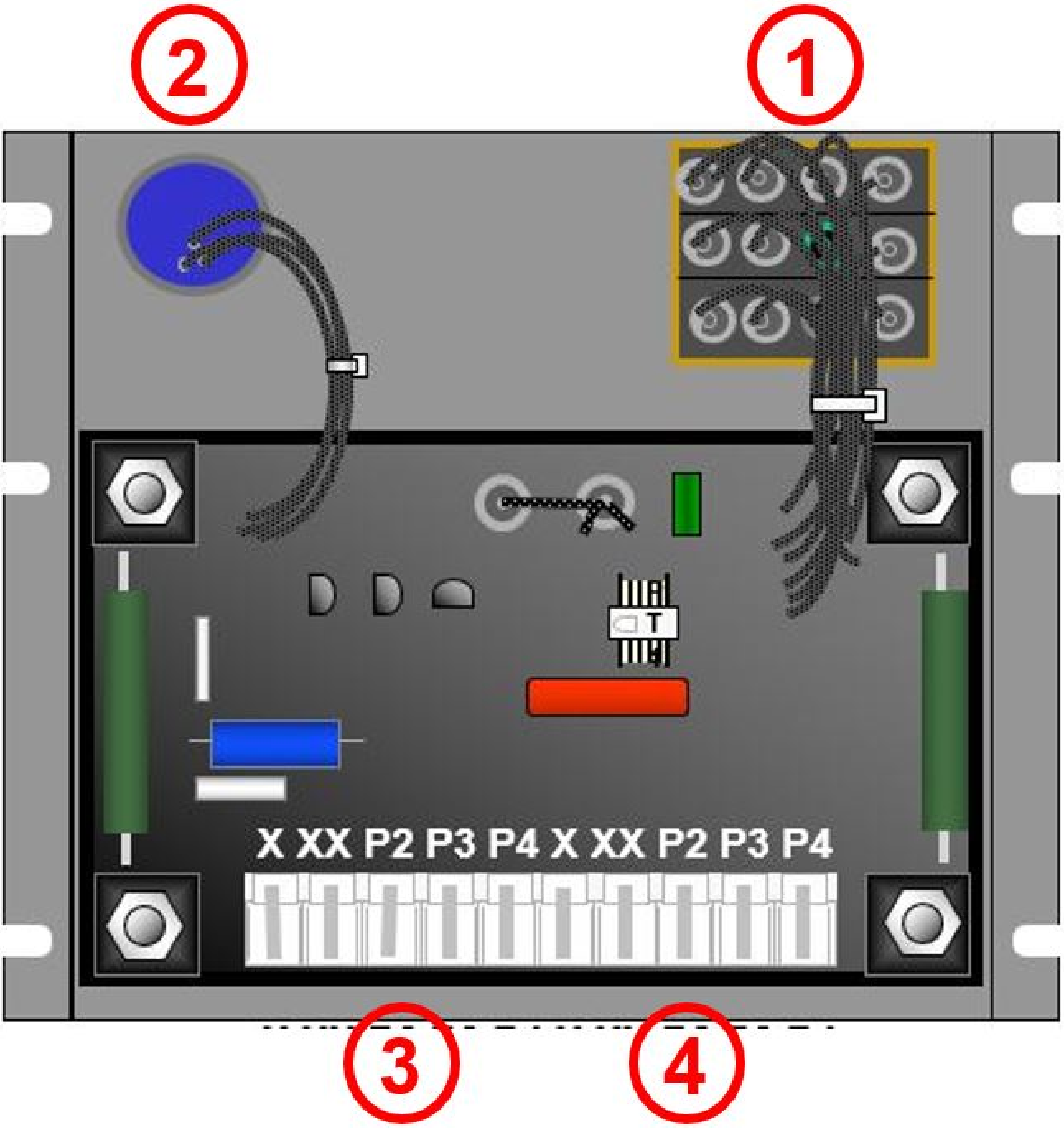
Live Electrical Conductors

Live electrical conductors at output, AVR and AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.

To prevent injury, take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.

NOTICE

Refer to alternator wiring diagram for connection details. Mount the ELM on a switchboard or bedplate, not in the alternator terminal box.



Ref.	Control	Function
1	Mode Select Switch	AUTO : exciter stator current controlled by AVR OFF : zero exciter stator current MANUAL : exciter stator current set by excitation control potentiometer
2	Excitation control potentiometer	Set exciter stator current in Manual mode
3	X, XX : exciter stator P2, P3, P4 : power supply from PMG	Connections to AVR
4	X, XX : exciter stator P2, P3, P4 : power supply from PMG	Connections to alternator

FIGURE 10. MANUAL VOLTAGE REGULATOR CONTROLS

4.7 Remote Control Interface

4.7.1 Description

The STAMFORD Remote Control Interface (RCI) is used with a STAMFORD Automatic Voltage Regulator (AVR) or a STAMFORD Power Factor Controller (PFC3) to control the alternator voltage or power factor (respectively) remotely.

The RCI has two inputs which accept unipolar 4-20Ma or bipolar 0-10 volt signals to control alternator power factor from 0.7 lag to 0.7 lead or alternator voltage up to +/- 10%. The input circuitry is fully floating for maximum application flexibility. Loss of the control signal provides a default Unity Power Factor setting or returns the voltage to the AVR no-load setting.

The RCI allows the power factors of alternators running in parallel to be controlled automatically from a convenient remote location, to suit local site conditions.

The RCI allows the voltage of several alternators to be matched simultaneously with one signal, to allow voltage matching before paralleling.

Key features include:

- Robust and reliable solid-state electronics
- Industry standard interfaces to control equipment
- Selectable power supply from alternator output
- Simple connection to the alternator.

4.7.2 Specification

- **Control Input**
  - Voltage: 0 VDC to 10 VDC, input resistance 100 Ω
  - Current: 4 mA to 20 mA, input resistance 38 kΩ[17]
  - Optical isolation: 1 kV input to output
- **Power Input**
  - Voltage: 110 VAC to 125 VAC, 50 Hz to 60 Hz
  - Voltage: 200 VAC to 230 VAC, 50 Hz to 60 Hz
  - Voltage: 231 VAC to 250 VAC, 50 Hz to 60 Hz
  - Voltage: 251 VAC to 290 VAC, 50 Hz to 60 Hz
  - Power: 5 VA
- **Output**
  - Single pole changeover relay rating: 5 A @ 30 VDC, 5 A @ 240 VAC
  - Optical isolation: 2 kV
- **Preset Range**
  - Power factor control: 0.7 lead (4 mA) to 0.7 lag (20 mA) or 0.7 lead (-10 VDC) to 0.7 lag (+10 VDC)[18]

[17] Use twisted pair, screened cables separated from power. Apply control input smoothly with alternator at rest, from default 12 mA. To allow the PFC3 to compensate after voltage matching, return the control input smoothly to 12 mA in not less than 15 seconds.

[18] see Figure 11 for response

  - Voltage control: -10% (4 mA) to +10% (20 mA) or -10% (-10 VDC) to +10% (+10 VDC)[19][20]
  - Response time constant: less than 20 ms
- **Environmental**
  - Vibration: 50 mm/s @ 10 Hz to 100 Hz, 4.4 g @ 100 Hz to 300 Hz
  - Relative humidity: 95%[21]
  - Storage temperature: -55 °C to +80 °C
  - Operating temperature: -40 °C to +70 °C.

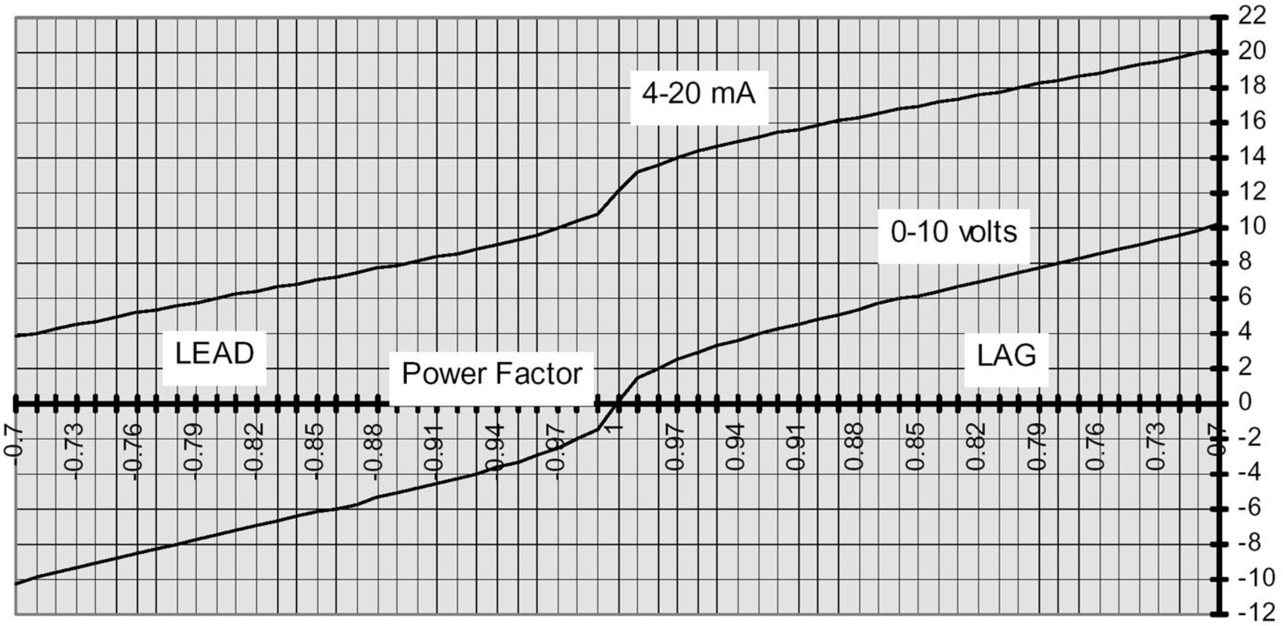


FIGURE 11. POWER FACTOR RESPONSE TO CONTROL INPUTS

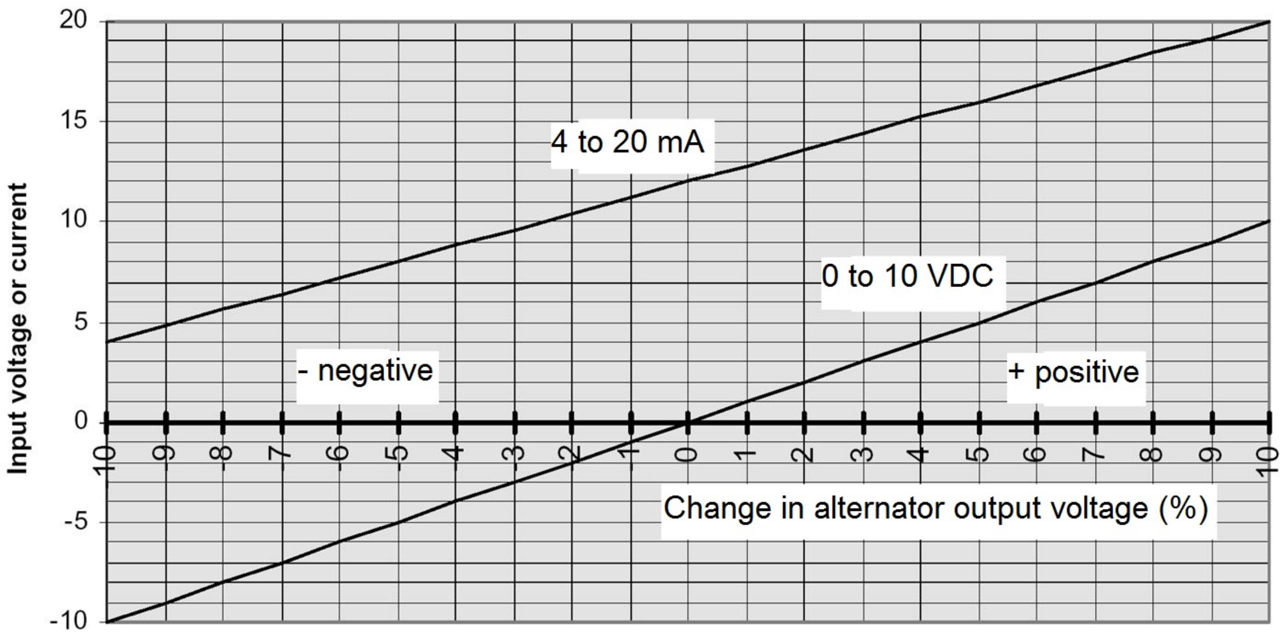


FIGURE 12. VOLTAGE RESPONSE TO CONTROL INPUTS

19 see **Figure 12** for response
20 Depends on AVR type and VTRIM setting.
21 Non-condensing

4.7.3 Controls

⚠ DANGER

Live Electrical Conductors

Live electrical conductors can cause serious injury or death by electric shock and burns.

To prevent injury and before removing covers over electrical conductors, isolate the generator set from all energy sources, remove stored energy and use lock out/tag out safety procedures.

⚠ DANGER

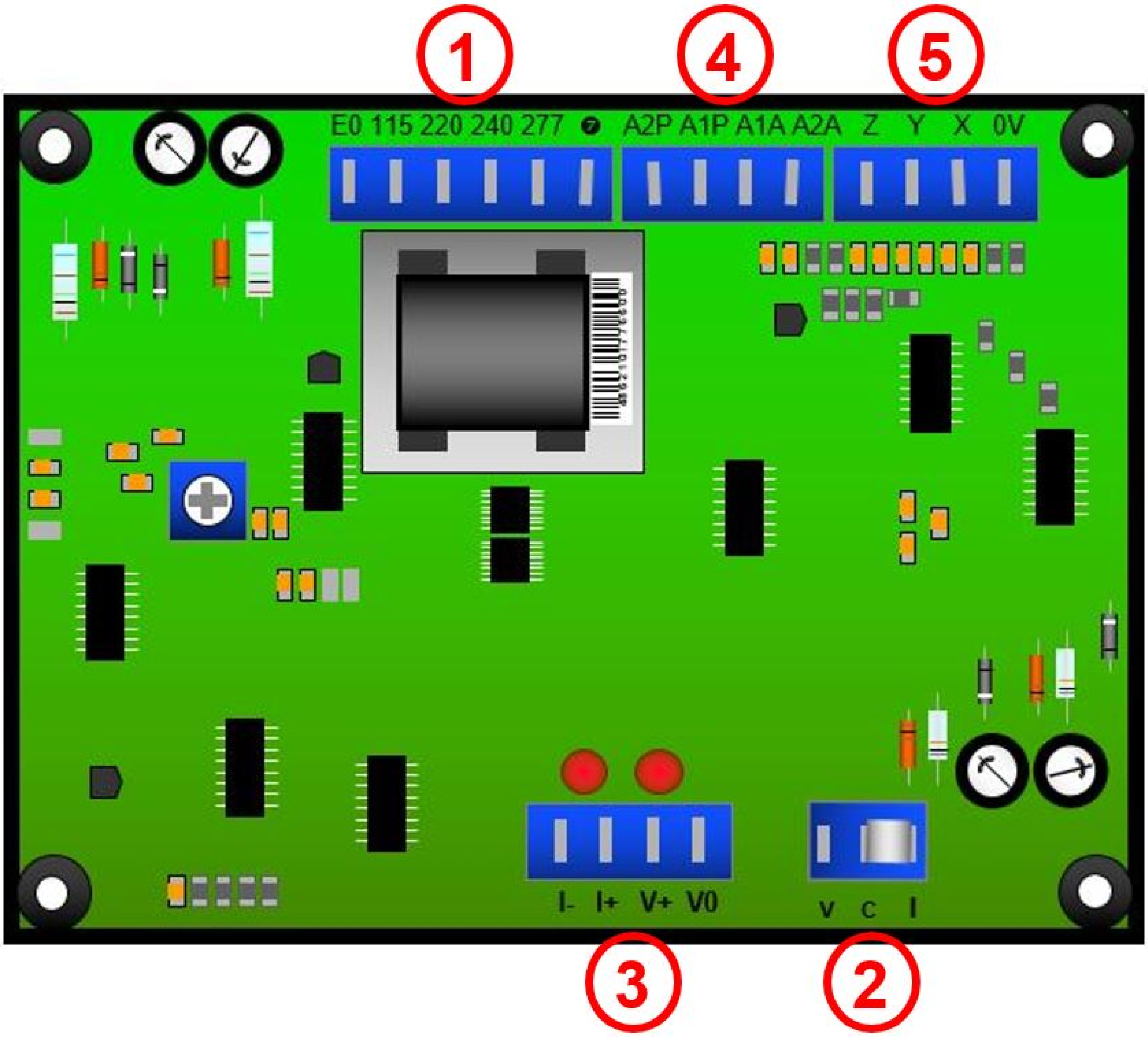
Live Electrical Conductors

Live electrical conductors at output, AVR and AVR accessory terminals, and AVR heat sink can cause serious injury or death by electric shock and burns.

To prevent injury, take suitable precautions to prevent contact with live conductors including personal protective equipment, insulation, barriers and insulated tools.

NOTICE

Refer to alternator wiring diagram for connection details. Mount the RCI on a standard AVR chassis with anti-vibration mounts.



Ref.	Control	Function
1	**Power Supply** E0, 115 : 110 VAC to 125 VAC E0, 220 : 200 VAC to 230 VAC E0, 240 : 231 VAC to 250 VAC E0, 277 : 251 VAC to 290 VAC	Connect to VAC supply voltage
2	**Link : Control Input** C-I : current signal C-V : voltage signal	Select current or voltage control input
3	**Control Input** I-, I+ : 4 mA to 20 mA signal V0, V+ : 0 VDC to 10 VDC signal	Connect to current or voltage control input
4	**Control Output : Voltage** A1A, A2A : connect to A1, A2 at AVR A1P, A2P : connect to A1, A2 at PFC3	Connect to AVR and/or PFC3
5	**Control Output : Power Factor** 0V, X, Y, Z : connect to 0V, RX, RY, RZ at PFC3	Connect to PFC3

FIGURE 13. REMOTE CONTROL INTERFACE CONTROLS

4.8 Hand Trimmer (for remote voltage adjustment)

A hand trimmer can be fitted in a convenient position (typically in the generator set control panel) and connected to the AVR to provide fine adjustment of the alternator voltage. The hand trimmer value and the adjustment range obtained is as defined in the Technical Specification. Refer to wiring diagram before removing the shorting link and connecting the hand trimmer.

4.9 Droop Transformer (for parallel operation – alternator to alternator)

A droop transformer can be fitted in a defined position in the alternator main output wiring and connected to the AVR to enable parallel operation with other alternators. The adjustment range is as defined in the Technical Specification. Refer to wiring diagram before removing the shorting link and connecting the droop transformer. The droop transformer MUST be connected in the correct main output terminal for proper operation (details are as shown in the machine wiring diagram).

4.10 Power Factor Controller (PFC) (for parallel operation – alternator to mains utility)

An electronic control module is available for use with the AVR to provide power factor control of the alternator output. The module uses alternator voltage and output current as inputs and interfaces with the AVR to ensure the necessary flexibility of the alternator excitation and hence control of the exported (or imported) kVAr. This allows full closed-loop control of the alternator power factor at the point of connection into the mains utility. Other features allow the alternator (or alternators) to be automatically ‘voltage-matched’ prior to paralleling.

STAMFORD

SPECIFICATIONS & OPTIONS

STANDARDS

Marine generators may be certified to Lloyds, DnV, Bureau Veritas, ABS, Germanischer-Lloyd or RINA.
Other standards and certifications can be considered on request.

VOLTAGE REGULATORS

MX341 AVR - STANDARD

This sophisticated Automatic Voltage Regulator (AVR) is incorporated into the Stamford Permanent Magnet Generator (PMG) control system, and is standard on marine generators of this type.
The PMG provides power via the AVR to the main exciter, giving a source of constant excitation power independent of generator output. The main exciter output is then fed to the main rotor, through a full wave bridge, protected by a surge suppressor. The AVR has in-built protection against sustained over-excitation, caused by internal or external faults. This de-excites the machine after a minimum of 5 seconds.
An engine relief load acceptance feature can enable full load to be applied to the generator in a single step.
If three-phase sensing is required with the PMG system the MX321 AVR must be used.
We recommend three-phase sensing for applications with greatly unbalanced or highly non-linear loads.

MX321 AVR

The most sophisticated of all our AVRs combines all the features of the MX341 with, additionally, three-phase rms sensing, for improved regulation and performance.
Over voltage protection is built-in and short circuit current level adjustments is an optional facility.

WINDINGS & ELECTRICAL PERFORMANCE

All generator stators are wound to 2/3 pitch. This eliminates triplen (3rd, 9th, 15th …) harmonics on the voltage waveform and is found to be the optimum design for trouble-free supply of non-linear loads. The 2/3 pitch design avoids excessive neutral currents sometimes seen with higher winding pitches, when in parallel with the mains. A fully connected damper winding reduces oscillations during paralleling. This winding, with the 2/3 pitch and carefully selected pole and tooth designs, ensures very low waveform distortion.

TERMINALS & TERMINAL BOX

Standard generators are 3-phase reconnectable with 12 ends brought out to the terminals, which are mounted on a cover at the non-drive end of the generator. A sheet steel terminal box contains the AVR and provides ample space for the customers' wiring and gland arrangements. It has removable panels for easy access.

SHAFT & KEYS

All generator rotors are dynamically balanced to better than BS6861:Part 1 Grade 2.5 for minimum vibration in operation. Two bearing generators are balanced with a half key.

INSULATION/IMPREGNATION

The insulation system is class 'H'.
All wound components are impregnated with materials and processes designed specifically to provide the high build required for static windings and the high mechanical strength required for rotating components.

QUALITY ASSURANCE

Generators are manufactured using production procedures having a quality assurance level to BS EN ISO 9001.

The stated voltage regulation may not be maintained in the presence of certain radio transmitted signals. Any change in performance will fall within the limits of Criteria 'B' of EN 61000-6-2:2001. At no time will the steady-state voltage regulation exceed 2%

DE RATES

All values tabulated on page 8 are subject to the following reductions

5% when air inlet filters are fitted.
3% for every 500 metres by which the operating altitude exceeds 1000 metres above mean sea level.
3% for every 5°C by which the operational ambient temperature exceeds 50°C.
Note: Requirement for operating in an ambient exceeding 60°C must be referred to the factory.

NB Continuous development of our products entitles us to change specification details without notice, therefore they must not be regarded as binding.

Front cover drawing typical of product range.

HCM434F

STAMFORD

WINDING 311

CONTROL SYSTEM	SEPARATELY EXCITED BY P.M.G.		
A.V.R.	MX321	MX341	
VOLTAGE REGULATION	± 0.5 %	± 1.0 %	With 4% ENGINE GOVERNING
SUSTAINED SHORT CIRCUIT	REFER TO SHORT CIRCUIT DECREMENT CURVES (page 7)		

INSULATION SYSTEM	CLASS H
PROTECTION	IP23
RATED POWER FACTOR	0.8
STATOR WINDING	DOUBLE LAYER LAP
WINDING PITCH	TWO THIRDS
WINDING LEADS	12
STATOR WDG. RESISTANCE	0.0073 Ohms PER PHASE AT 22°C SERIES STAR CONNECTED
ROTOR WDG. RESISTANCE	1.37 Ohms at 22°C
EXCITER STATOR RESISTANCE	18 Ohms at 22°C
EXCITER ROTOR RESISTANCE	0.068 Ohms PER PHASE AT 22°C
R.F.I. SUPPRESSION	BS EN 61000-6-2 & BS EN 61000-6-4,VDE 0875G, VDE 0875N. refer to factory for others
WAVEFORM DISTORTION	NO LOAD < 1.5% NON-DISTORTING BALANCED LINEAR LOAD < 5.0%
MAXIMUM OVERSPEED	2250 Rev/Min
BEARING DRIVE END	BALL. 6317 (ISO)
BEARING NON-DRIVE END	BALL. 6314 (ISO)

	1 BEARING	2 BEARING
WEIGHT COMP. GENERATOR	1160 kg	1160 kg
WEIGHT WOUND STATOR	535 kg	535 kg
WEIGHT WOUND ROTOR	463 kg	440 kg
WR² INERTIA	5.4292 kgm^2	5.2304 kgm^2
SHIPPING WEIGHTS in a crate	1230 kg	1230 kg
PACKING CRATE SIZE	155 x 87 x 107(cm)	155 x 87 x 107(cm)

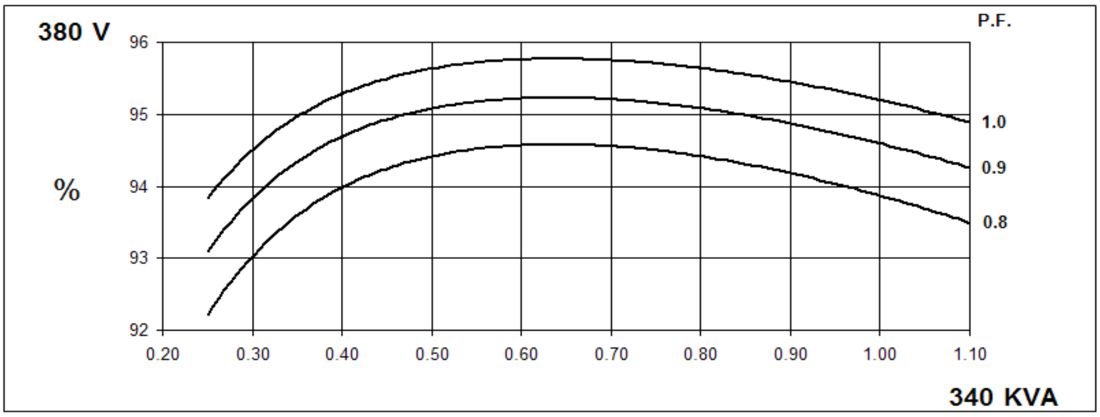
	50 Hz				60 Hz			
TELEPHONE INTERFERENCE	THF<2%				TIF<50			
COOLING AIR	0.80 m³/sec 1700 cfm				0.99 m³/sec 2100 cfm			
VOLTAGE SERIES STAR	380/220	400/231	415/240	440/254	416/240	440/254	460/266	480/277
VOLTAGE PARALLEL STAR	190/110	200/115	208/120	220/127	208/120	220/127	230/133	240/138
VOLTAGE SERIES DELTA	220/110	230/115	240/120	254/127	240/120	254/127	266/133	277/138
kVA BASE RATING FOR REACTANCE VALUES	340	340	340	340	395	405	415	425
Xd DIR. AXIS SYNCHRONOUS	2.31	2.09	1.94	1.72	2.85	2.61	2.45	2.30
X'd DIR. AXIS TRANSIENT	0.15	0.14	0.13	0.11	0.16	0.14	0.13	0.13
X''d DIR. AXIS SUBTRANSIENT	0.11	0.10	0.09	0.08	0.11	0.10	0.10	0.09
Xq QUAD. AXIS REACTANCE	2.00	1.80	1.67	1.49	2.52	2.31	2.16	2.03
X''q QUAD. AXIS SUBTRANSIENT	0.26	0.24	0.22	0.20	0.37	0.34	0.32	0.30
X_L LEAKAGE REACTANCE	0.05	0.05	0.04	0.04	0.06	0.06	0.05	0.05
X_2 NEGATIVE SEQUENCE	0.19	0.17	0.16	0.14	0.25	0.23	0.22	0.20
X_0 ZERO SEQUENCE	0.07	0.06	0.06	0.05	0.09	0.08	0.07	0.07
REACTANCES ARE SATURATED	VALUES ARE PER UNIT AT RATING AND VOLTAGE INDICATED							

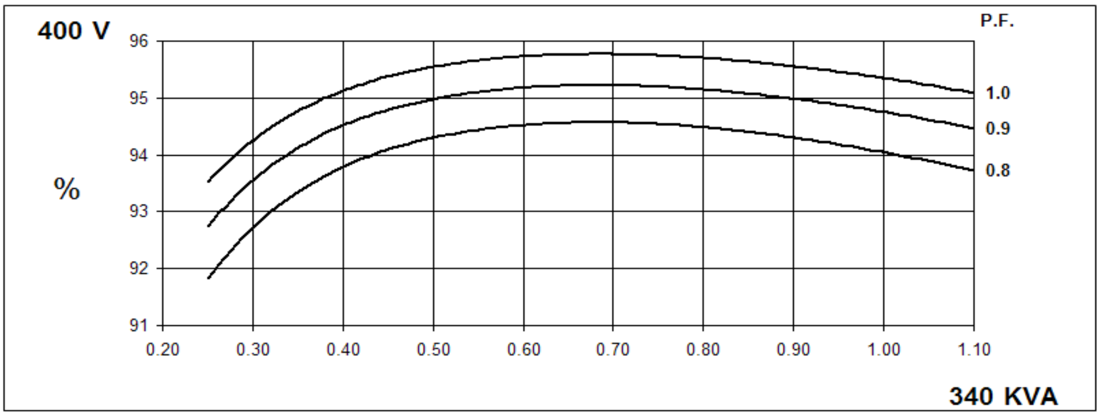
T'd TRANSIENT TIME CONST.	0.08s
T''d SUB-TRANSTIME CONST.	0.019s
T'do O.C. FIELD TIME CONST.	1.7s
Ta ARMATURE TIME CONST.	0.018s
SHORT CIRCUIT RATIO	1/Xd

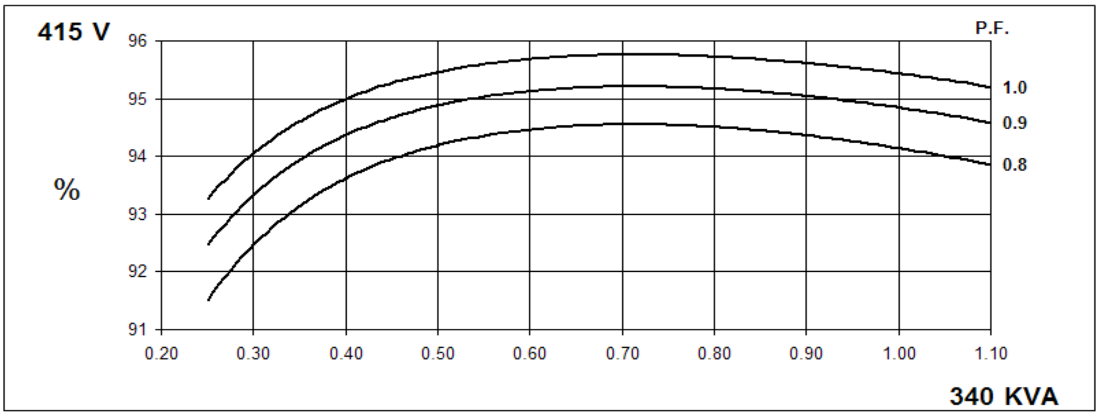
HCM434F

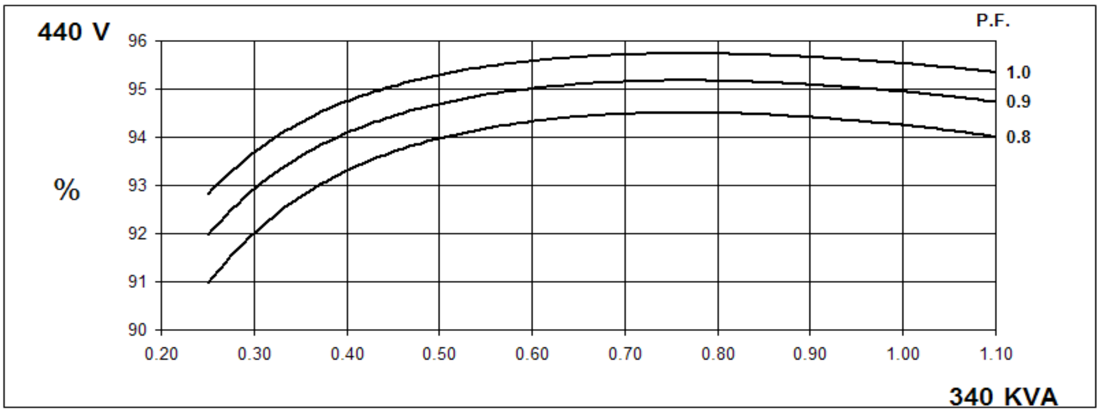
Winding 311

THREE PHASE EFFICIENCY CURVES









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Winding 311

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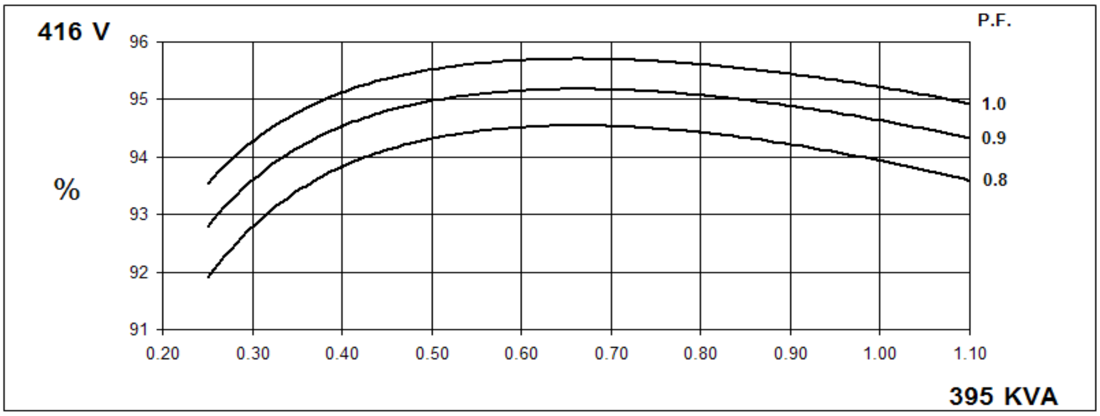
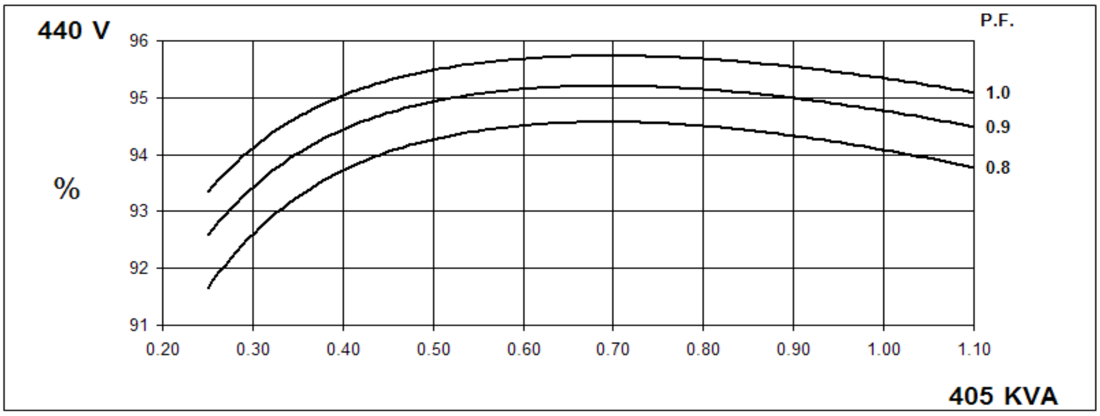
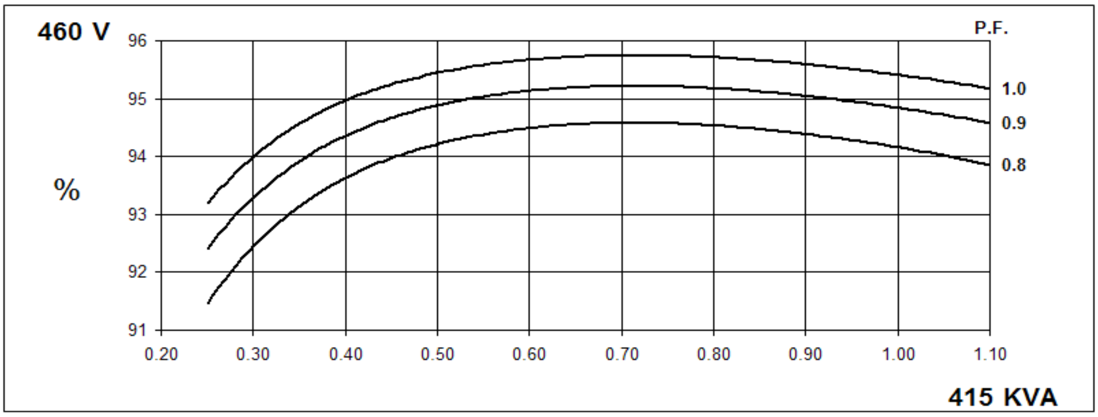
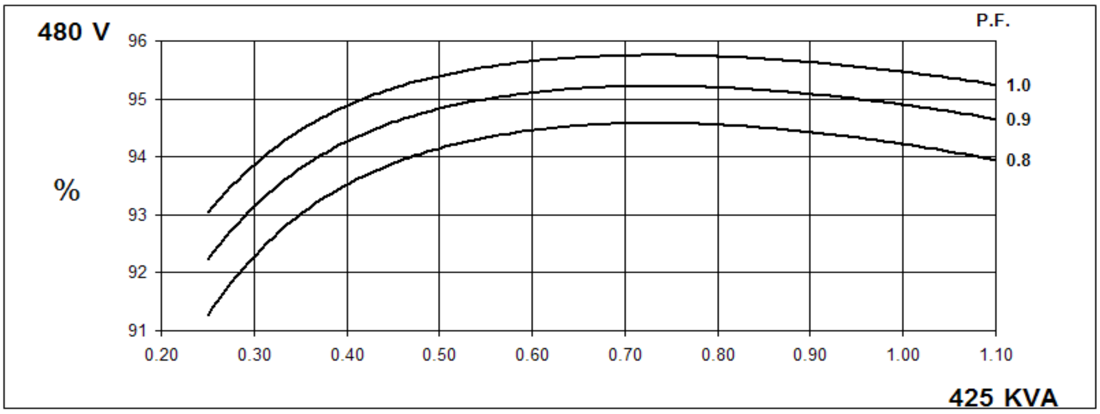
THREE PHASE EFFICIENCY CURVES









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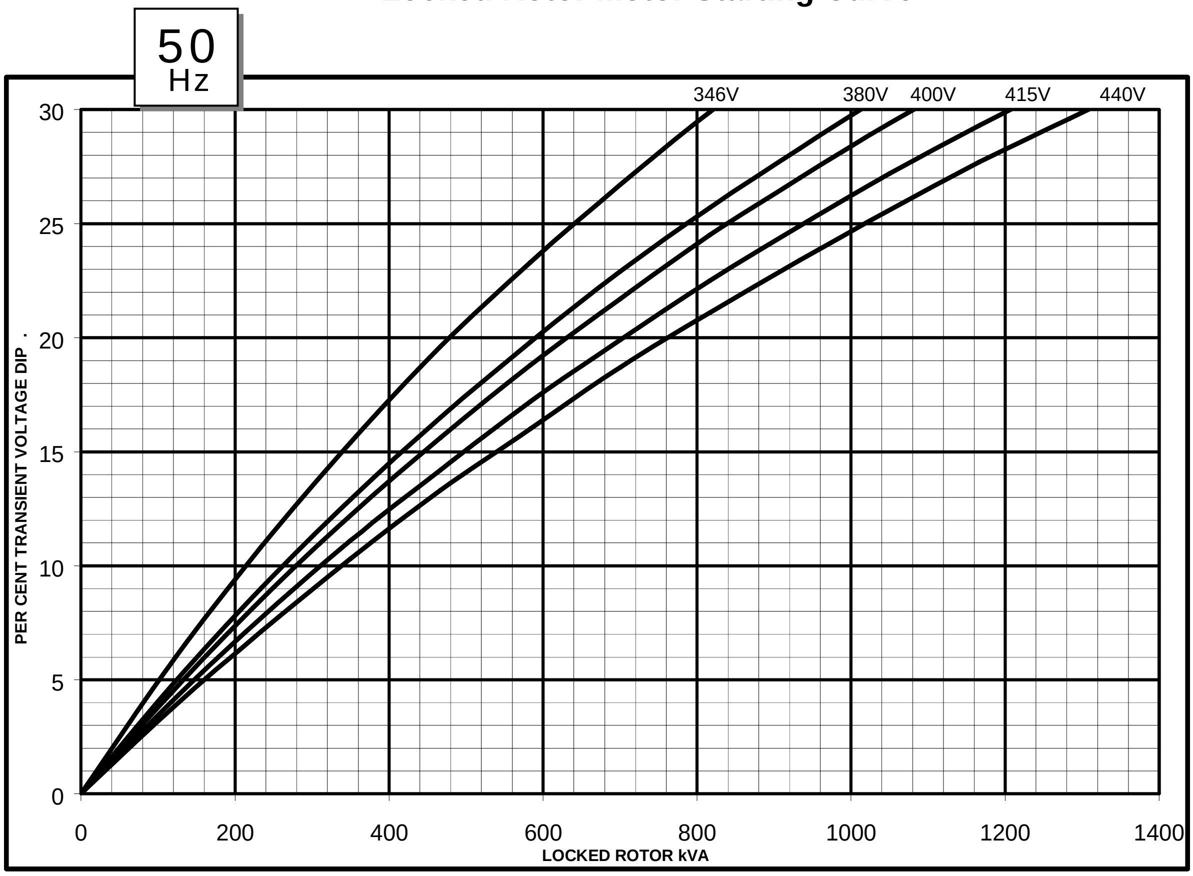
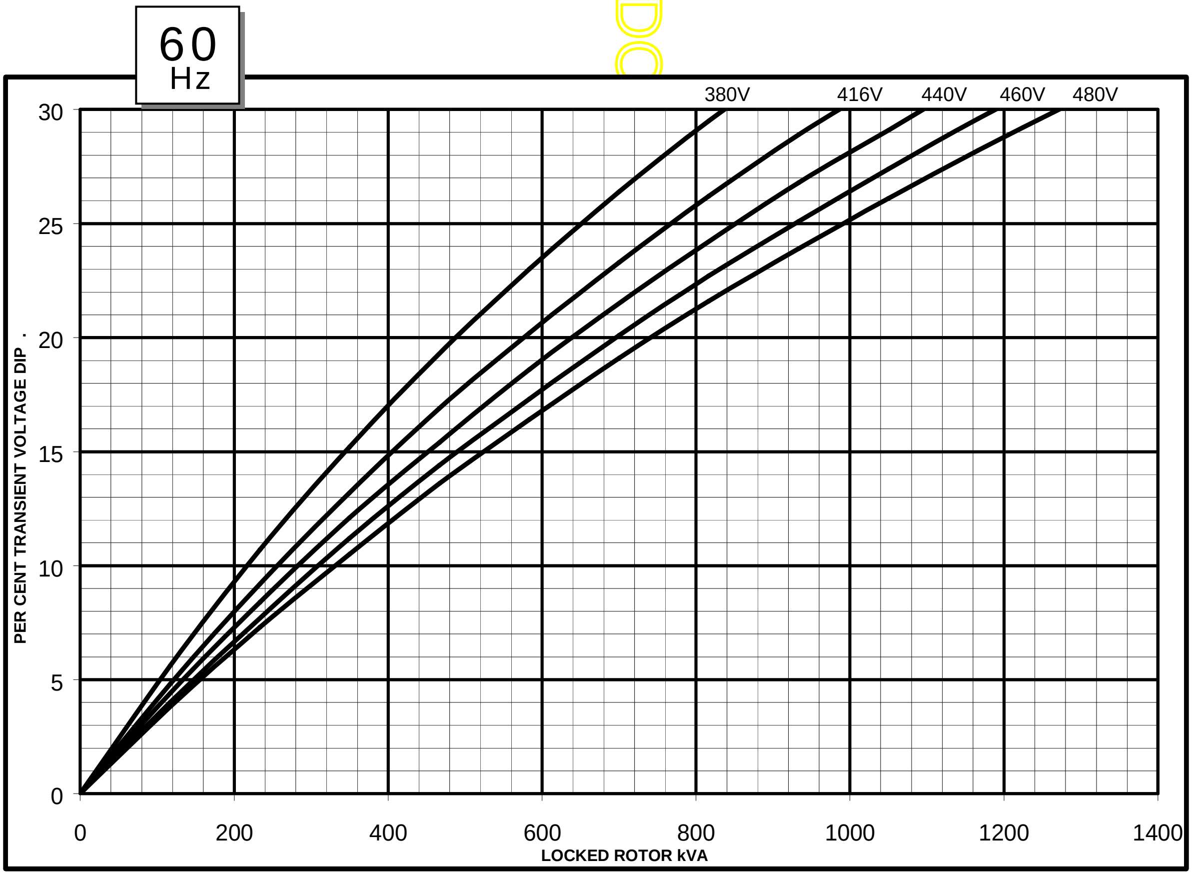
Winding 311

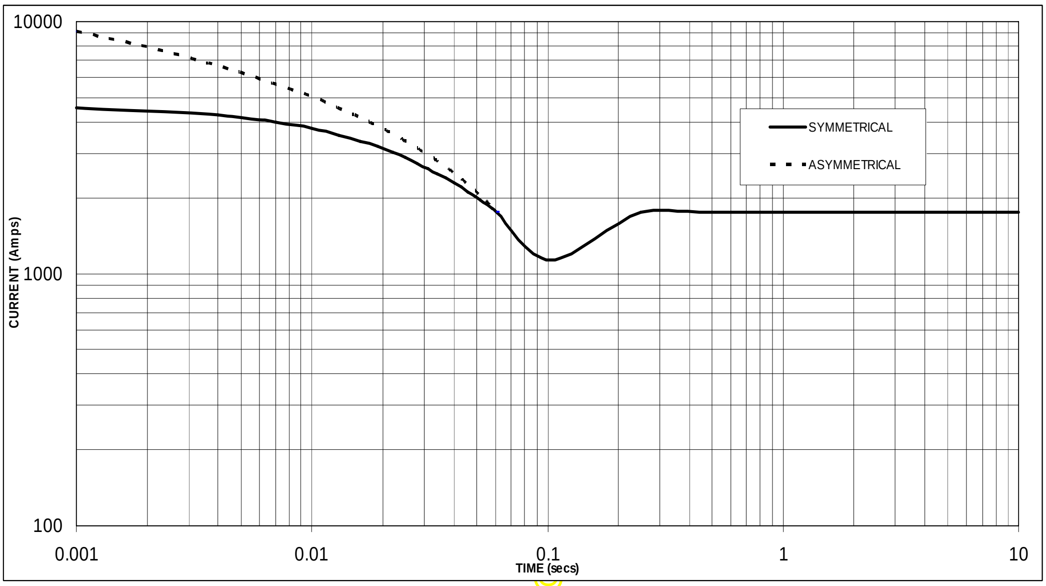
Locked Rotor Motor Starting Curve





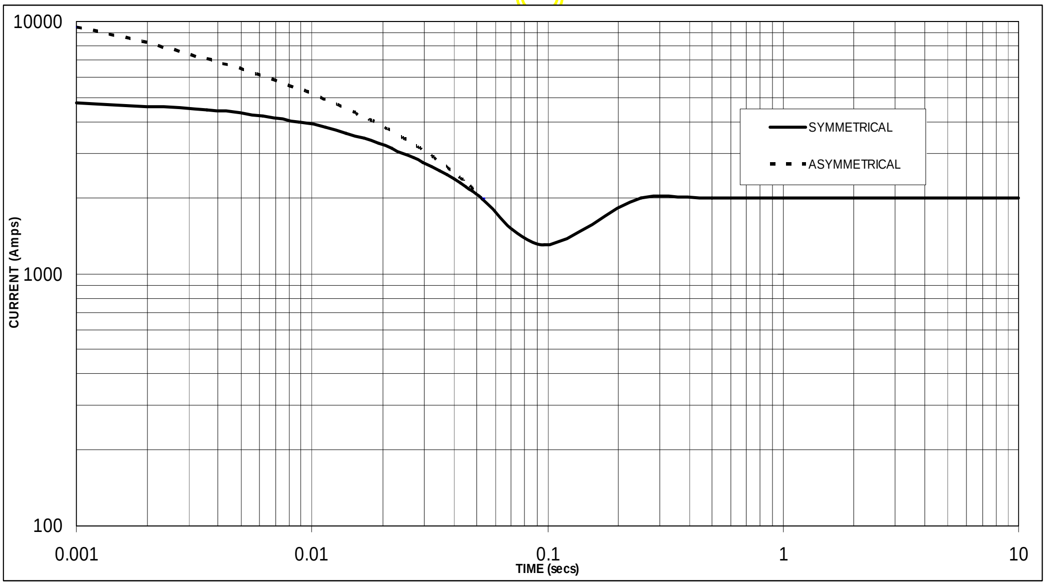
Three-phase Short Circuit Decrement Curve. No-load Excitation at Rated Speed Based on star (wye) connection.

50 Hz



Sustained Short Circuit = 1,750 Amps

60 Hz



Sustained Short Circuit = 2,000 Amps

Note 1

The following multiplication factors should be used to adjust the values from curve between time 0.001 seconds and the minimum current point in respect of nominal operating voltage :

50Hz		60Hz	
Voltage	Factor	Voltage	Factor
380v	X 1.00	416v	X 1.00
400v	X 1.05	440v	X 1.06
415v	X 1.09	460v	X 1.10
440v	X 1.16	480v	X 1.15

The sustained current value is constant irrespective of voltage level

Note 2

The following multiplication factor should be used to convert the values calculated in accordance with NOTE 1 to those applicable to the various types of short circuit :

	3-phase	2-phase L-L	1-phase L-N
Instantaneous	x 1.00	x 0.87	x 1.30
Minimum	x 1.00	x 1.80	x 3.20
Sustained	x 1.00	x 1.50	x 2.50
Max. sustained duration	10 sec.	5 sec.	2 sec.

All other times are unchanged

Note 3

Curves are drawn for Star (Wye) connected machines. For other connection the following multipliers should be applied to current values as shown :

Parallel Star = Curve current value X 2

Series Delta = Curve current value X 1.732

HCM434F

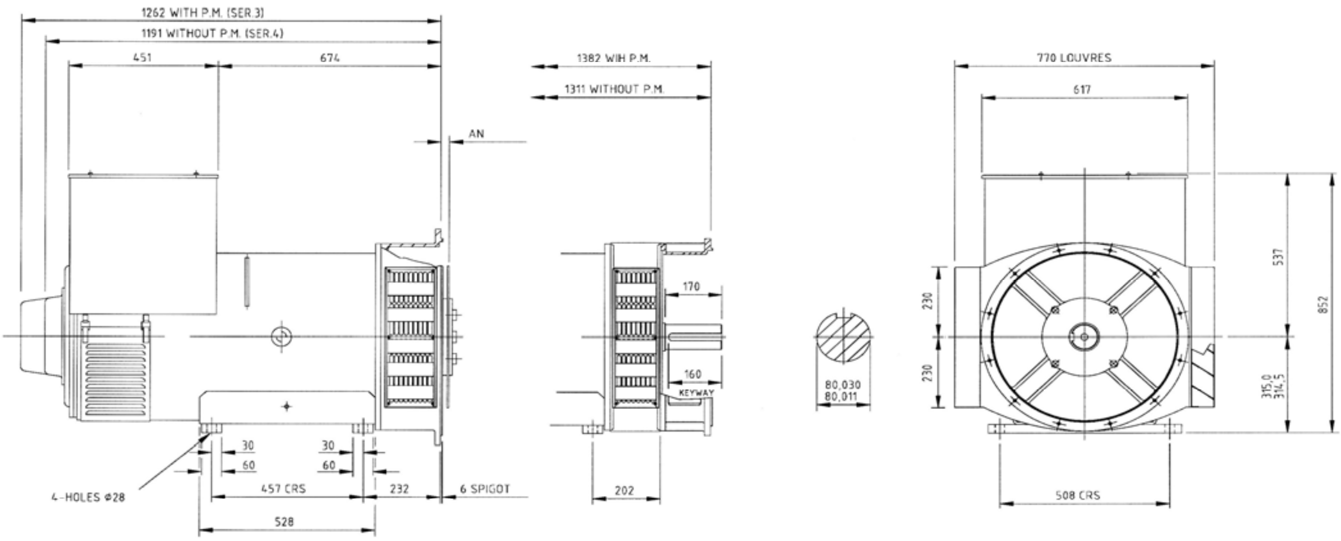
Winding 311 / 0.8 Power Factor

RATINGS

Class - Temp Rise	Cont. E - 65/50°C				Cont. B - 70/50°C				Cont. F - 90/50°C				Cont. H - 110/50°C			
50 Hz Series Star (V)	380	400	415	440	380	400	415	440	380	400	415	440	380	400	415	440
Parallel Star (V)	190	200	208	220	190	200	208	220	190	200	208	220	190	200	208	220
Series Delta (V)	220	230	240	254	220	230	240	254	220	230	240	254	220	230	240	254
kVA	260	260	260	260	275	275	275	275	310	310	310	310	340	340	340	340
kW	208	208	208	208	220	220	220	220	248	248	248	248	272	272	272	272
Efficiency (%)	94.5	94.5	94.5	94.5	94.4	94.5	94.5	94.5	94.1	94.3	94.3	94.4	93.9	94.0	94.1	94.2
kW Input	220	220	220	220	233	233	233	233	264	263	263	263	290	289	289	289

60 Hz Series Star (V)	416	440	460	480	416	440	460	480	416	440	460	480	416	440	460	480
Parallel Star (V)	208	220	230	240	208	220	230	240	208	220	230	240	208	220	230	240
Series Delta (V)	240	254	266	277	240	254	266	277	240	254	266	277	240	254	266	277
kVA	305	315	320	330	320	330	335	345	365	375	380	395	395	405	415	425
kW	244	252	256	264	256	264	268	276	292	300	304	316	316	324	332	340
Efficiency (%)	94.5	94.5	94.6	94.6	94.4	94.5	94.5	94.5	94.2	94.3	94.4	94.4	93.9	94.1	94.2	94.2
kW Input	258	267	271	279	271	279	284	292	310	318	322	335	337	344	352	361

DIMENSIONS



COUPLING DISC	AN
SAE 11,5	39,68
SAE 14	25,4
SAE 18	15,87

CUMMINS INDIA LIMITED
Kothrud, Pune 411029
ENGINE DATA SHEET

MARINE ENGINE MODEL	: NTA-855-MG	DATA SHEET NO	: 3243525
DESIGN STANDARD NO	:	DATE	: Sept 2000
		PERFORMANCE CURVE	:3243525-C

CPL NUMBER
- Water Cooled Exhaust Manifold : **X-231**

GENERAL ENGINE DATA :

Type		4 cycle, Inline, 6 cylinder
Aspiration		Turbocharged & Aftercooled
Bore x Stroke	inx in(mmxmm)	5.5 x 6 (140 x 152)
Displacement	in Cu. (litre)	855(14.0)
Compression ratio		14:01
Dry Weight Heat Exchanger Cooled Engine	lb(kg)	2830 (1284)
Dry Weight Fan to Flywheel Engine	lb(kg)	3060 (1388)
Wet Weight Heat Exchanger Cooled Engine	lb(kg)	2956 (1341)
Wet Weight Fan to Flywheel Engine	lb(kg)	3246 (1472)
C.G. From Rear Face of flywheel Housing	in (mm)	27.7(704)
C.G. Above Crankshaft Centerline	in (mm)	5.5 (140)

ENGINE MOUNTING :

Maximum Bending Moment at Rear Face of Block	- lb-ft (N-m)	1000 (1356)

EXHAUST SYSTEM :

Maximum Back Pressure	- in Hg. (mm Hg.)	3.0 (76)

AIR INDUCTION SYSTEM :

Maximum Intake Restricton Clean Element	- In H2O (mm H2O)	10 (254)
Dirty Element	- In H2O (mm H2O)	25 (635)

COOLING SYSTEM :

Coolant Capacity (Engine Only)	US Gal (litre)	6.5 (24.6)
Coolant Capacity (With Heat Exchanger)	US Gal (litre)	14 (53)
Maximum Coolent Friction Head External to Engine - 1800 rpm	PSI (Kpa)	6 (41)
Maximum Coolent Friction Head External to Engine - 1500 rpm	PSI (Kpa)	5 (34)
Maximum Static Head of Coolent above engine crank C.L	ft (m)	60(18.3)
Standard Thermostat (modulating range)	Deg F (Deg C)	175-195 (80-90)
Pressure Cap Rating With Heat Exchanger ,	PSI (Kpa)	7 (50)
Maximum Coolant Temperature ,	Deg F (Deg C)	205 (96)
Minimum Raw water Flow @ 90 Deg F	US gpm (litre/min)	69 (260)
Maximum Raw water pressure at H.E.	PSI (Kpa)	50(345)

LUBRICATION SYSTEM :

Oil Pressure @ Idle Speed Minimum	PSI (Kpa)	15 (103)
Oil Pressure @ Rated Speed Range	PSI (Kpa)	35-45(241-310)
Maximum Oil Temperature	Deg F (Deg C)	250 (121)
Bypass Filter Capacity	US Gal (litre)	.73 (2.8)
Oil Capacity Of Shallow Pan (High-Low)	US Gal (litre)	9-7 (36-28)
Total system Capacity (Excluding bypass filter)	US Gal (litre)	9.8(37)
Angularity of Oil Pan	Front Down	45 Deg
	Front Up	45 Deg
	Side to Side	45 Deg

FUEL SYSTEM :

Type of Injection System			Direct Injection Cummins PT
Maximum Allowable Restriction to Pump	With Clean Filter	In Hg (mm Hg)	4 (100)
	With Dirty Filter	In Hg (mm Hg)	8 (200)
Maximum Allowable Return Line Restriction	....	In Hg (mm Hg)	6 (152)
Maximum Fuel Flow to Injection Pump	....	US gph (litre/hr)	97 (370)

ELECTRICAL SYSTEM :

Maximum Allowable Resistance of Cranking Circuit			
With 24 Volt Starter	....	Ohms	0.002
Battery Charging System, Negative Ground	....	Ampere	35
Minimum Recommended Battery Capacity			
Cold Soak @ 50-F (10 C) and Above	....	0 Deg F CCA	600
Cold Soak @ 32 to 50-F (0 to 10 C)	....	0 Deg F CCA	640
Cold Soak @ 0 to 32 -F (-18 to 0 C)	....	0 Deg F CCA	900
Minimum Ambient for Unaided cold start	....	Deg F(Deg C)	40(4)

PERFORMANCE DATA CONDITIONS :

All Data is Based on :

- Engine operating with fuel system, water pump, lubricating oil pump,air cleaner and exhaust silencer, not included are alternator, fan , and optional driven components.
- Engine Operating with No 2 diesel or a fuel corrosponding to ASTM D2.
- ISO 3046 Part I Standard referance Conditions of :

Barometric Pressure : 100 Kpa (29.53 in Hg)   Air temperature : 25 Deg C(77 Deg F)

Altitude : 110 m(361 ft)   Relative Humidity : 30 %

Steady state stability band at any constant load .... % +/- 0.25

EMISSIONS :

NOx (Per ISO 8178 Cycle D2) for 365 BHP 1800 RPM prime rating... g/kw-hr(g/bhp-hr) 6.43(4.79)

for 380 BHP 1500 RPM prime rating... g/kw-hr(g/bhp-hr) 7.24(5.4)

		STANDBY 60 hz	STANDBY 50 hz	PRIME POWER 60 hz	PRIME POWER 50 hz
Governed Engine Speed RPM	rpm	1800	1500	1800	1500
Engine Idle Speed RPM	rpm	1080-1120	1080-1120	1080-1120	1080-1120
Gross Engine Power Output BHP (KW)	HP(kWm)	402(300)	420(313)	365(272)	380(283)
Brake Mean Effective Pressure	PSI (Kpa)	207(1427)	259(1785)	188(1296)	235(1620)
Piston Speed	Ft/min (m/sec)	1800(9.1)	1500(7.6)	1800(9.1)	1500(7.6)
Friction horsepower	HP(kWm)	47(35)	30(22)	47(35)	30(22)
Engine water Flow	US gpm (lit/s)	106(6.7)	89(5.6)	106(6.7)	89(5.6)
Intake Air Flow	cfm (Litre/s)	887(418)	762(360)	857(404)	730(344)
Exhaust Gas Temperature	Deg F (Deg C)	800(427)	927(497)	794(423)	902(483)
Exhaust Gas Flow	cfm (Litre/s)	1978(933)	1867(881)	1910(901)	1802(850)
Heat Rejection to Ambient	BTU/min (kWm)	2400(42)	2200(39)	2100(37)	1800(32)
Heat Rejection to Coolant	BTU/min (kWm)	9200(162)	10200(179)	9000(158)	9100(160)
Heat Rejection to Exhaust	BTU/min (kWm)	12800(225)	13100(230)	12200(214)	12200(214)

Engine Model	NTA-855-MG
Data Sheet	3243525
Curve No	3243525-C
Date	Nov 2000

All Data is Subject to change Without Notice

Cummins India Ltd,
Kothrud, Pune-411029

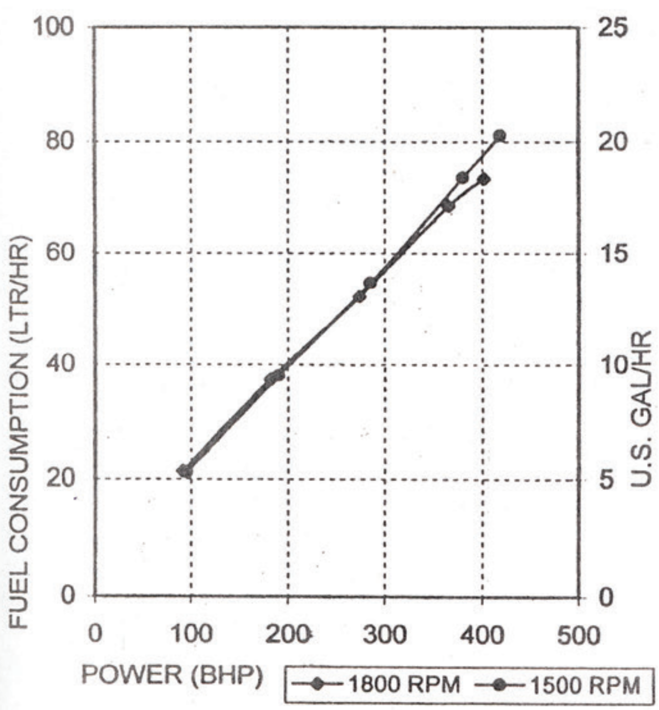
CUMMINS INDIA LIMITED Kothrud, Pune 411029	**Basic Engine Model** NTA-855-MG		**Curve No.** 3243525-C	
ENGINE PERFORMANCE CURVE	**Engine Family** 855	**CPL** X-231	**Date** Sep 2000	**By:** VMK

Displacement cu.in (lts.)	**855(14)**	**Aspiration**	**TURBOCHARGED & AFTERCOOLED**	
Bore in. (mm)	**5.5(140)**	**No. of Cyl. :**	**6**	**Rating**
Stroke in. (mm)	**6.0(152)**	**Fuel System**	**PT**	**HP (KWm) @ RPM**
				402 (300) @ 1800

power output curves are based on the engine operating with Fuel System, Water Pump and lubricating oil pump,
Not included are battery charging alternator,fan optional equipments and driven components.
CERTIFIED : This marine diesel engine confirms with the NOx requirements of the International Meritime Organisation(IMO), MARPOL 73/78 Annex VI, Regulation 13 as applicable.

Gross Engine Power Output

Engine Speed	Standby power		Prime Power	
	BHP	KWm	BHP	KWm
1800	402	300	365	272
1500	418	312	380	283



OUTPUT POWER			FUEL CONSUMPTION	
%	BHP	KWm	USGAL/HR	LTR/HR
		1800 RPM		
110	402	300	19.4	73
100	365	272	18.1	69
75	274	204	13.8	52
50	183	136	9.9	37
25	91	68	5.6	21
		1500 RPM		
110	418	312	20.3	77
100	380	283	18.4	70
75	285	213	13.7	52
50	190	142	9.5	36
25	95	71	5.3	20

Data shown above represent gross engine performance capabilities obtained and corrected in accordance with ISO-3046 conditions of 100 Kpa (29.61"Hg) barometric pressure [300 Ft (90m) altitude],77 deg F (25 deg C) air inlet temp, and relative humidity of 30 % with #2 Diesel or a fuel corrosponding to ASTM D2.

The Fuel consumption data is based on diesel fuel weight at 7.0 lbs.U.S. gal (0.84 kg/litre)

CERTIFIED WITHIN 5%

VICE PRESIDENT - RESEARCH & DEVELOPMENT

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