CLIENT: SABA SOUTHEAST POWER GENERATION CO.	CONSULTANT:

PROJECT: Steam Portion of Chabahar Combined Cycle Power Plant

DIESEL GENERATOR OPERATION & MAINTENANCE MANUAL

CAT. I
Approved
NIROO Cons. Eng.
Sign.: Date:

IN-HOUSE REVISIONS						DOCUMENT REVISIONS					
D						D					
C						C					
B						B					
A						A					
0	FIRST ISSUE	H.K	H.K	A.V	Jul 20	0	FIRST ISSUE	H.K	H.K	A.V	Jul 20
Rev.	Description	DESG.	CHCK	APPR.	Date	Rev.	Description	DESG.	CHCK	APPR.	Date

MAPNA GROUP (Public Stock)	Subontractor : Nama Mad Pasargad Ind , Group.	Doc. No. : MD2-CQ-00-EL-E-99-UDI-508	Rev: 0
	MONENCO'S DOC. No.:	File No. :	Design Stage BASIC
MAPNA'S DWG No.	Based on: طرح نیام	Contract No. :	Page 1 of 6

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Page No.	DOCUMENT REVISIONS								Remarks	Page No.	IN-HOUSE REVISIONS								Remarks
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Table of contents: Page

Interactive CD

Bulletin No. 3243798-00 (March, 2001)

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

Table of Contents

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 (PUNE) 5436680

Fax : 020 (PUNE) 5445916

Toll Free : 1-600-332000

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,

CUSTOMER ASSISTANCE CELL

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 Diesel Sales and Service (India) Limited.

CUMMINS
CUSTOMER ASSISTANCE CELL

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

Cummins Diesel
Sales and Service (India) Limited
35 A/1/2, Erandawana, Pune 411 038

Engine Specifications

TABLE 1 : INDUSTRIAL APPLICATIONS								
Engine Model*	No. of Cyl.	Bore & Stroke Inch (mm)	Displace-ment C.I.D. (Liter)	Engine Breathing	Maximum H.P.	R.P.M.	Peak Torque Ft. Lb.	R.P.M.
6BT-5.9-C	6	(102 X 120)	(5.9)	T	137	2000	532	1400
6BTA-5.9-C	6	(102 X 120)	(5.9)	TA	155	2150	662	1500
N-495-C	4	5 1/8 X 6 (130 X 152)	495 (8.1)	N.A.	125	2000	387	1500
NT-495-C	4	5 1/8 X 6 (130 X 152)	495 (8.1)	T	180	2100	495	1500
NTA-495-C	4	5 1/8 X 6 (130 X 152)	495 (8.1)	T.A.	212	2100	583	1500
N-743-C	6	5 1/8 X 6 (130 X 152)	743 (12.2)	N.A	212	2100	583	1500
NT-743-C	6	5 1/8 X 6 (130 X 152)	743 (12.2)	T	295	2100	811	1500
N-743-T-C	6	5 1/8 X 6 (130 X 152)	743 (12.2)	T	240	2100	655	1500
NTA-743-C	6	5 1/8 X 6 (130 X 152)	743 (12.2)	T.A.	335	2100	963	1500
6CTA-8.3-C	6	(114 X135)	(8.3)	T.A.	230	2000	990	1500
NT-855-C	6	$5^1/_2$ X 6 (140 X 152)	855 (14.00)	T	335	2100	921	1500
NTA-855-C	6	$5^1/_2$ X 6 (140 X 152)	855 (14.00)	T.A.	400	2100	1150	1500
KT-1150-C	6	$6^1/_4$ X $6^1/_4$ (159 X 159)	1150 (18.9)	T	450	2100	1350	1500
KTA-1150-C	6	$6^1/_4$ X $6^1/_4$ (159 X 159)	1150 (18.9)	T.A.	525	2100	1575	1500
KTA-1150-C	6	$6^1/_4$ X $6^1/_4$ (159 X 159)	1150 (18.9)	T.A.	600	2100	1650	1500
KTTA-19-C	6	$6^1/_4$ X $6^1/_4$ (159 X 159)	1150 (18.9)	T.A.	700	2100	2014	1400
VTA-28-C	12	$5^1/_2$ X 6 (140 X 152)	1710 (28.0)	T.A.	900	2100	2200	1500
KT-2300-C	12	$6^1/_4$ X $6^1/_4$ (159 X 159)	2300 (37.8)	T	900	2100	2700	1500
KTA-38-C	12	$6^1/_4$ X $6^1/_4$ (159 X 159)	2300 (37.8)	T.A.	1050	2100	3020	1500
KTA-38-C	12	$6^1/_4$ X $6^1/_4$ (159 X 159)	2300 (37.8)	T.A.	1200	2100	3300	1500
KTA-50-C	16	$6^1/_4$ X $6^1/_4$ (159 X 159)	3067 (50.3)	T.A.	1600	2100	4400	1500
KTA-50-C	16	$6^1/_4$ X $6^1/_4$ (159 X 159)	3067 (50.3)	T.A.	1600	2100	4400	1500
KTA-3067-S-C	16	$6^1/_4$ X $6^1/_4$ (159 X 159)	3067 (50.3)	T.A.	1200	1500	—	—
QSK-60	16	$6^1/_4$ X $6^1/_4$ (159 X 190)	60	TA	2700	2100	10625	1500

*Following are the Equivalent Engine Models (based on units of displacement in C.I.D or liters).

KT/KTA 1150 --- KT/KTA 19
V/VT/VTA 1710 --- V/VT/VTA 28
KT/KTA 2300 --- KT/KTA 38
KTA 3067 --- KTA 50

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

Engine Specifications

TABLE 2 : GENERATOR SET APPLICATION

Performance Ratings are for 300 Ft. (90 m) 77°F (25°C)

Engine Model	No. of Cyl.	Bore & Stroke Inch (mm)	Displacement Cub. Inch (litre)	Prime Power Rating BHP (kW)* at 1500 R.P.M.	Prime Power Rating BHP (kW)* at 1800 R.P.M.	Engine Breathing
NT-495-G	4	$5^1/_8$ X 6 (130 X 152)	495 (8.1)	127 (95)	139 (104)	T
NTC-495-G	4	$5^1/_8$ X 6 (130 X 152)	495 (8.1)	154 (115)	—	T
NTA-495-G	4	$5^1/_8$ X 6 (130 X 152)	495 (8.1)	173 (129)	200 (149)	T.A.
NT-743-G1	6	$5^1/_8$ X 6 (130 X 152)	743 (12.2)	205 (150)	—	T
NT-743-G	6	$5^1/_8$ X 6 (130 X 152)	743 (12.2)	231 (172)	257 (191)	T
NTA-743-G	6	$5^1/_8$ X 6 (130 X 152)	743 (12.2)	255 (190)	—	T.A.
NTA-855-G1	6	$5^1/_8$ X 6 (130 X 152)	855 (12.2)	280 (208)	—	T.A.
NTA-855-G	6	$5^1/_8$ X 6 (130 X 152)	855 (12.2)	306 (228)	360 (268)	T.A.
NTA-855-G2	6	$5^1/_2$ X 6 (140 X 152)	855 (14.00)	340 (253)	—	T.A.
KT-1150-G	6	$6^1/_4$ X $6^1/_4$ (159 X 159)	1150 (18.9)	380 (283)	420 (313)	T
KTA-1150-G	6	$6^1/_4$ X $6^1/_4$ (159 X 159)	1150 (18.9)	450 (336)	525 (391)	T.A.
KTA-19-G4	6	$6^1/_4$ X $6^1/_4$ (159 X 159)	1150 (18.9)	600 (448)	—	T.A.
VT-1710-G	12	$5^1/_2$ X 6 (140 X 152)	1710 (28.0)	530 (395)	620 (462)	T
VTA-28-G	12	$5^1/_2$ X 6 (140 X 152)	1710 (28.0)	614 (458)	750 (560)	T.A.
VTA-28-G3	12	$5^1/_2$ X 6 (140 X 152)	1710 (28.0)	710 (530)	—	T.A.
VTA-28-G5	12	$5^1/_2$ X 6 (140 X 152)	1710 (28.0)	750 (560)	—	T.A.
KT-2300-G	12	$6^1/_4$ X $6^1/_4$ (159 X 159)	2300 (37.8)	750 (560)	910 (679)	T
KTA-2300-G	12	$6^1/_4$ X $6^1/_4$ (159 X 159)	2300 (37.8)	890 (664)	1085 (809)	T.A.
KTA-3067-G	16	$6^1/_4$ X $6^1/_4$ (159 X 159)	3067 (50.3)	1180 (880)	1350 (1007)	T.A.
KTA-50-G3	16	$6^1/_4$ X $6^1/_4$ (159 X 159)	3067 (50.3)	1470 (1097)	1635 (1220)	T.A.
QTA-60-G3	16	6.25 X 7.48 (159 X 190)	3660 (60)	2117 (1579)	—	T.A.

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

NOTE : 1. * This is conversion of engine Horsepower to KW and not electrical output of alternator.
2. All the above ratings of engines for generator set conform to ISO 3046.

Engine Specifications

TABLE 3 : FIRE PUMP APPLICATION

ENGINE MODEL	R.P.M.	2100	2000	1900	1800	1700	1600	1500
N-495-F	H.P.	—	107	104	103	101	96	92
NT-495-F	H.P.	155	150	145	140	134	127	119
NT-495-F1	H.P.	—	—	—	—	—	—	127
NTA-495-F	H.P.	183	179	173	166	159	151	143
NTA-495-F1	H.P.	—	—	—	—	—	—	173
N-743-F	H.P.	182	179	174	168	161	153	144
N-743-TF	H.P.	207	203	198	191	182	173	162
NT-743-F	H.P.	255	250	244	237	229	219	207
NT-743-F1	H.P.	—	—	—	—	—	—	231
NTA-743-F	H.P.	285	278	269	268	248	235	—
NTA-743-F1	H.P.	—	—	—	—	—	—	255
NT-855-F	H.P.	289	284	283	267	256	244	—
NTA-855-F (FFC)	H.P.	345	343	337	327	315	301	268
NTA-855-F1	H.P.	—	—	—	—	—	—	306
NTA-855-F2	H.P.	352	—	—	—	—	—	—
KT-1150-F	H.P.	400	397	391	383	373	361	—
KT-1150-F1	H.P.	—	—	—	—	—	—	380
KTA-1150-F	H.P.	534	526	512	495	465	450	—
KTA-1150-F1	H.P.	—	—	—	—	—	—	450
V-1710-F	H.P.	415	413	407	396	382	364	342
VT-1710-F	H.P.	548	532	515	499	479	458	—
VT-1710-F1	H.P.	—	—	—	—	—	—	530
VTA-1710-F	H.P.	691	670	651	626	605	573	—
VTA-1710-F1	H.P.	—	—	—	—	—	—	614
KT-2300-F	H.P.	801	800	792	780	755	723	—
KT-2300-F1	H.P.	—	—	—	—	—	—	750
KTA-2300-F	H.P.	1069	1047	1016	982	941	890	—
KTA-2300-F1	H.P.	—	—	—	—	—	—	890
KTA-3067-F	H.P.	1425	1390	1356	1306	1254	1194	1150
KTA-3067-F1	H.P.	—	—	—	—	—	—	1180

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

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 temperatures
5. Guard against corrosion
6. Let the engine breathe
7. Prevent overspeeding
8. Know your engine's condition
9. Correct troubles while they are simple
10. Schedule and control your maintenance

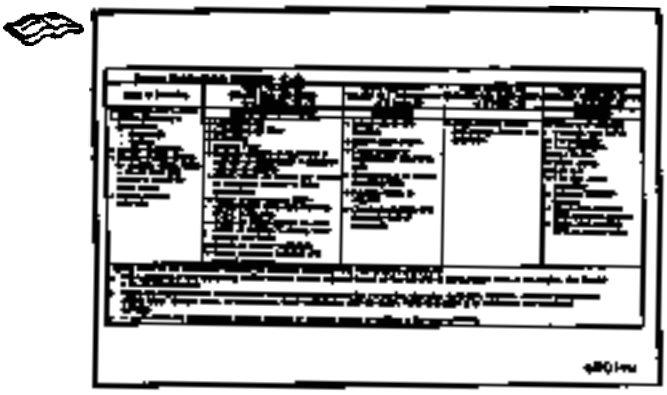
NOTES

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.

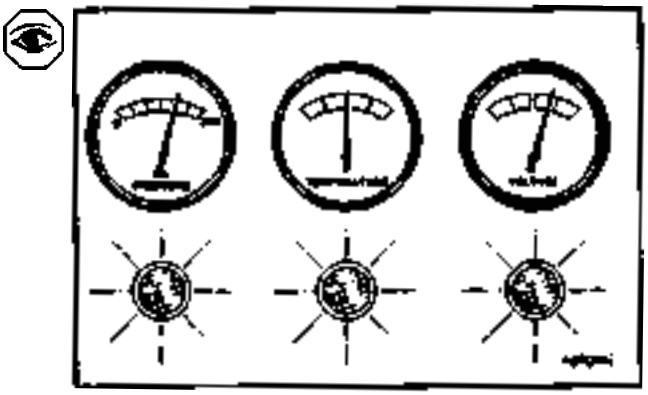
General-AII Applications

GENERAL INFORMATION



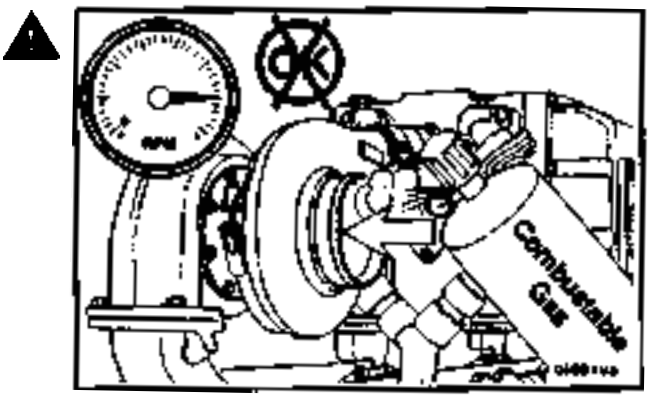
Correct care of your engine will result in longer life, better performance and more economical operation.

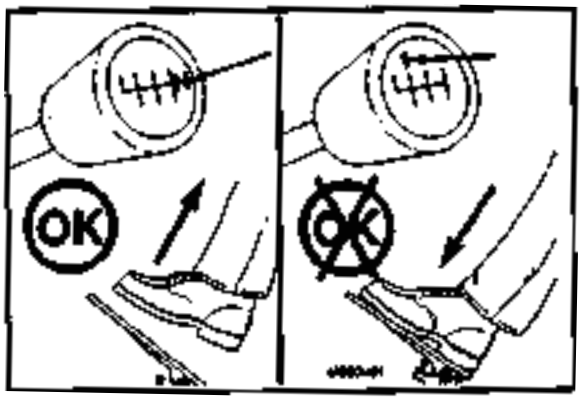
- Follow the daily maintenance checks listed in Maintenance Guidelines, Section 2.



- 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 airintake 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 COMMINS AUTHORIZED REPAIR LOCATION FOR FUTHER INFORMATION.



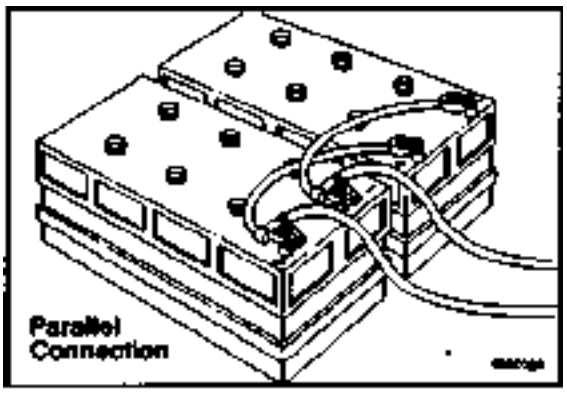


NORMAL STARTING PROCEDURE (ABOVE O°C [32°F])

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

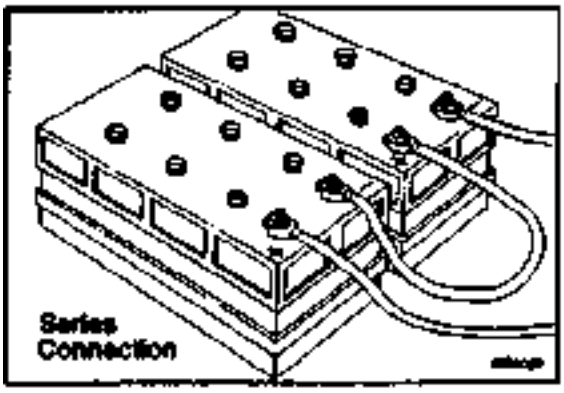
Engines equipped with air starters require a minimum of 480 kPa [70 psi] compressed air pressure.

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

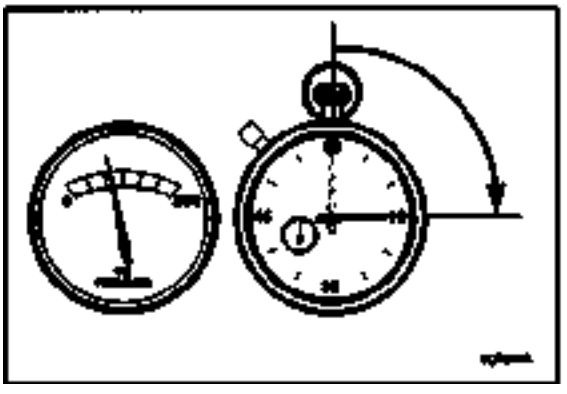


Caution : When using jumper cables to start the engine, make sure to connect the cables in parallel; positive (+) to positive (+) and negative (-) to netative (-). When using an external electrical source to start the engine, turn the disconnect switch to the OFF position. Remove the key before attaching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

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

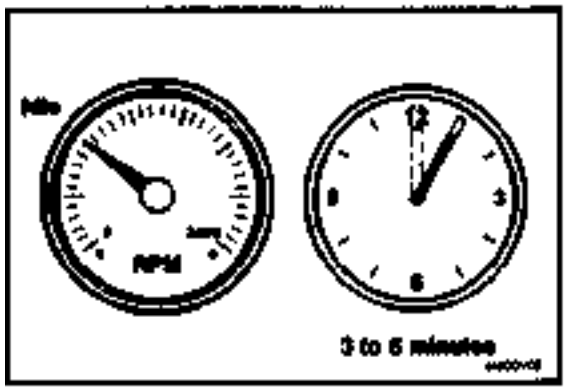


This illustration shows a typical series battery connection. This arrangement, positive to negative, doubles the voltage.

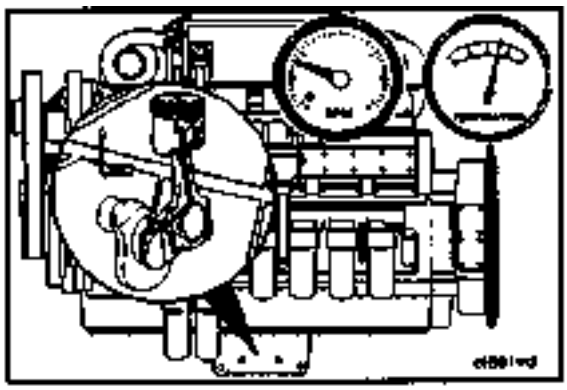


- Engine oil pressure **must** be indicated on the gauge within 15 seconds after starting. If oil pressure is **not** registered within 15 seconds, shut off the engine immediately to avoid engine damage. Confirm the correct oil level in the oil pan.

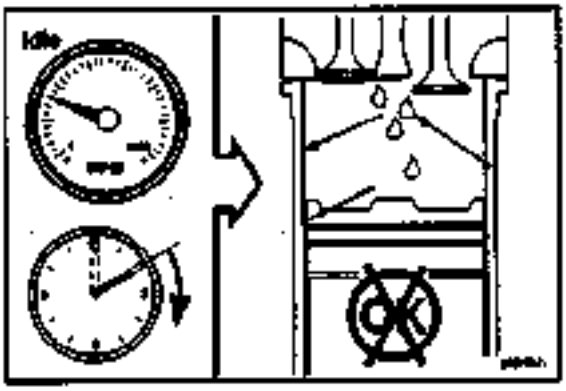
- Idle the engine three (3) to five (5) minutes at approximately 1,000 RPM before operating with a load.



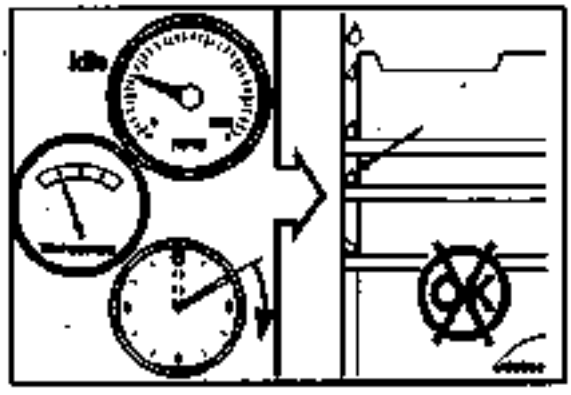
- When starting a cold engine, increase the engine speed (RPM) slowly to provide adequate lubrication to the bearings, and to allow the oil pressure to stabilize.

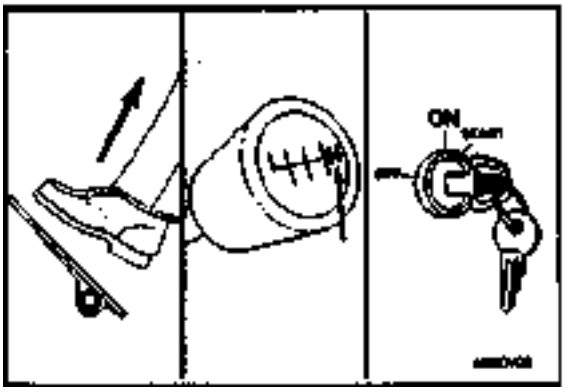


Do **not** idle the engine for excessively long periods. Long periods of idling, more than 10 minutes, can damage an engine because combustion chamber temperatures drop so low the fuel will **not** burn completely. This will cause carbon to clog the injector spray holes and piston rings, and can cause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

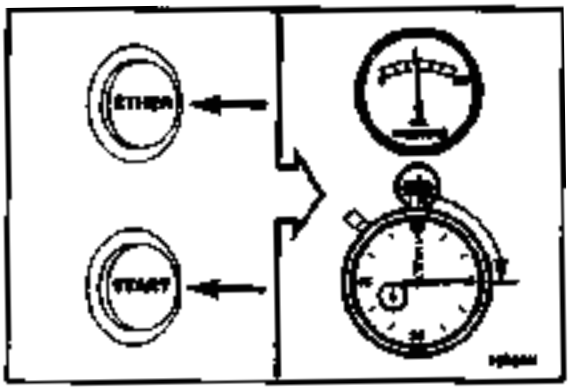




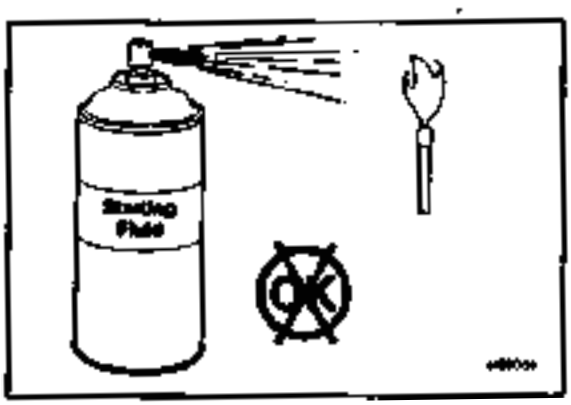
COLD WEATHER STARTING

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.



Usint 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 U.S. Bureau of 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 Engine Company, Inc. does **NOT** recommend the use of starting fluid without metering equipment.

COLD WEATHER ENGINE OPERATION

Satisfectory performance of a diesel engine operating in low ambient temperature conditions requires modification of the engine, surrounding equipment, operating practices and maintenance procesures. The colder the temperatures encountered, the greater the amount of modification required and yet with the modificaitons 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.

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 starting and operation are possible in the lowest temperature to be encountered requires :

1. use of correct materials.
2. Proper lubrication, low temperature lubricating oils. Refer to Lubricating Oil Specifications, Section V.
3. Protection from the low temperature air. The metal temperature does **not** change, but the rate of heat dissipation is affected.
4. Fuel of a proper grade for the lowest temperature.
5. 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.
6. Proper external heating source available.
7. 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 ar eproperly prepared and maintained. The correct lubricants, fuels and coolant **must** be used for the cold weather range for which the venicle is being operated. Refer to the chart below for recommendations in different operating ranges.

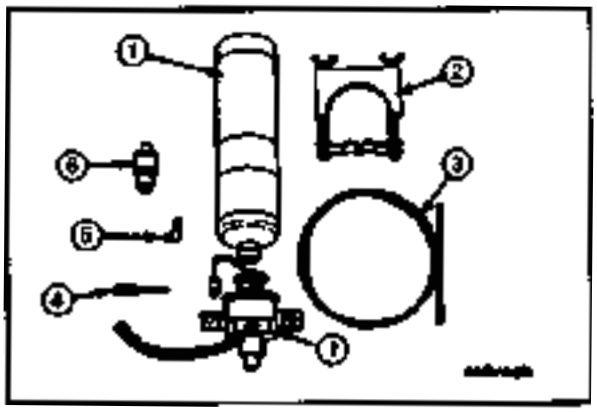
Winterize 0° to -23°C [32° to -10°F]	**Winterize -23° to 32°C [-10° to -25°F]**	**Winterize -32° to -54°C [-25° to -65°F]**
Use ethylene glycol antifreeze to protect to -29° C [-20°F]	Use 50 percent ethylene glycol antifreeze, 50 percent water mixture.	Use 60 percent ethylene glycol antifreeze 40 percent water mixture.
Use multi viscosity oils meeting API, CE or CF4 specifications.	Use multi viscosity oil meeting API, CE or CF4 specifications.	Use Artic oil meeting API, CE or CF4 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.

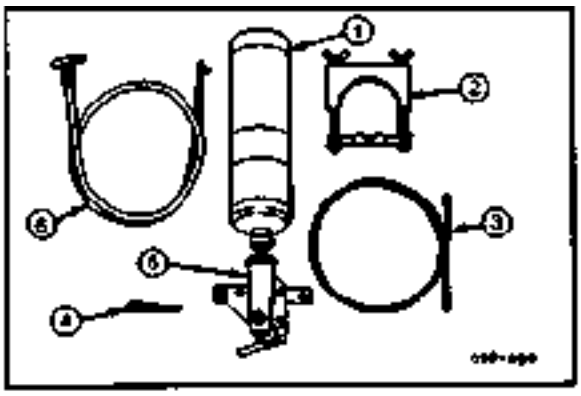
COLD WEATHER STARTING AIDS

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.

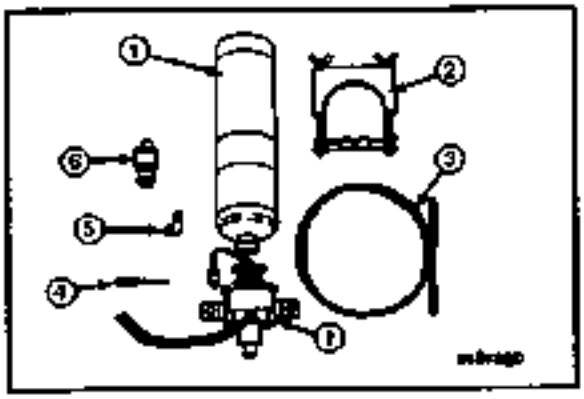




Manually Operated Ether Valve

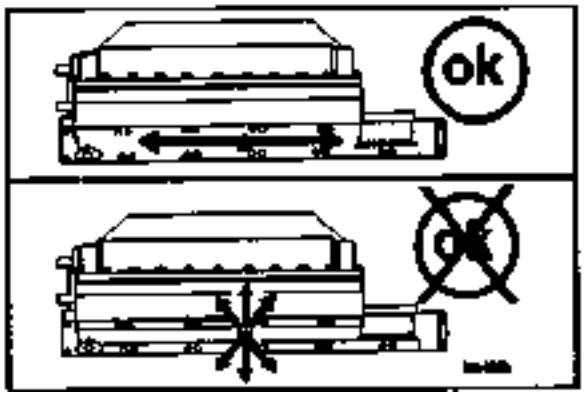
The manually operated ether valve includes the valve body assembly (5), clamp (2), and nylon tube (3). The fuel cylinder (1), atomizer fitting (4) and pull control (6) **must** be ordered separately.

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



Electrically Operated Ether Valve

The electrically operted 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 Catalogfor fuel cylinder 91) and fuel atomizer fittings (4). These fittings **must** be ordered separately, as required.



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.

Preheater

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

To aid in starting engine when temperature is 50°F (10°C) or below, an intake air preheater is available. 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.

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

To use preheater for cold starting:

1. Set throttle in idle position. Turn glow plug toggle switch to 'ON' position. Red indicator light must be on.

2. 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.

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

4. 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.

5. 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.)

6. 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- or 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 –25°F (–32°C).

Caution: Do not attempt to use vapor compound type starting aids near heat, open flame or on engines equipped with glow plug system.

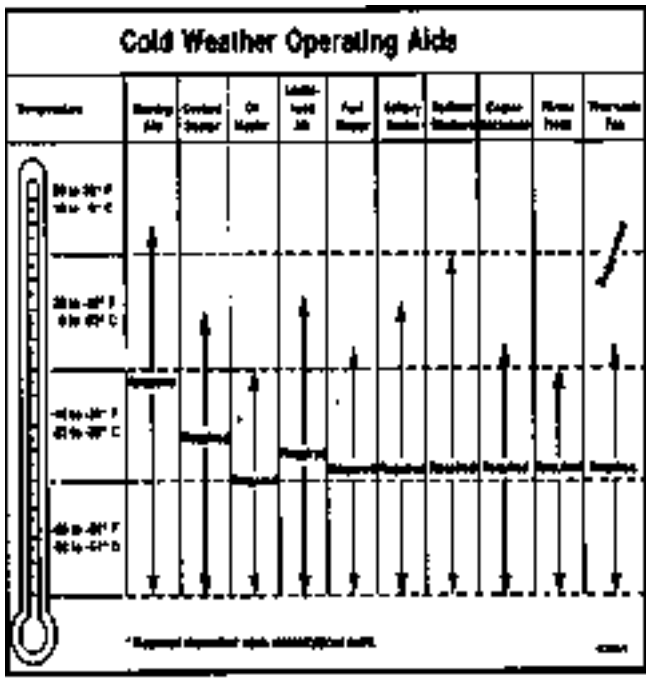


Fig. 1-8. Manually operated valve

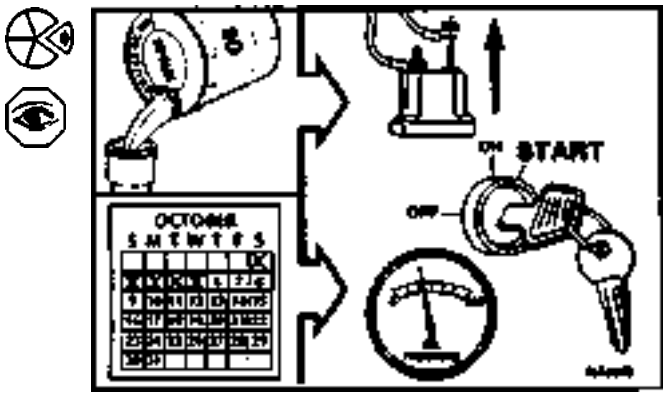


Fig. 1-9 Electrically operated valve

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 engine starting with a parasitic load, such as a fire pump, coolant temperature must be a minimum of 120°F (49°C).

Engine Speeds

All Cummins engines are equipped with governors to prevent speeds in excess of maximum or predetermined lower speed rating.

The governor has two functions : First, it provides the fuel needed for idling when the throttle is in idle position. Second, it overrides the throttle and shuts off fuel if engine rpm exceeds maximum rated speed.

Speed listed in Table 1-1 are for engines rated at maximum rpm and fuel rate.

Table 1-1: Engine Speeds (RPM)

Engine Series	Maximum Rated
495	2000
743	2100
855	2100
1710, 1710 (28 Litres)	2100
1150	2100
2300	2100
3067	2100
QSK-60	1500

Note : Engines in many applications are applied at a lower than maximum rated speed; check the serial dataplate.

Power generator units are pre-set to operate at 1500 governed rpm i.e. at 1500 or 1800 RPM.

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.

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.

Oil Temperature

The oil temperature gauge normally should read between 167°F (75°C) and 221°F (105°C). Under full load conditions, an oil temperature of 240°F (116°C) 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 140°F (60°C). 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.

Water Temperature

A water temperature of 167° to 203°F (75°C to 95°C) 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 203°F (95°C).

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

Oil Pressure

Normal engine oil pressure at 221°F (105°C) 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 .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.

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 smokey, corrective action should be taken.

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.

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 :

1. Place the VS speed control lever in operating position.
2. Lock the standard throttle in full-open position.
3. Engage power take-off.

To return to standard throttle :

1. Disengage power take-off.
2. Return standard throttle to idle position.
3. Lock the VS speed control lever in maximum speed position.

Engine Shut-Down

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.

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.

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 shutdown valve is being used, turn button fully counterclockwise to stop engine. Refer to 'Normal Starting Procedure'. VALVE CANNOT BE REOPENED BY SWITCH KEY UNTIL AFTER ENGINE COMES TO COMPLETE STOP. NEVER TURN OFF THE SWITCH KEY WHILE GOING DOWN HILL. With the engine still in gear, fuel pressure will build up against the shut-down valve and may prevent it from operating when the switch key is turned on.

Caution : Never leave switch key or override button in valve 'open' or in 'run' position when engine is not running. With overhead tanks this would allow fuel to drain into cylinders, causing hydraulic lock.

Do Not Use the Compression Release Lever to Stop the Engine

Some old engines are equipped with a compression release lever. Pulling this lever lifts the intake or exhaust (depending on engine model) valve push tubes and opens the valves. The push tubes are lifted off their sockets and extensive wear on the balls and sockets will result from using the compression release to stop the engine.

The compression release lever can be used as an aid in cranking, before starting, or while making injector and valve adjustment, but not to stop the engine. However CIL has obsoleted use of decompression system.

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. See Section 11.

2. Drain cylinder block and heads on all engines by opening petcocks and removing drain plugs as shown in Fig's. 1-10 to 1-15. If an air compressor (Fig. 1-15), heat exchanger or other 'water cooled' accessory is used, open petcock and drain. 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.

Fig. 1-10 N/NT 855 C.I.D. Engine Cooling System drain point

Fig. 1-11. V/VT-1710 Coolant drain point

Fig. 1-12. KT (A)-1150 Coolant drain point

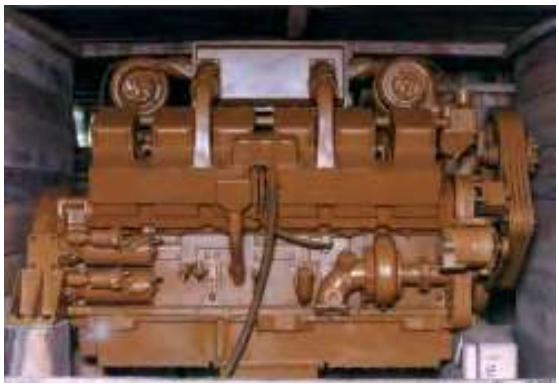


Fig. 1-13 KT (A)-2300 Coolant drain point

Fig 1-14 KTA-3067 Coolant drain point

Fig 1-15. Two cylinder air compressor coolant drain

2. Oil Pan Capacities

Table 1-1 : Oil Pan Capacities

Engine C.I.D.	Lub oil Capacity	
	High U.S. gal. (Litres)	Low U.S. gal. (Litres)
495	4.5 (17)	3.5 (13) 4 (15)
743	7 (27)	5 (19)
855	7 (27)	5 (19)
1150	10 (38)	8.5 (32)
1710	18 (68)	16 (61)
2300	30 (114)	23 (87)
3067	40 (152)	32 (122)

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

3. Fill engine with amount of oil listed as low-level oil pan capacity.

4. Allow five (5) minutes or more for oil to drain to the oil pan. If engine and/or oil temperature is below 40° F (4°C), a longer period may be required for full drain.

5. Insert dipstick into gauge tube until fully seated; hold for five (5) ten (10) seconds, then with-draw slowly.

6. Mark oil level indicated on dipstick with an electric etch. Depth of mark must not exceed 0.010 inch (0.24 mm). Etch “L” above mark.

7. Add enough additional oil to fill engine to listed high-level capacity.

8. Repeat Steps 4, 5 and 6. Etch letter “H” directly above the second or ‘high’ level mark.

9. Start engine and operate at idle for 3 minutes. Stop engine wait for 10 minutes and fill to high mark. Additional oil may be required to fill oil filters and lines.

The above procedure determines dipstick gauge marking for oil pan capacity only. Do not confuse with complete oil system capacity which also includes drilled passages, lines and filters.

Priming the Lubricating System

Fig. 1-1. 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 11.
2. Remove plug from head of lubricating oil filter housing (Fig’s. 1-2, 1-3) or filter can to prime system. On the KT-1150 Engines remove plug from front of oil cooler housing. Fig. 1-5.

Fig. 1-2. Lubricating system priming point—NH/NT engines.

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.

Fig. 1-3. Lubricating system priming point—V-1710 engines.

Fig. 1-4. Lubricating system priming point—KT(A) 2300/3067 engines.

Fig. 1-5. Lubricating system priming point—KT/KTA-1150 engines.

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 11. 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. Fig. 1-6. The dipstick has an “H” (high) and “L” (low) level mark to indicate lubricating oil supply. The dispstick 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 Raw 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.

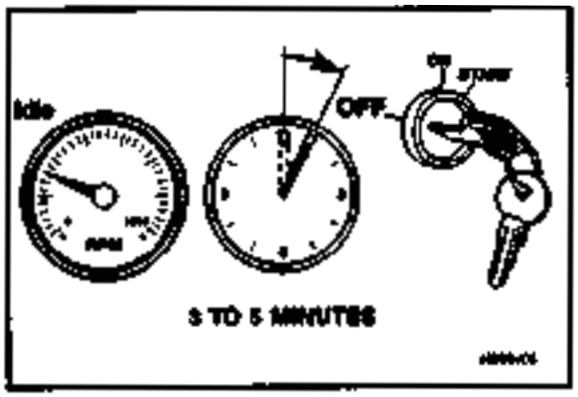
4. Open manual fuel shut-down valve, if so equipped. Fig. 1-7. Electric shut-down valves operate as switch is turned on. A manual override knob provided on forward end of electric shut-down valve allows valve to be opened in case of electric power failure. To use, turn fully clockwise; return to “run” position after electric repair.

Fig. 1-7 : Using manual override knob

5. Press starter button or turn switchkey to “start” position and crank the engine till it fires.

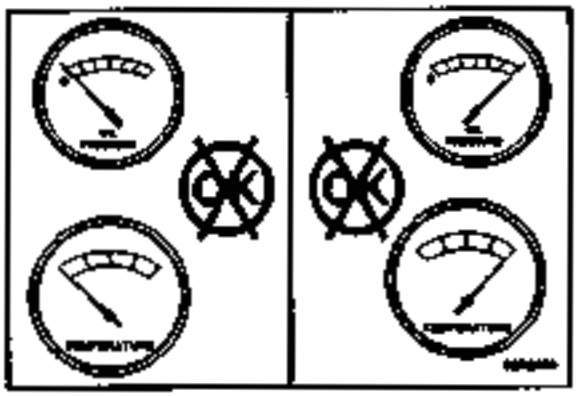
Caution : To prevent permanent cranking motor damage, do not crank engine for more than 10 seconds continuously. If the engine does not start fater about three repeated attempts, with an interval of two minutes between successive starts then the starter should not be operated and the fuel system has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



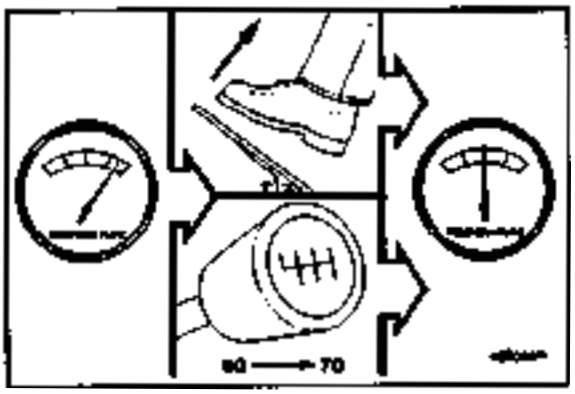
OPERATING THE ENGINE

- 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.



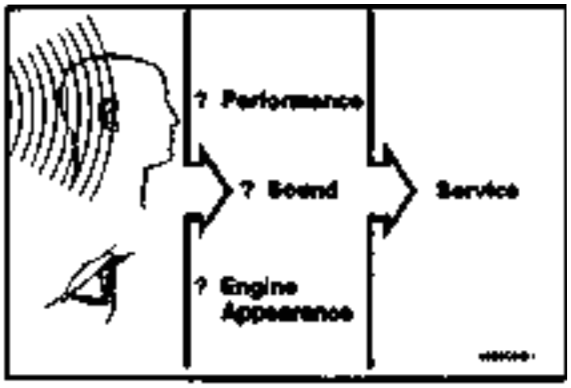
NOTE : Continuous operation with low coolant temperature, below 60°C [140°F], or high coolant temperature, above 100°C [212°F], can damage the engine.

- 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.



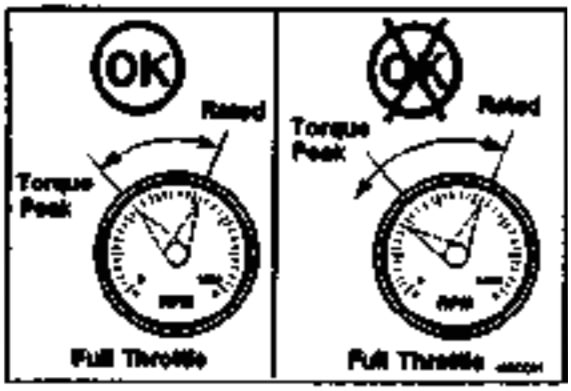
- If an overheating condition starts to occur, reduce the power output of the engine by releasing the throttle pressure or shifting the transmission to a lower gear or both until the temperature returns to normal operating range. If engine temperture does **not** return to normal, shutoff the engine 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.

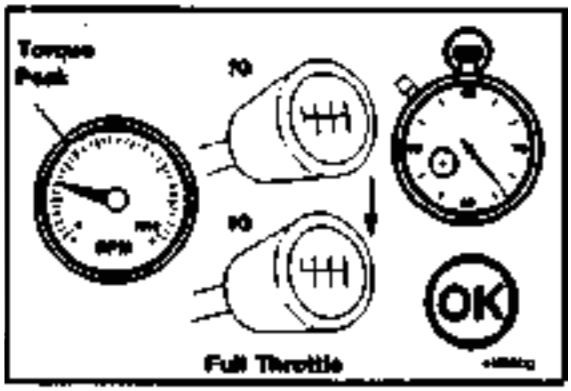


Engine Operting Range

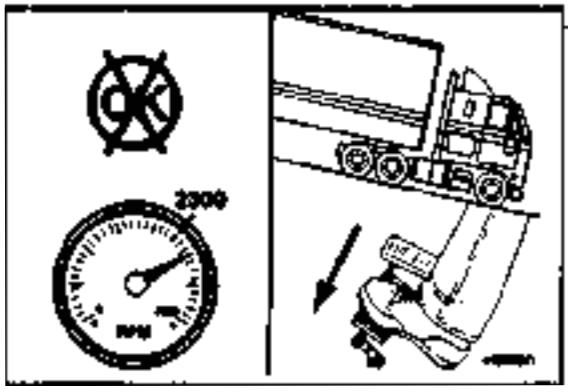
Excessive full throttle operation below peak torque RPM (lugging) will shorten engine life to overhaul, can cause serious engine damage and is considered engine abuse. Cummins engines are designed to operate successfully at full throttle under transient conditions down to peak torque engine speed.

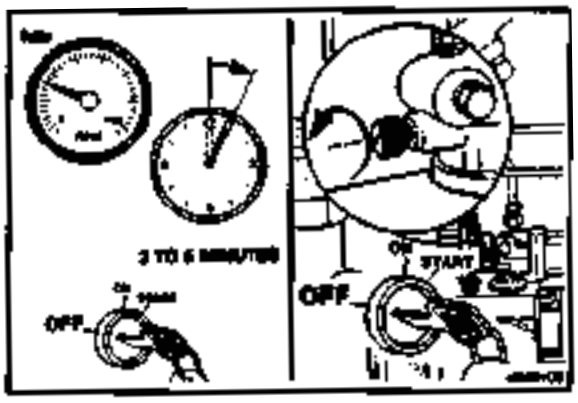


Operation of the engine below peak torque RPM can occur during gear shifting due to the difference of ratios between transmission gears, but engine operation **must not** be sustained more than 30 seconds at full throttle below peak torque RPM.



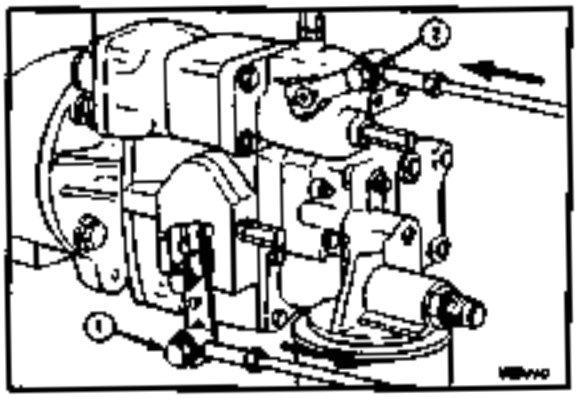
Caution : Operating the engine beyond high idle speed can cause severe engine damage. The engine speed MUST NOT exceed 2,400 RPM under any circumstances. When descending a steep grade, use a combination of transmission gears or vehicle braking systems to control the vehicle and engine speed.





Engine Shut-down

- Allow the engine to idle three (3) to five (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.



Power Takeoff Application with Variable Speed Controls

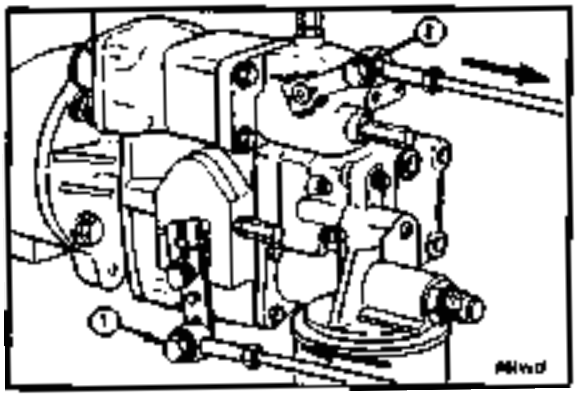
The variable speed governor on power takeoff applications is used to control engine speed at the desired RPM.

To engage the variable speed governor with the engine idling on standard throttle :

- Put the variable speed control lever 92) in the idle position.
- Lock the standard throttle lever (1) in the full open position.
- Adjust the variable speed control lever (2) to the speed desired.

To return to standard throttle operation :

- Return the standard throttle lever (1) to the idle position.
- Lock the variable speed control lever (2) to the maximum speed position.



STC	
Advanced	**Normal**
Starting and Light Load	High Load

Step Timing Control (STC)

Some engine models are equipped with step timing control (STC), formerly called HVT (Hydraulic Variable Timing). STC allows the engine to operate in advanced injection timing immediately after start-up and light duty engine load conditions, and to return to normal timing during medium and high engine load conditions.

Benefits include :

- Improved cold weather idling characteristics.
- Reduced cold weather white smoke.
- Improved light load fuel economy.

Electronic control panel
DOE'S AND DONT'S

1. Connect the mounting stand to the engine body/ battery -ve electrically by a thick wire. (preferably 4 sq.mm).

2. Make sure that the polarity of the battery connections is correct before applying power to the ECP.

3. Do not open the front plate of the ECP without first detaching the engine harness connector / OEM connector.

4. Do not test wire leads to see if they are "live" by flashing them on either the engine body or the ECP mounting stand.

5. Do not use PIN A of the 10-pin OEM connector for any purpose other than connecting the relay coil returns of the three alarm relays.

Description

The Electronic control panel (ECP) is used on all CIL G drive engines for monitoring engine parameters. This panel eliminates the conventional Electronic Instrument panel and mechanical gauges. The ECP comprises of the control panel, harness, sensors and mounting enclosure and mounting stand.

The ECP is a set of two electronic sub assemblies housed in the enclosure.
The ECP receives inputs from various sensors like magnetic pick up, coolant temperature sensor, lube oil pressure sensor, lube oil pressure switch and auxillary temperature sensor. These inputs are in the form of electrical voltage.

These voltage inputs signals are conditioned in the I/O (Input/ Output) board and are fed to the digital board.

The digital board comprises of the central processor, memory and display unit for indicating the measured parameters.

Inputs

1. Battery Supply Voltage
2. Coolant temperature sensor
3. Auxiliary temperature sensor (Intake Manifold temperature (only on KTA50G8 and KTA38G5 engine models)
4. Oil Pressure sensor
5. Oil Pressure switch
6. Engine speed sensor i.e. magnetic pickup
7. Low coolant level switch
8. Scan push button
9. Key switch
10. Remote start
11. Remote stop

Outputs

1. Fuel shutoff valve
2. Starter magnetic switch
3. High coolant temperature relay driver
4. Low lube oil pressure relay driver
5. Auxiliary temperature relay driver
6. Charging alternator "W" terminal

ECP Installation and Startup

a. Connector Installation

   The engine harness is connected to the 19-pin connector. The ECP gets its 24 Volts supply from this connector.

b. With the Key switch in Off position, The ECP power is cut off.

   Make sure that the battery connections to the ECP are of correct polarity. Turn the key switch to the 'ON' position.

c. The display check is carried out first. The display shows ' 0000' to '9999' sequentially.

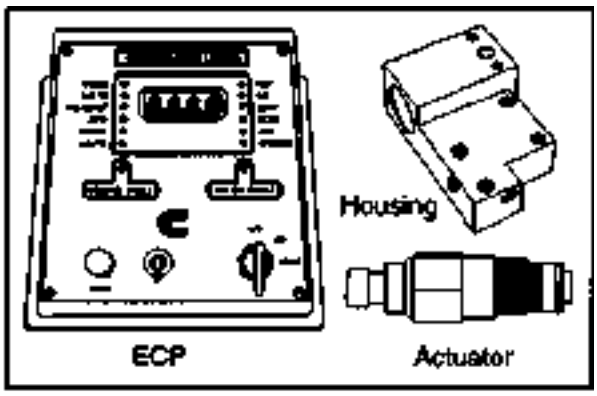
   The LED's in the left column Glow one by one followed by the LED's in the right column.

   This completes the ECP hardware check that is performed by the software internally. On completing the hardware check, the ECP enters into the parameter scan mode.

Electronic control panel with built in governor feature

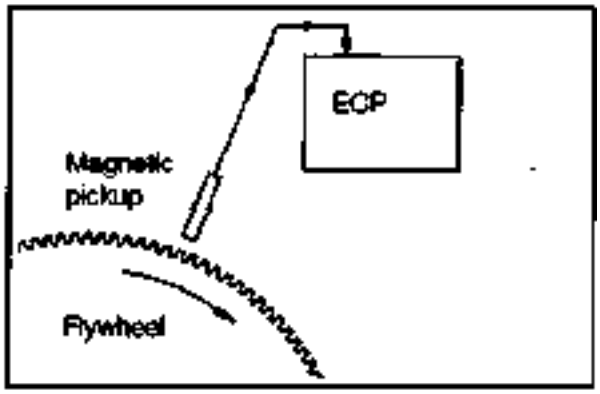
1. Description

The Electronic control panel (ECP) with built in governor feature (part number 4071949) is used on engines for monitoring engine parameters and governing engine speed. The ECP with built in governor comprises of, ECP with software to govern the engine speed, actuator mounted in an aluminum housing, mounting parts, cable harness for interconnection, engine sensors. This ECP eliminates the conventional electronic fuel controller (EFC) and the related harness.



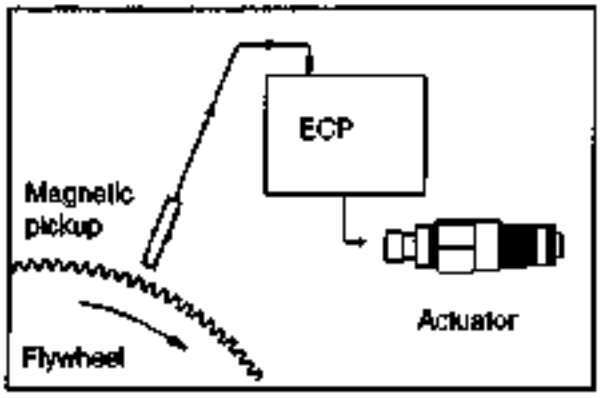
2. Theory of operation:

The magnetic pickup senses the engine speed at the flywheel ring gear and generates an AC voltage with its frequency proportional to the engine speed. The signal is sensed by the ECP and is used as a speed feedback.



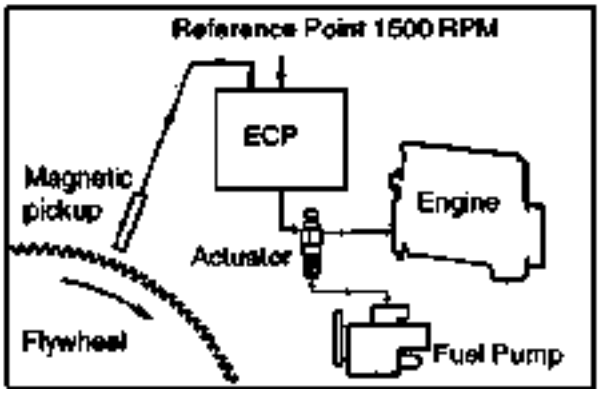
The actuator mounted in the actuator housing is used to control the fuel flow from the fuel pump to the injectors. Actuator valve (with no current flowing in the actuator coil) is normally closed. Actuator opens depending upon the current through the actuator coil.

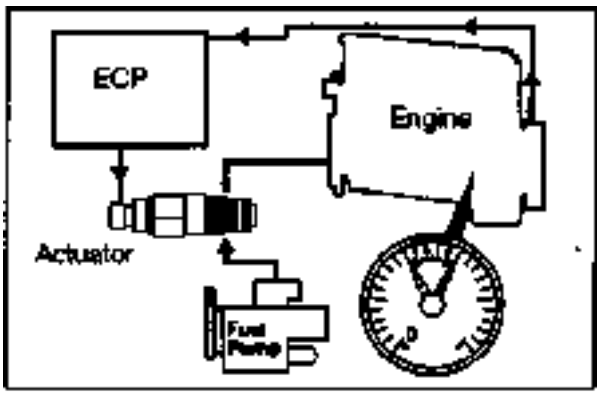
The ECP compares the electrical signal from the magnetic pickup with a preset speed reference point (for e.g. 1500 RPM). If there is a difference in the two signals, the controller will change the amount of current into the actuator.



A change in the amount of current in the actuator coil make the actuator shaft to linearly open/ close the fuel outlet port, and control the amount of fuel flow to the engine. This in turn controls the engine speed.

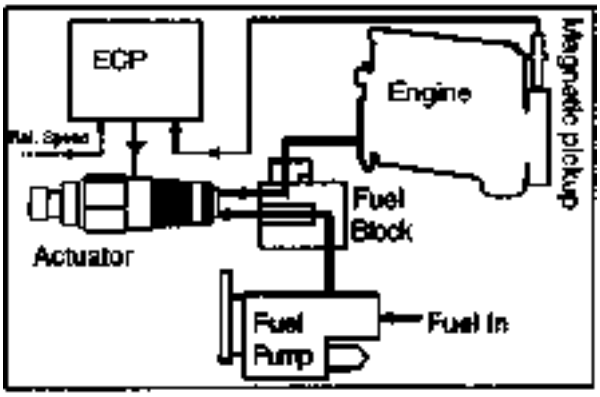
The ECP controls the engine speed at the set reference speed (for e.g. 1500 RPM) from No load to full load. (Isochronous operation). It requires no special settings as the software in the ECP controls the engine speed.



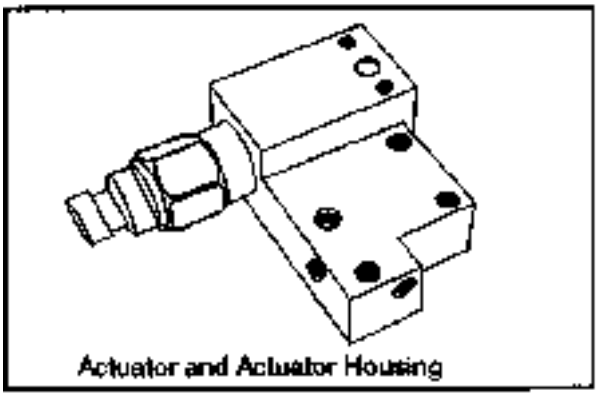


3. Introduction to Parts

The figure shows various parts that are functionally connected

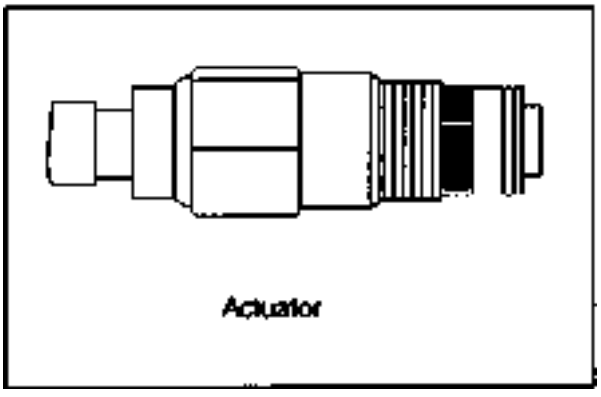


ECP with sensors



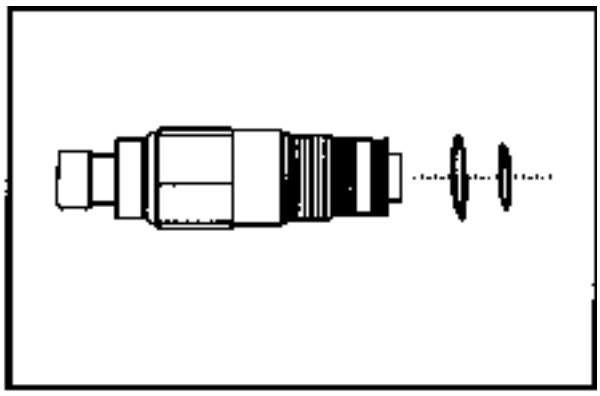
Actuator and actuator housing:

The actuator (part number 3330601) is of linear spool type. The actuator is housed in the aluminum housing. This assembly is used as a valve for controlling the speed and horsepower of an engine.

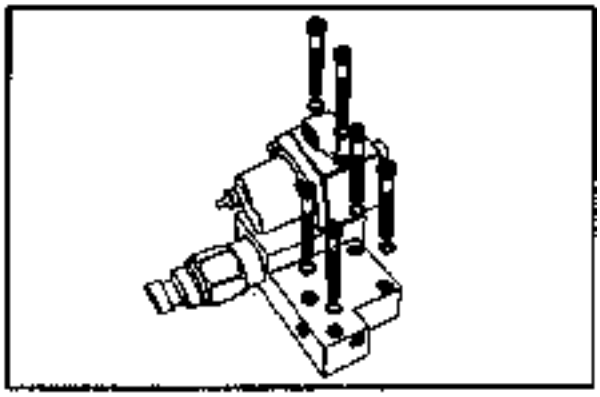


Actuator is closed when no current is flowing in the actuator coil. When current is passed into the actuator coil, the actuator port opens passing fuel through it.

Two “0” rings are used for mounting the actuator in the housing (part numbers).

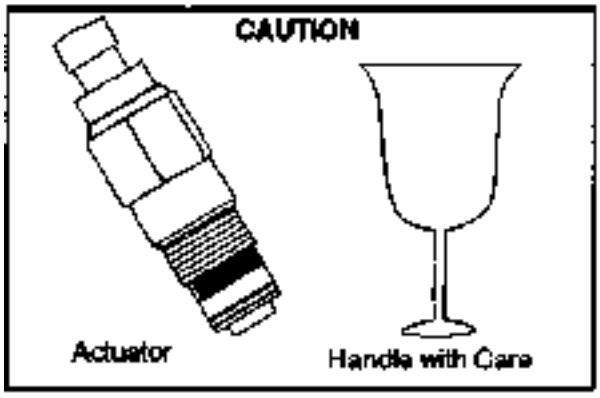


Two “0” rings and four Alien screws and washers are used to clamp the housing on the fuel pump. (Part numbers 4071946). The actuator cable is used to connect actuator terminals to a metripack connector (part number 3823255) in the engine harness.



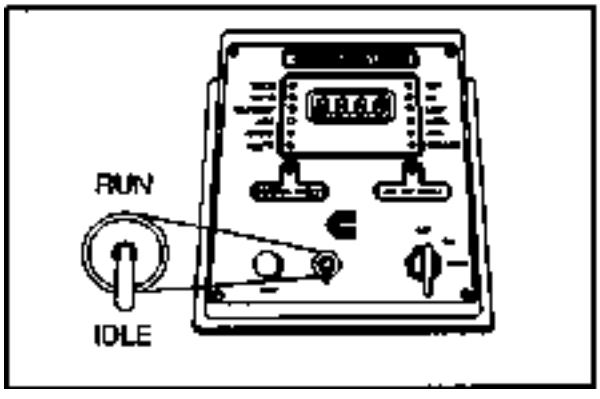
Caution!

Actuator is a delicate part and should be handled with care, while removing, cleaning or putting back in the housing.



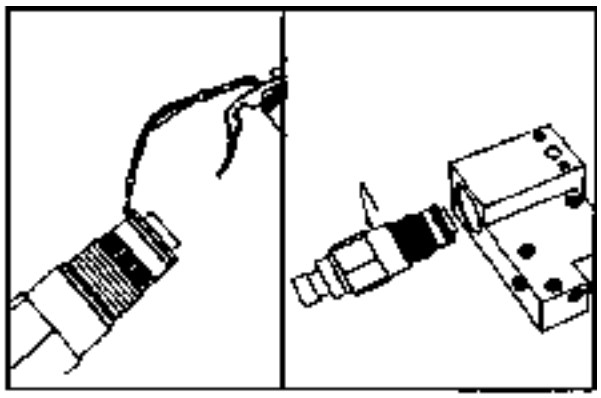
Run idle switch (504395) :

Run / Idle switch on the ECP front panel is used to select either of the two engine speeds. Run/Idle toggle switch is mounted on the ECP front plate. When the switch is closed, Idle speed is selected by the ECP as reference speed. The ECP then controls the engine speed to 1100 RPM. The switch is Open in the Run position. The ECP controls the engine speed to the reference rated speed (for e.g. 1500 RPM).



Wiring Harness (4055911)

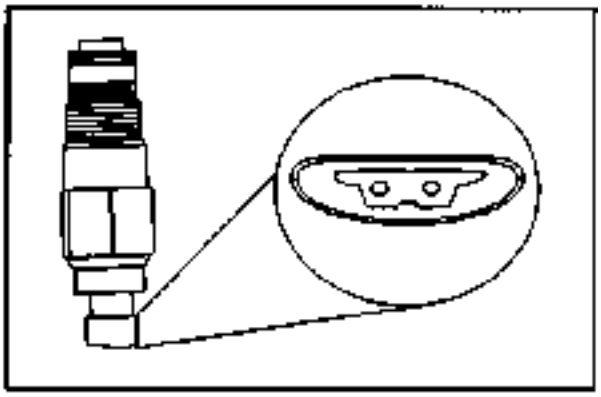
The actuator is connected to the engine sensor harness at points “D” and “F”. The harness for the ECP with built in governor is functionally similar to the harness used with the conventional ECPs (Part numbers: 3414797,4053453).



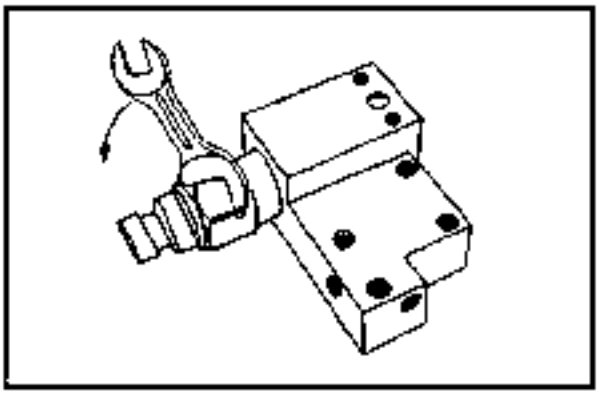
4. Installation

Actuator

Lubricate the two-barrel “0” rings with clean engine oil. Insert the actuator in the housing and rotate it clockwise till it is inserted complete inside. Using a 1,1/4-inch spanner, tighten the actuator, (torque: ....)



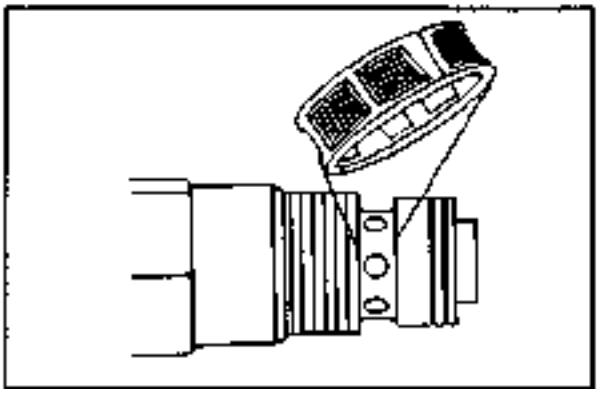
Connect the metripack connector to the actuator. The connector is “keyed”, so that it connects in one direction only.



Actuator removal from the housing (4071944)

Actuator may be needed to be removed from the housing for cleaning the fuel filter, replacing or for diagnostic purpose.

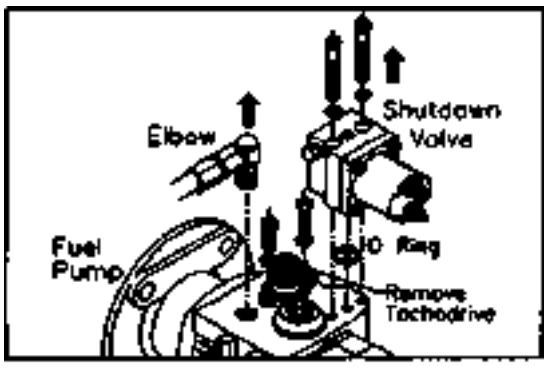
Remove the actuator connection connector. Using the 1,1/4" spanner, remove the actuator from the housing. Always shut off the supply to the ECP by removing the battery cables, before servicing the actuator.



Cleaning the fuel Screen:

There is a 10-micron fuel screen in the inlet side of the actuator; the filter should be periodically cleaned.Hold the actuator in both the hands, with the connector pointed outwards. Pull the two fuel filter windows which are smallest outwards, the fuel filter screen opens, Clean the filter with shop air at pressure ~1Kg/cm2. Snap the filter back into place by pushing the filter windows together.

Actuator Housing



The actuator housing is mounted on the fuel pump as per following procedure:

1. Remove the fuel shut off valve with the 0 ring

2. Remove the fuel pump return pipe along with the elbow if used.

Retrofitting preparation:

a) Remove the copper tubing connecting the fuel shutoff valve to the injectors from the fuel shutdown valve side.

b) Remove the shutdown valve with the 0 ring.

c) Remove the fuel pump return tine along with the elbow, if used.

d) Remove the tacho drive, if it is on the top of the pump.

e) Plug it with an aluminum plug (part number).

f) Clean the top of the fuel pump, with this the fuel pump is ready for mounting the actuator housing.

Note: In case of retrofitting, the fuel pump needs recalibration along with the actuator housing, using proper code for calibration.

3. Place the actuator housing with two “O” rings, these O rings act as a face seal in fuel output and fuel return path respectively.

4. Clamp the housing on the fuel pump using four Alien screws. Torque of 5.6 Nm should be given.

5. Mount shutdown coil on the actuator housing as per standard procedure.

6. Connect the fuel pump return line on the housing actuator.

7. Connect suitable copper tubing going to injectors from the fuel shut off valve.

Trouble shooting

Symptom: The Engine cranks but will not start

Check and corrections:

1. Check for fuel in tank and at fuel shut off valve
2. Check whether fuel is reaching the injectors while cranking.
3. Check whether fuel shut off valve is open while engine cranking.
4. Check the voltage on the actuator terminals during cranking,
   It should be more than 8 volts. If it is less than that, replace the controller.

Symptom: Engine has rough performance or surge.

Checks and corrections:

1. Check for air in fuel line.
2. Check AC ripple on the 24 V DC supply to the ECP. It should be less than 1 volts. Remove the cause of ripple.
3. Check the system voltage. If it is less than 18 volts, replace / charge the batteries.
4. Remove actuator, housing, and check the “O” rings, replace defective “O” rings.
5. Check whether the actuator is stick by removing it from the housing and applying 24 v DC directly to it. If found sticky, clean it with isopropyl alcohol and reinstall it as per the procedure given in the installation section.

Symptom: Engine has low power

Checks and corrections:

1. Check battery voltage. If it is below 18 volts, charge the battery.
2. Calibrate the fuel pump with the actuator mounted in the housing.
3. Check the fuel system.

Replaceable Parts list

1. Actuator Part number 3330601,
   24 volts, normally closed, linear spool type.
2. Actuator mountings
3. O ring actuators
4. O ring housing
5. Housing,
6. Alien screw
7. Washers plain
8. Washer ring
9. Spanner

Controller part number
Wiring harness
Idle rated switch.
Specifications:
Controller Operation

Governor mode	0 % (Isochronous) droop
Steady state stability	better than +/- 0.5 %
Idle speed setting	1100RPM
Rated speed setting	1500 RPM.

Recommended Battery Capacity :

Model	Battery Capacity AH	Cable Size mm^2
S-3.8	120	50
B-5.9/495	150	50
N8/855	180	50
K19	180	70
V28	180	70
KV & above	360	70

NOTE : The number of plates within a given battery size determines reserve capacity. Reserve capacity is the length of time sustained cranking can occur.

Batteries (Specific Gravity)

Battery State of Charge	Specific Gravity @ 27°C [80°F]
100%	1.260-1.280
75%	1.230-1.250
50%	1.200-1.220
25%	1.170-1.190
Discharged	1.110-1.130

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 necessory 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 vary 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.

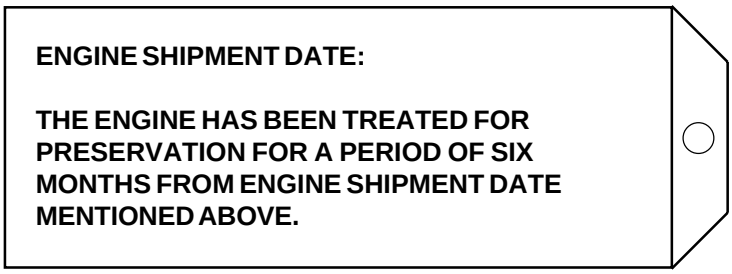
Note

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, 
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 :

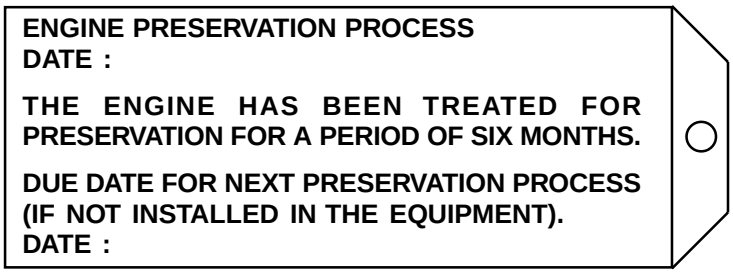
SR NO	DESCRIPTION	REMARKS
a	Prepare engine for Lub oil priming.	Use lub oil priming pump for priming.
b	Prime the engine with engine lub oil 15W40. (CF-4 category)	Use engine Lub oil trolley for priming. Circulate the lub oil till the lub pressure gauge shows 1 kg / cm sq. pressure. It will take max 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).



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 generelly 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 CSS& S / 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.

Industrial Fire Pump Engines

Fire pump engines are built and applied under conditions set down by agencies such as Tarif Advisory Committee (TAC), National Fire Protection Association-20 (NFPA-20), Underwriters Laboratory and Factory Mutual Research; therefore, parts originally supplied must not be deviated from without qualifying agency approval. The following instructions are those special items necessary to this application, and should be used in conjunction with those previously stated.

Engine Starting Procedure

Initial Start-Up

Note : Contact operating personnel responsible for fire protection system before starting. Obtain approval to service or repair. Make sure that the connecting lines to and from the fire pump are open and that there is water to the pump.

1. Close all cooling system drains.

2. Remove the heat exchanger cap, check or fill the engine coolant supply; open the water filter inlet and outlet valves.

3. Prelubricate the engine with oil meeting API Class CF4 and viscosity of SAE 15W40. This includes removal of the turbocharger oil inlet line on turbocharged engines to prelubricate the housing by adding 2 to 3 oz. (60 cc) of clean engine lubricating oil.

4. Check the crankcase oil level and fill to the 'H' mark on the dipstick.

5. Remove the fuel pump solenoid wire and crank the engine through two cranking cycles using the fire pump controller. Make sure that the fuel pump solenoid wire terminal does not touch the engine.

6. Turn the governor idle adjusting screw **counter-clockwise** 6 turns. This wlll permit the engine to run at or near idle speed at the initial start-up.

   On turbocharged models, removal of the delay cylinder and bracket from the fuel pump will permit operation of the engine at idle speed.

7. Idle speed may be adjusted by turning the governor idle adjustment screw **counter-clockwise** to decrease RPM or **clockwise** to increase RPM.

8. Verify that the lube oil system is under pressure.

9. Operate the engine for 8-10 minutes and look for leaks, unusual noises or other indications of improper operation. The engine should be run long enough to open the thermostat(s).

10. Set the overspeed stop switch. Refer to the sections on overspeed switches following this section.

11. Stop the engine and check the engine oil and expansion tank coolant levels. Top up if necessary. Clean the raw water strainer.

12. Start the engine and bring it to the fire pump required operating speed.

13. Adjust the raw water pressure regulator to obtain the required pressure.

14. **Readjust the engine speed if necessary.**

15. **Once engine speed and water pressure are set, lock the governor lever in position on naturally aspirated models, and the max. speed screw on turbocharged models.**

16. Shut off the engine. Contact operating personnel responsible for fire protection system that engine is ready for service. Obtain authorized signature of acceptance.

Normal Operation

The unit should be operated at least once a week, during this, the engine must reach normal operating temperature. The engine is started and stopped under load on some installations. High water temperature alarm if provided may activate after stopping due to afterboiling.

In addition to engine operation, routine examination of the engine should be made to see that oil and water levels are maintained, and that the battery specific

gravity remains within the battery manufacturer's specifications.

Cooling

Heat Exchanger

These engines are cooled by a heat exchanger in which the engine cooling water circulating around the heat exchanger tube bundle is cooled by raw water (from the discharge side of the fire pump) flowing through the tubes of the heat exchanger bundle.

Water Flow

The engine water flows through the heat exchanger to the engine water pump, through the engine around the cylinder liners, through the heads, out to the water-cooled exhaust manifolds (if provided), through the thermostats and finally back to the heat exchanger for cooling before it starts its return trip through the engine.

Raw water used for cooling the engine water is supplied from the fire pump prior to the pump discharge flange. It is forced through a cooling loop, by fire pump pressure to the heat exchanger where it flows through the tubes in the bundle and is discharged to an open waste cone.

NOTE : It is recommended that the fire pump engine must be test at least once in a week. The test should be carried out at engine operating temperature.

Use of Lub Oil By-Pass Filter

1. **All engines manufactured by Cummins India Limited must be fitted with by-pass filter EXCEPT for engines for following applications where the by-pass filter may be used as "Optional" part.**

   a) **All natural aspirated engines.**
   b) **All engines for fire fighting pumps**
   c) **All stand-by turbine starting engines.**

Caution : Reverse Rotation of Pump

Engines are used as prime movers on various fire fighting installations as well as for city water supply schemes.

Generally, combination of multiple motor driven pumps along with engine driven pumps are utilised which are fed with positive suction and deliver to common header/ hydrant. Whenever such installations are made, manually operated gate valves and / or non return valves (NTVs) are provided in the individual delivery line of the each pump. Similar arrangements are made for city water supply schemes when water source is at lower level and city is located at height.

It has been noticed over the years that operational / installation lapses i.e. wrong positioning of manual control valve, quality issues related to functioning of NRVs and growth of sea mass, debris, entrapment of sea shells cause improper sealing of NTV. Water in the delivery pipe flows back to in-operative pump causing the pump to rotate it in reverse direction. As generally pump to engine coupling used are of direct drive type, the engine also starts rotating in reverse direction along with the pump. All gear pumps ofthe engine i.e. lubricating oil & PT fuel pump rotate in reverse. This in turn leads to rotation of various engine parts with out lubrication causing severe damages to components mainly, camshaft, cambushes, cylinder blocks, connecting rod bearing, main bearings & crankshaft etc.

The solutions to this problem are :

- Training and awareness of the operating staff of consequences in case manual gate valves are not positioned appropriately as per safety & operational requirements.
- Use good quality non return valves and manual gate valves and their maintenance.
- Ensure NRV sealing while commissioning new engines.
- To failsafe turther, provide unidirectional coupling between engine and the pump in consultation with respective OEM.
- Do periodic inspectionand maintenance of NRVs and gate valves to prevent occurrences of such failure.

Water Heater Tank :

Guidelines for connecting water heater to engines.

- Mount water heater tank along the base rail preferablity on engine exhaust side.
- Conect the adaptors, thermostat, heater etc., as per layout diagram.

- Ensure that the water heater is always on, so that the desired engines water temperature (38-49°C) is maintain. This is important. The water heater tank is provided so that engine is always ready to take instant load, in case of fire alarm.

USE OF WATER HEATER TANK :

Please refer to the Sketch 2-1 for typical mounting of the water heater tank. The details of per coonnecting water heater tank are given below.

- Typical schematic for cooling circuit
- Part Nos & their position in the circuit
- Electrical specifications for heater & thermostatic switch

The Thermostat provided for coolant heaters is to be adjusted in the field in such a way that water temperture is maintained between 38°C & 49°C. This adjustment depends upon working environments of the fire pump applicaiton engines (ambient temperature), quantity of coolant in the cooling system etc.

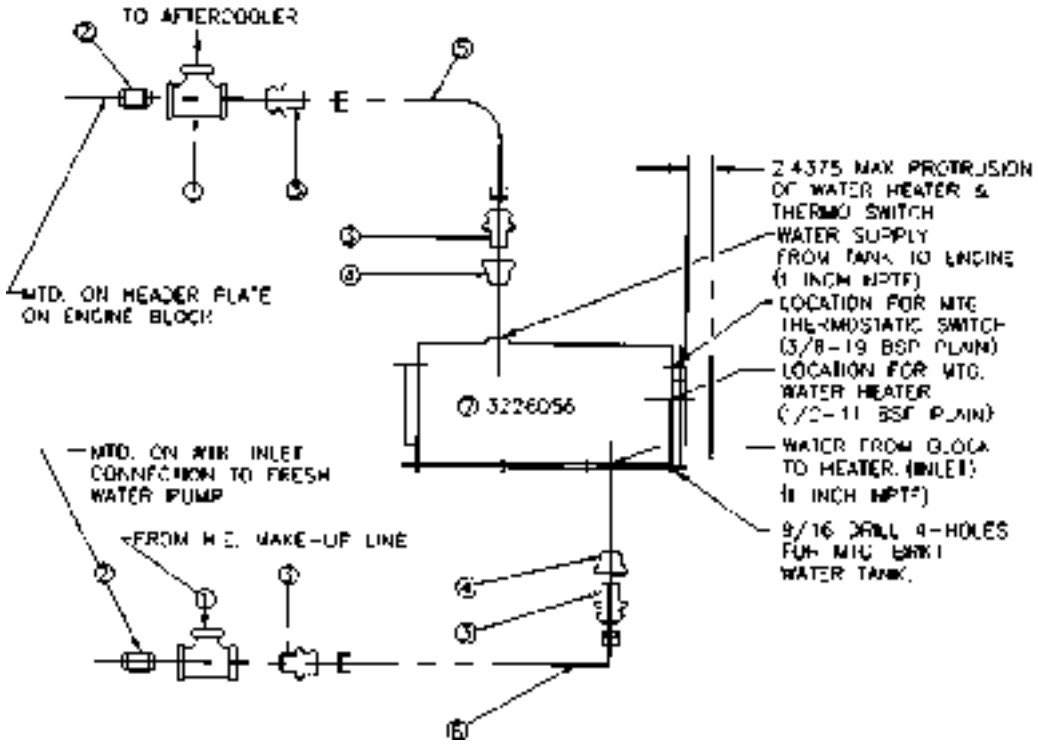


Fig. 2-1 : Typical sketch for connecting Water Heater Tank.

Tank Water Heater Part No. 24/AR3247847 consists of

Sr. No.	Part No.	Description	Qty.
—	S670	Washer, Plain	10
1	S904A	Bushing Pipe	2
2	S939B	Nipple Close	1
—	S962	Plug Pipe	2
—	S966	Plug Pipe	1
3	S981	Tee Pipe	1
	S988	Elbow, Plain	4
4	AS1607000SS	Hose Assembly	1
5	AS1610000SS	Hose Assembly	1

Sr. No.	Part No.	Description	Qty.
—	0067622	Plug Pipe	1
6	0119984	Connector, Male	4
—	3226053	Water Heater (220V, 2 kw)	1
—	3226055	Valve Thermost (23V, 20 A.A.C.)	1
7	3226056	Tank Water heater	1
—	3226144	Bracket Water Heater	1
—	S106	Screw Hexagaon	4
—	S145	Screw Hex Head	6
—	S200	Nut Regular	10
—	S608	Washer Lock	10

NOTES

Maintenance Operations

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

Maintenance Schedule

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 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.

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.

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.

For Maintenance Schedule of all other Engines refer page 3.2.

For Maintenance Schedule of Industrial Fire Pump Engines refer page 3.3.

For Maintenance Schedule of Starter & Alternator refer page 3.4.

Maintenance Schedule

CUMMINS DIESEL ENGINES

(OTHER THAN INDUSTRIAL FIRE PUMP ENGINES)

A–CHECK (SECTION 4, 5)	B–CHECK (SECTION 6)	FIRST 1500 HRS. CHECK	C–CHECK (SECTION 7)	D–CHECK (SECTION 8)	1500 HRS. AFTER EVERY 'D' CHECK
☐ Daily / weekly **Lubrication** ☐ Check Engine Oil Level **Fuel System** ☐ Drain Sediments from Fuel Tanks **Air System** ☐ Clean Pre-Cleaner Dust Pan Weekly ☐ Check Air Cleaner Restriction Clean / Change Air Cleaner Element if required **Cooling System** ☐ Check Coolant Level **Other Maintenance** ☐ Drain Air Tank ☐ Check & Correct Leaks ☐ Drain Fuel Filter/ Water Separator Daily ☐ Check oil level of marine gear & Raw Wtr pump ☐ Check belts, adjust if required	☐ Repeat "A" **Lubrication** ☐ Change Engine Oil ☐ Change Engine Full-Flow Oil Filter ☐ Change By-Pass Filter ☐ Change Marine Gear Oil ☐ Record Oil Pressure **Fuel System** ☐ Check Aneroid Oil ☐ Check Hyd. Gov. Oil ☐ Check Throttle Linkage ☐ Lubricate ball joints of the throttle linkage of Hyd. governor. ☐ Change Fuel Filter ☐ Clean Fuel Tank Breather **Air System** [2] ☐ Clean / Change Crankcase Breather ☐ Check Air Piping **Cooling System** ☐ [1] Check coolant inhibitor. Add coolant concentrate, if required. ☐ Check Heat exchanger Zinc plugs	ALL STEPS OF C-CHECK AND ADDITIONAL STEPS ☐ Adjust Injectors and Valves ☐ Replace rocker cover gaskets	☐ Repeat "A" and "B" **Lubrication** (None) **Fuel System** ☐ Change Hyd. Gov. Oil ☐ Change Aneroid Oil ☐ Check Aneroid Adjustment ☐ Replace Aneroid Breather. ☐ Clean Fuel Tank from inside. **Cooling System** ☐ Clean Radiator / Charge Air Cooler externally ☐ Check Fan Hub / idler and Water Pump / idler **Other Maintenance** ☐ Inspect following parts & replace as required. (Alternator/ Starter, etc.) ☐ Check air Cleaner Evacuator valve. Change if required.	☐ Repeat "A, B and C" **Lubrication** (None) **Fuel System** ☐ Clean and Calibrate Injectors if required. ☐ Replace rocker cover gaskets ☐ Replace Fuel Pump Filter Screen and Magnet ☐ Check Fuel Pump Calibration ☐ Replace Anaroid Belows & Calibrate **Air System** ☐ Clean Turbocharger Compressor Wheel and Diffuser if required ☐ Check Turbocharger Bearing Clearance ☐ Tighten Manifold Nuts or Capscrews **Cooling System** ☐ Change coolant ☐ Descale cooling system **Other Maintenance** ☐ Check Vibration Damper ☐ Check Air Compressor ☐ Check Safety Controls	ALL STEPS OF C-CHECK AND ADDITIONAL STEPS ☐ Adjust Injectors and Valves ☐ Replace rocker cover gaskets
Engine Series **Interval**	**B**		**C**	**D**	
All (except NT/NTC-495-G) Hours **Calendar**	**Every 300 hours** **Every 6 months**	**To be done at first 1500 hours only**	**Every 1500 hours** **Every 1 year**	**Every 6000 hours** **Every 2 years**	**To be done at 1500 hours after every D Check**
NT-495-G NTC-495-G Hours **Calendar**	**Every 500 hours** **Every 6 months**	**To be done at first 1500 hours only**	**Every 1500 hours** **Every 1 year**	**Every 6000 hours** **Every 2 years**	**To be done at 1500 hours after every D Check**

1. Any time cooling system is completely drained and/or flushed, check coolant using coolant checking kit. Refer "Check Engine Coolant" details on Page 11.5 & 11.7.
2. Under extremely dusty condition perform at more frequent intervals.

Maintenance Schedule

CUMMINS DIESEL ENGINES

FOR INDUSTRIAL FIRE PUMP ENGINES ONLY

EQUIPMENT SR. NO. **ENGINE SERIAL NO.** _____

A–CHECK (SECTION 4, 5)	**B–CHECK** (SECTION 6)	**FIRST 1500 HRS. CHECK**	**C–CHECK** (SECTION 7)	**D–CHECK** (SECTION 8)	**1500 HRS. AFTER EVERY 'D' CHECK**
☐ Daily **Lubrication** ☐ Check Engine Oil Level **Fuel System** ☐ Drain Sediment from Fuel Tanks ☐ Drain Water from the Water Separator ☐ Check Fuel Supply **Air System** ☐ Check Air Cleaner **Cooling System** ☐ Check Coolant Level **Other Maintenance** ☐ Check leaks and Correct ☐ Check Engine Lubricating Oil and Water Heater ☐ Check Raw Water Strainer ☐ Check Starting Batteries ☐ Check belts, adjust if required	☐ Repeat "A" **Lubrication** ☐ Change Engine Oil ☐ Change Engine Full-Flow Oil Filter ☐ Record Oil Pressure **Fuel System** ☐ Check Throttle Linkage ☐ Clean Fuel Tank Breather ☐ Change Fuel Filters **Air System** ☐ Clean / Change Crankcase Breather ☐ Check Air Cleaner Restriction **Cooling System** ☐ Change Water Filter/Water Softner[2] ☐ Check coolant inhibitor. Add coolant concentrate, if required. ☐ Record Water Temp. ☐ Record RPM	ALL STEPS OF C-CHECK AND ADDITIONAL STEPS ☐ Adjust Injectors and Valves ☐ Replace rocker cover gaskets	☐ Repeat "A" and "B" **Cooling System** ☐ Check Heat Exchanger Core ☐ Check Water Pump **Fuel System** ☐ Clean Fuel Tank from inside. **Other Maintenance** ☐ Inspect following items and replace as reqd. (Alternator/ Starter, etc.) ☐ Check air Cleaner Evacuator valve. Change if required.	☐ Repeat "A, B and C" **Fuel System** ☐ Clean and Calibrate injectors if required. ☐ Replace rocker cover gaskets ☐ Replace Fuel Pump Filter Screen and Magnet **Air System** ☐ Tighten Manifold Nuts or Capscrews ☐ Check Turbocharger Comprssor and Turbine wheel. ☐ Check Turbocharger bearing clearance. **Other Maintenance** ☐ Steam Clean Engine ☐ Tighten Mounting Bolts and Nuts (As Required) ☐ Check Crankshaft End Clearance ☐ Check Vibration Damper Check Air Compressor ☐ Check Safety Controls	ALL STEPS OF C-CHECK AND ADDITIONAL STEPS ☐ Adjust Injectors and Valves ☐ Replace rocker cover gaskets
Engine Series **Interval** **All** **Hours Calendar**	**B** **Every 300 hours Every 6 months**	**To be done at first 1500 hours only**	**C** **Every 1500 hours Every 1 year**	**D** **Every 6000 hours Every 2 years**	**To be done at 1500 hours after every D Check**

Notes : 1. Perform checks on operating basis of interval that occurs first.
2. Any time cooling system is completely drained and/or flushed, check coolant using coolant checking kit.
3. It is suggested to operate the engine at operating temperatures once in a week.

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 - Cummutator end

GENERAL INSTRUCTIONS :

Ensure the panel switch is not stickly.
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	VOLTAGHE	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.

SAMPLE FOR REFERENCE ONLY

Maintenance due after_____Hrs._____Carried out detail.

SCHEDULED MAINTENANCE

Schedule 1, Schedule ll

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 3.6)

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 ll is used with continuous duty applications. (Refer page 3.7)

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

Engine Systems	Schedule I		Checks A Daily	A Weekly	A Monthly	B 6 Mos./ 300* Hrs	B 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				●	●
Switchgear	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			●	●	●

* For NT/NTC-495-G/N-4.8-G engines the oil change period is 500 hours.

Continuous Duty Generator Set Maintenance

Engine Systems		Schedule II	Daily	6 Mos./ 300* Hrs.	1 Year/ 1500 Hrs.	2 Years/ 6000 Hrs.	Annual
		Checks	**A**	**B**	**C**	**D**	
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					●

* For NT/NTC-495-G/N-8 engines the oil change period is 500 hours.

"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. 4-1. 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. 4-1. Checking engine oil level

2. If necessary, add oil of the same quality and brand as already in the engine. See Section 11.

Check Belts

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

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

Inline 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. 4-2. Checking belt tension with ST-1138

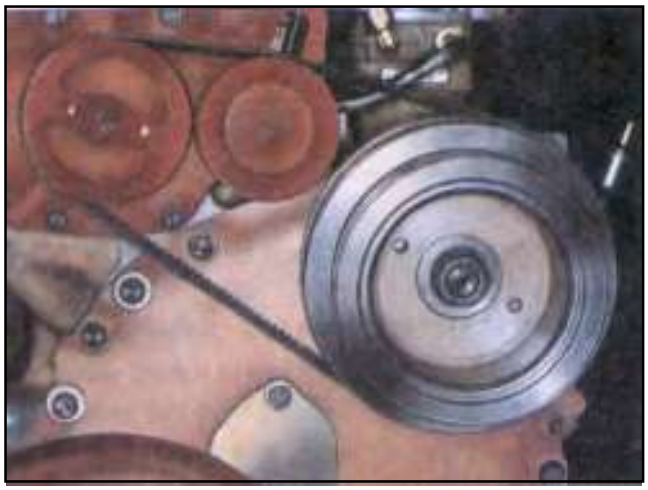


Fig. 4-3. Water pump — with idler on N series

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 increasirlg belt tension to final value.

Table 4-1: 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
NT-855 (Water pump with idler)			
15/32	ST-1274	130	80

* New belts must be retensioned to values listed under "New Belt Tension".

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

Inline Engine Water Pump Belts (With Idler)

1. Loosen locknut securing idler pulley to bracket or water pump. Fig. 4-3.

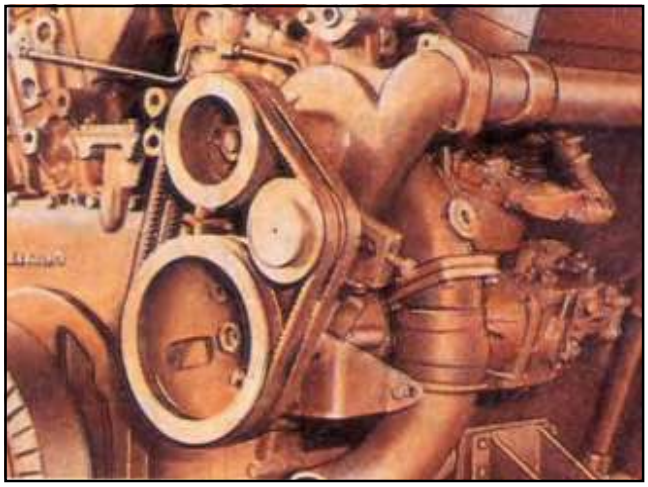


Fig. 4-4. Water pump with idler 28 lit. series

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 4-1.

Note : Self tensioning idler if present on V-1710 belt driven water pumps requires no adjustment or belt tension check.

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.

Fiy 4-5. Fan hub installation NT 855 (FFC)

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 4-1 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 4-1.

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 Seperator

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 4-6. 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. 4-6. 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.

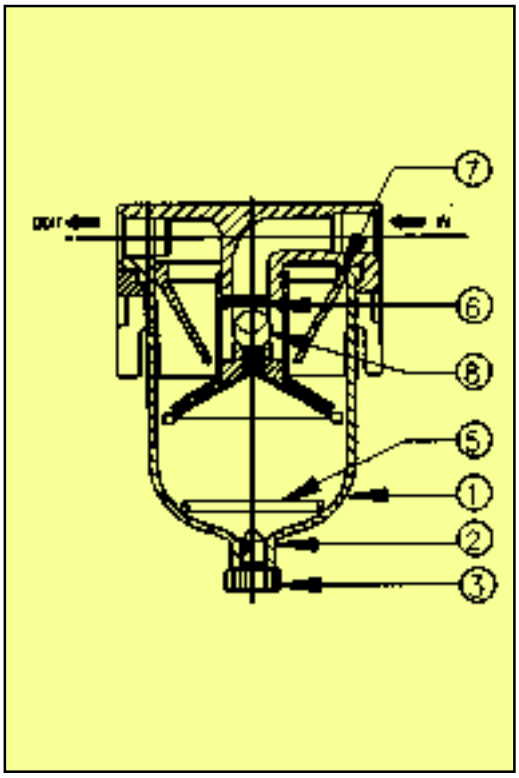


Fig. 4-6. Water seperator

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

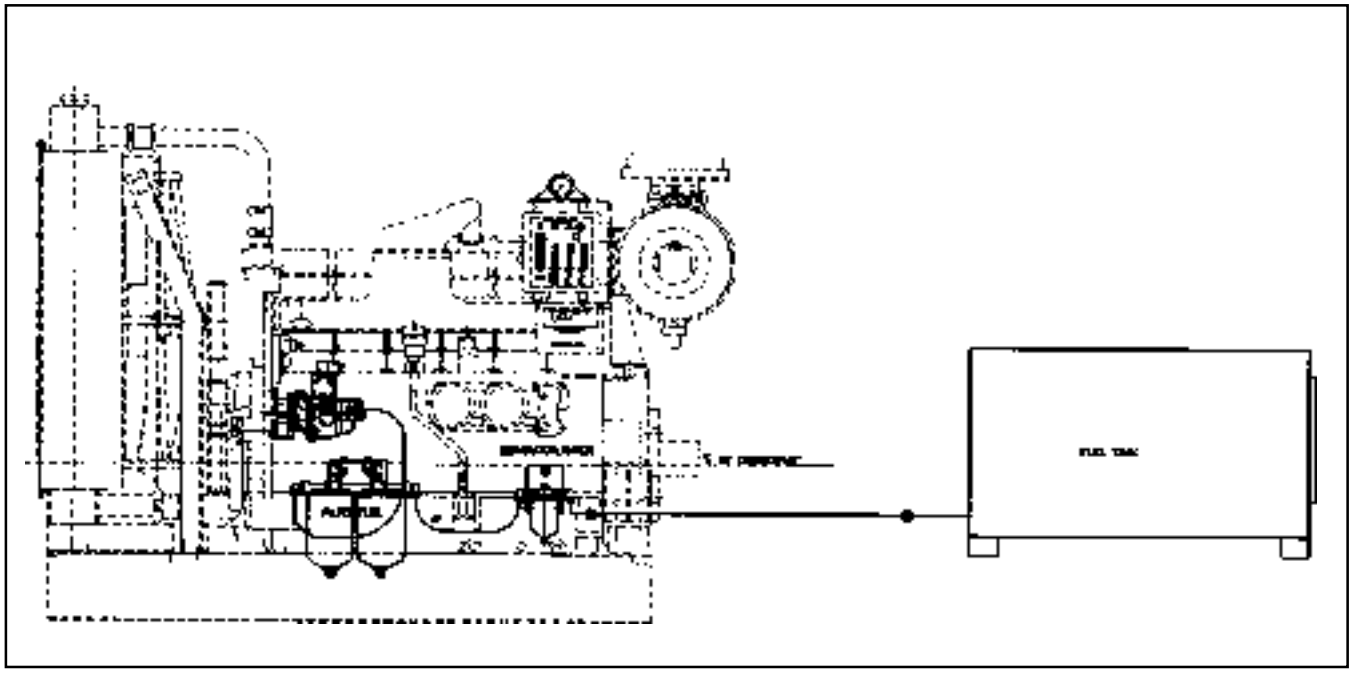
The marine gear is a separate unit and carries its own lubrication. Fill housing according to manufacturer's recommendations.

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 Layot for Water Separator & Fuel Filter on Engine

NOTES

"A" Maintenance Checks – Weekly

Check Air Cleaner

Clean Pre-Cleaner and Dust Pan

Under extremely dirty conditions an air precleaner 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 drytype air cleaner. This unit can be mounted in air cleaner outlet or on vehicle instrument panel. The red flag (1, Fig. 5-1) in window gradually rises as cartridge loads with dirt. After changing or replacing cartridge, reset indicator by pushing reset button (2).

Fig. 5-1. Air inlet restriction indicator

Air restriction on turbocharged / aftercooled engins must not exced 25 inches (635 m.m.) of water column.

Air restriction for naturally aspirated engines must not exceed 20 inches (508 m.m.) 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 5.2)

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.

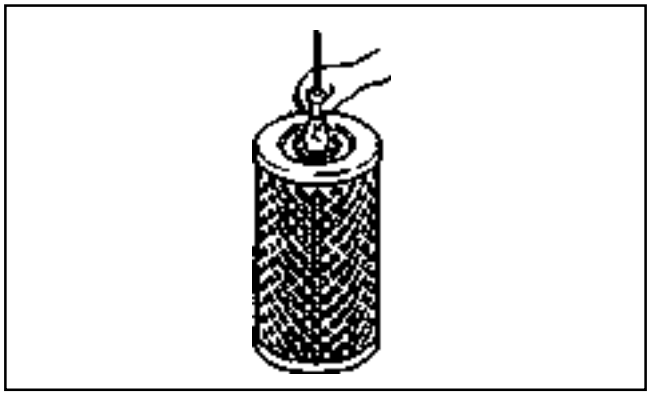


Fig. 5.2 Element checking with electric bulb

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.

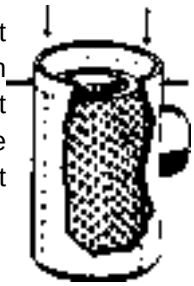
Don't use a damaged or bunched filter.

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.

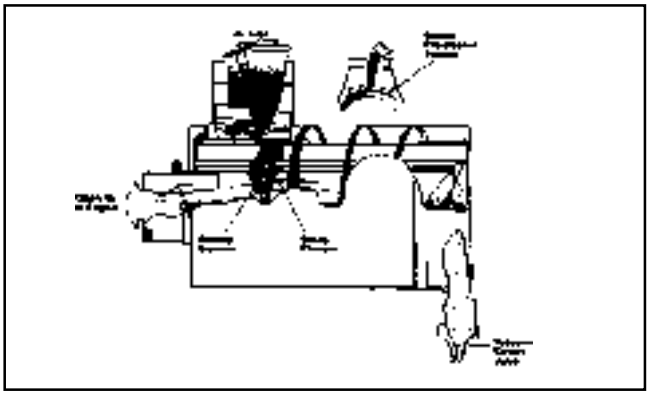


Fig. 5-3. Air cleaner (light duty)

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.

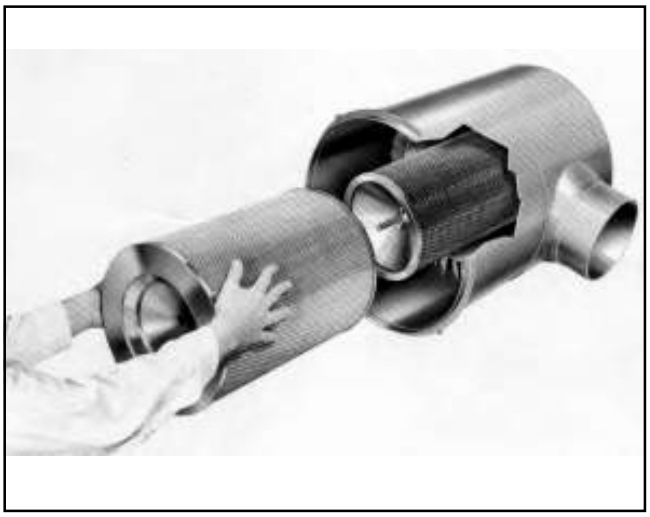


Fig 5.4. Removing elements.

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

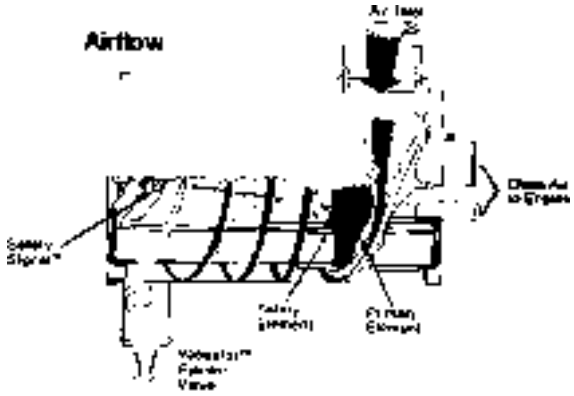


Fig. 5-5. Air cleaner (heavy duty)

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.

"B" Maintenance Checks– 600 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. The oil change period for NT/NTC-495-G and N-4.8-G engines is 500 hours of operation or every 6 months.

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 (the oil change period for NT/NTC-495-G and N-4.8-G engines is 500 hours of operation or every 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 nominculature 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 6-1 : 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. (On 495, 743, 855, 1150, 2300 and 3067 series engines, and torque to 65 to 70 ft-lbs for cast iron or sheet metal oil pans. Apply 40 to 45 torque ft/lbs for aluminium oil pans).

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 11, and genuine Cummins filters on engines.

Change Lubricating Oil Filter Elements

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

Fig. 6-1. 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 retangular 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.

On K19, V28, KV38 and KV 50 to change element lub oil, remove centre bolt, takeout element and seal “O” ring and discard them. Replace new element and “O” ring. Fill can with oil and mount element and can back to the position. Torque bolt to the 30 to 35 ft-lbs.

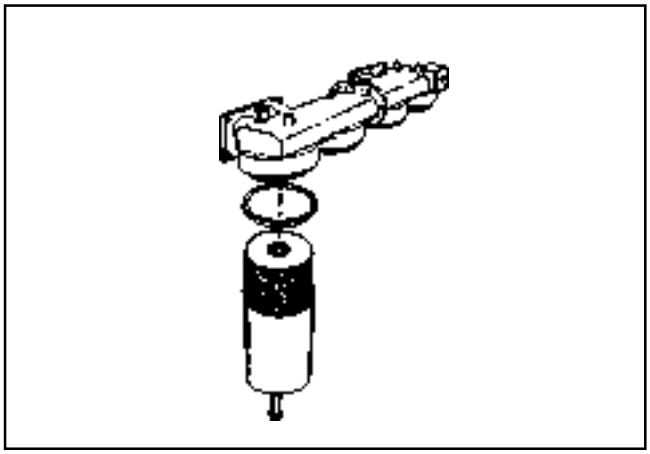


Fig. 6-2. Changing L.O. element on KV-12/KV-16 engines.

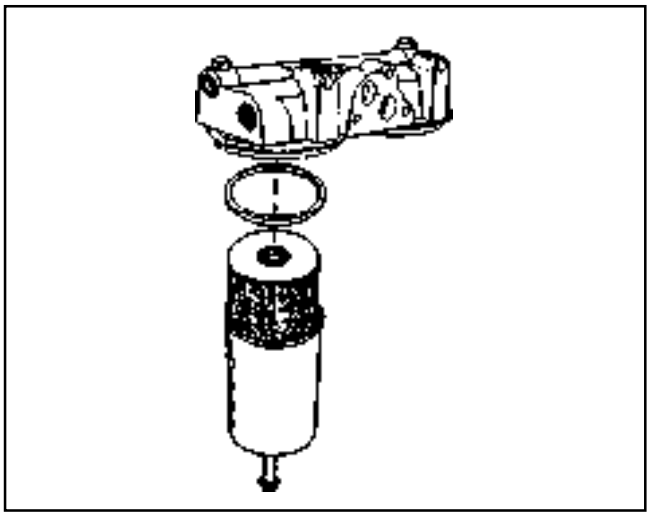


Fig. 6-3. Changing L.O. element on K6 engines.

Change Super Lub Oil By-Pass Filter Element

1. Loosen four capscrews from head and remove head super L.O. bypass filter.

Fig. 6-4. 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. 6-7), lockwasher (2) and plain washer (3).

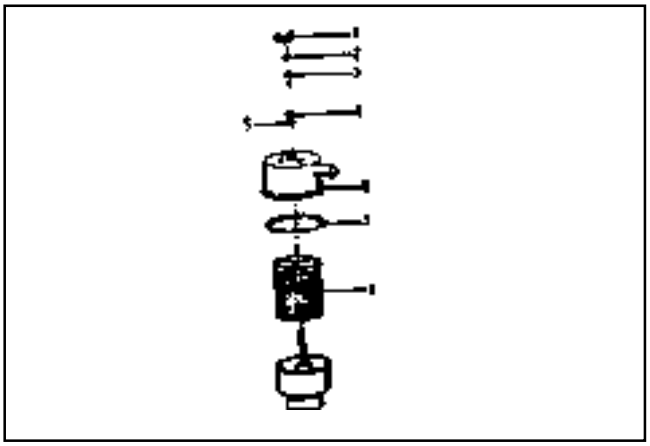


Fig. 6-5. Crankcase Breather-Element type.

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. Inslall 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 necesary.

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

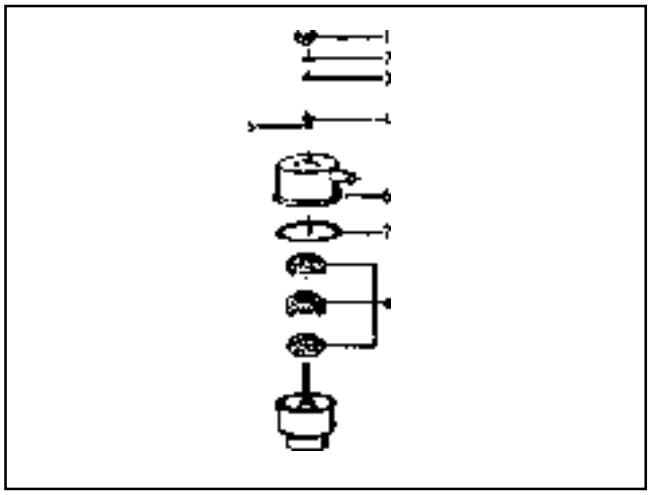


Fig. 6-6. Crankcase breather—Baffel type

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 11 for coolant checking details.

2. Check Heat Exchanger Zinc Plugs

Check zinc plugs in heat exchanger and change if badly erroded. 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).

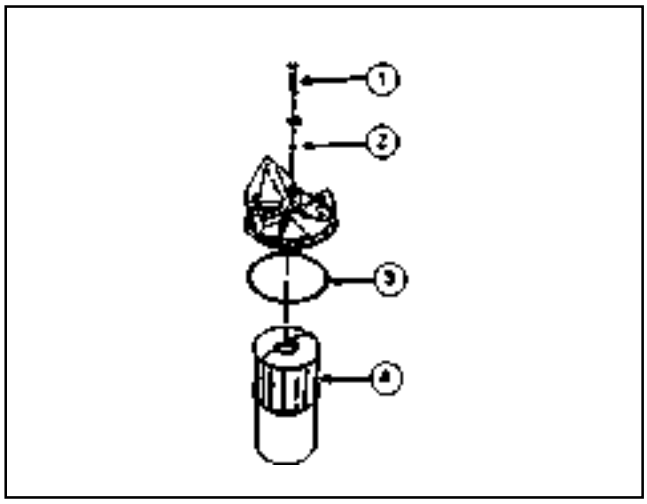


Fig. 6-7. Changing fuel filter element.

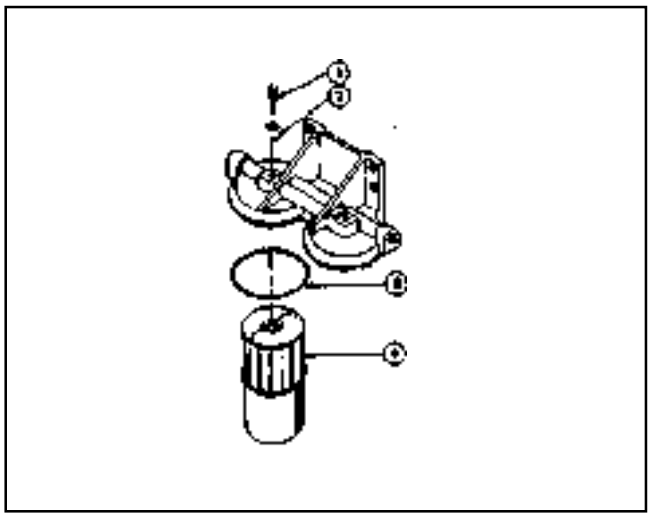


Fig. 6-8. Changing duel elements.

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

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 140°F (60°C) 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)

1. Bar engine until “A” or 1-4 VS mark on pulley is aligned with pointer on gear case cover. In this position, both valve rocker levers for cylinder No. 2 must be free (valves closed). Injector plunger for cylinder No. 2 must be at top of travel; if not, bar engine through 360 deg., realign marks with the pointer.

Note : Before checking or setting valves, be sure crossheads are adjusted (Refer crosshead adjustment procedure under V-1710 CID engines) and determine if rocker housings are made of cast iron or aluminium. See Table 7-2.

2. Set up ST-1170 indicator support with indicator extension or injector plunger top at No. 2 cylinder. Make sure indicator extension is not against rocker lever.

3. Using ST-1193 rocker lever actuator; or equivalent, bar lever toward injector until plunger is bottomed to squeeze oil film from cup. Allow injector plunger to rise, bottom again, set indicator at zero (0). Check extension contact with plunger top.

4. Bottom plunger again, release lever; indicator must show travel as indicated in Table 7-2 (use proper value depending if adjustment or recheck). Adjust as necessary.

5. If loosened, tighten locknut to 30 to 40 ft-lb (41 to 61 N•m) and actuate injector plunger several times as a check of adjustment. Tighten 25 to 35 ft-lb (34 to 41 N•m) when using ST-669 adapter.

6. Adjust valves on cylinder No. 2 to values in Table 7-2. Torque locknuts to same value as Injectors. Move to next cylinder as indicated in Table 7-1 and repeat adjustment.

7. Discard old rocker cover gaskets and use new gaskets. Mount rocker covers and tighten capscraws to 16 to 23 N•M (12 to 17 ft-lb)

Table 7-1: Injector and valve set position N-495

Bar in Direction	Pulley Position	Set Cylinder Injector	Valve
START	A OR 1-4VS	2	2
ADV. TO	B OR 2-3VS	4	4
ADV. TO	A OR 1-4VS	3	3
ADV. TO	B OR 2-3VS	1	1

Table 7-2 : Uniform plunger travel adjustment limits

TEMP. Setting	Injector plunger travel inch (mm)		Valve clearance inch (mm)	
	Adj. Value	Recheck Limit	Intake	Exhaust
Aluminium rocker housing				
Cold	0.170 (4.32)	0.169 to 0.171 (4.29 to 4.34)	0.011 (0.28)	0.023 (0.58)
Cast iron rocker housing				
Cold	0.175 (4.45)	0.174 to 0.176 (4.42 to 4.47)	0.013 (0.33)	0.025 (0.63)

Note : All travel and clearance values are with locknuts properly torqued. Adjustment and/or recheck must be performed only at stabilized "Cold Set" temperature conditions. Do not perform adjustment or recheck when engine is warming-up or cooling-down.

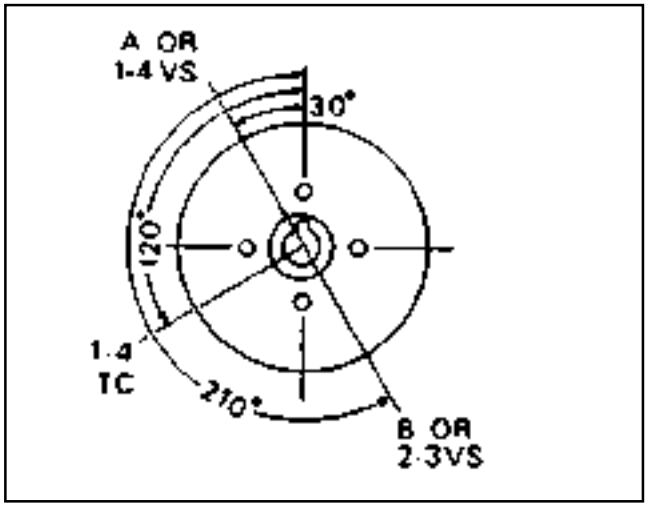


Fig. 7-1. N-495/NT-495 Engine Accessory drive pulley markings

Torque Method: NH/NT-495

Bar in Direction	Pulley Position	Set Cylinder Injector	Set Cylinder Valve
START	A OR 1-4VS	1	1
ADV. TO	B OR 2-3VS	2	2
ADV. TO	A OR 1-4VS	4	4
ADV. TO	B OR 2-3VS	3	3

INJECTOR ADJUSTMENT : (Torque Method)
COLD SET

Aluminium Rocker Housing :
72 Inch Lbs.
(8.1) N.m.

Cast Iron Rocker Housing :
48 Inch Lbs.
(5.4 N.m.)

VALVE CLEARANCE - Inch (mm)

Inntake Valves	Exhaust Valves
Cold Set	Cold Set
Aluminium Rocker Housing :	
0.014 (0.36)	0.027 (0.69)
Cast Iron Rocker Housing :	
0.016 (0.41)	0.029 (0.74)

NH-743, N-855, C.L.D. ENGINES, INJECTOR AND VALVE ADJUSTMENT (DIAL INDICATOR METHOD)

Note : Before adjusting the injectors and valves be sure crossheads are adjusted (Refer crosshead adjustment procedure under V-1710 CID engines) and determine if the rocker housings are made of cast iron or aluminium and use the appropriate setting.

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. 7-2, 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.

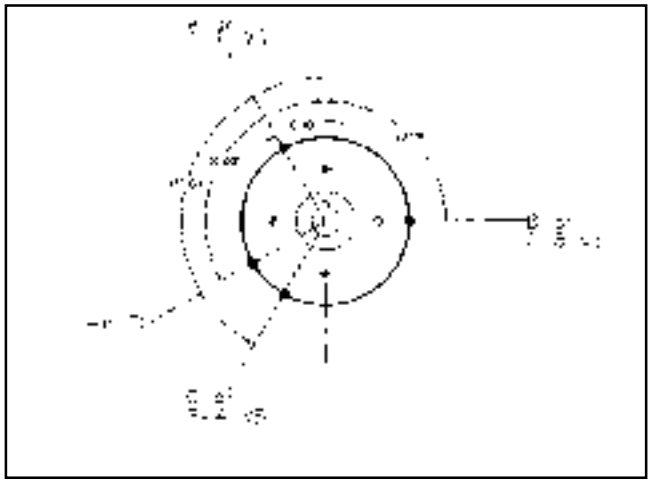


Fig 7-2. Accessory drive pulley marking—N-855/N-743

2. Set up ST-1170 Indicator Support with the indicator extension on the injector plunger top at No. 3 cylinder, Fig. 7-3. 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 7-3.

Fig. 7-3. Extension in contact with plunger

Table 7-3 : Injector and Valve Set Position N-855 and N-743 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. 7-4, 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. 7-4. Actuating rocker lever

4. Bottom the plunger again, release the lever; the indicator must show travel as indicated in Table 7-4. 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 7-4. Torque locknuts to same value as injectors. Move to next cylinder as indicated in Table 7-3 and repeat adjustment.
7. Discard old rocker cover gaskets and use new gaskts. Mount rocker covers and tighten capscrews to 16 to 23 N•m (12 to 17 ft-lb).

Table 7-4 : Adjustment Limits Using Dial Indicator Method Inch (mm), for N-855 and N-743 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.

ADJUST INJECTORS AND VALVES (TORQUE METHOD) V/VT/VTA-1710 CID ENGINES

Timing Mark Alignment

1. If used, pull the compression release lever back and block in the open position only while barring the engine.

2. Loosen the injector rocker lever adjusting nut on all cylinders. This will aid in distinguishing between cylinders adjusted and not adjusted.

Note : Before adjusting the injectors and valves be sure to determine if the rocker housings are made of cast iron or aluminium and use the appropriate setting.

3. Bar the engine in the direction of rotation until a valve set mark (Fig's. 7-5, 7-6 and 7-7) aligns with the mark or pointer on the gear case cover. Example : A or 1-6 "VS" on Inline Engines or 1-6R "VS" on V-1710 Engines.

Fig. 7-5. Valve set mark V-1710

Fig 7-6. Valve set mark — N-855

4. Check the valve rocker levers on the two cylinders aligned as indicated on the pulley. On one cylinder of the pair, both rocker levers will be free and the valves closed; this is the cylinder to be adjusted.

5. Adjust the Injector plunger first then the cross heads and valves to the clearances indicated in the following paragraphs.

6. For the firing order see Table 7-5 for Inline Engines and Table 7-6 and Fig. 7-7 for V-1710 Engines.

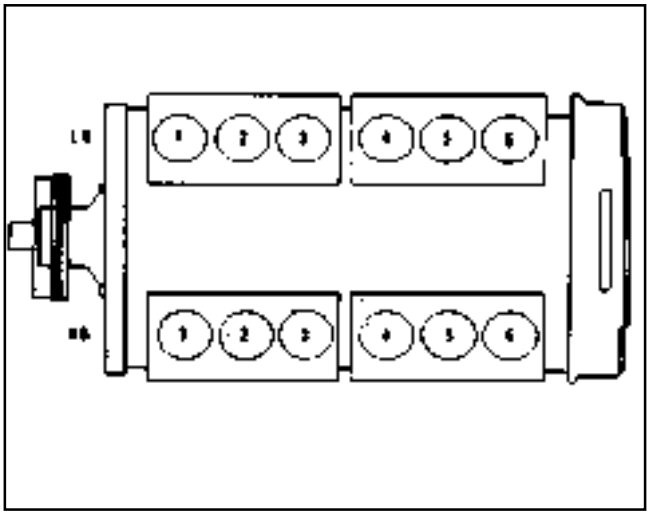


Fig. 7-7. V-1710 Piston position

Table 7-5 : Engine Firing Order for N-855 Engines

Right Hand Rotation	Left Hand Rotation
1-5-3-6-2-4	1-4-2-6-3-5

Table 7-6 : Firing Order for V-1710 Engines

Right Hand -

1L-6R-2L-5R-4L-3R-6L-1R-5L-2R-3L-4R

Left Hand -

1L-4R-3L-2R-5L-lR-6L-3R-4L-5R-2L-6R

7. Continue to bar the engine to the next "VS" mark and adjust each cylinder in the firing order.

Note : Only one cylinder is aligned at each mark. Two complete revolutions of the crankshaft are required to adjust all cylinders.

Injector Plunger Adjustment

The injector plungers must be adjusted with an inch-pound torque wrench to a definite torque setting. Snap-On Model TE-12 or torque wrench and a screwdriver adapter can be used for this adjustment. See Fig. 7-8.

Table 7-7 : Injector Plunger Adjustment — Inch-lbs (N•m)

Cold Set
V-1710 Engines
70 (8)

1. Turn the adjusting screw down until the plunger contacts the cup and advance an additional 15 degrees to squeeze the oil trom the cup.

Fig. 7-8. Adjusting injector plunger—V-1710

Note : Number one L and one R cylinders on V-1710 Engines are at the gear case of the engine.

2. Loosen the adjusting screw one turn; then using a torque wrench calibrated in inch-pounds and a screwdriver adapter tighten the adjusting screw to the value shown in Table 7-7 and tighten the locknut to 40 to 45 ft-lbs (54 to 61 N•m) torque. If ST-669 Torque Wrench Adapter is used, torque to 30 to 35 ft-lbs (41 to 47 N•m).

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

1. Loosen the valve crosshead adjusting screw locknut and back off the screw (4. Fig 7-9) one turn.

2. Use light finger pressure at the rocker lever contact surface (1) to hold the crosshead in contact with the valve stem (2).

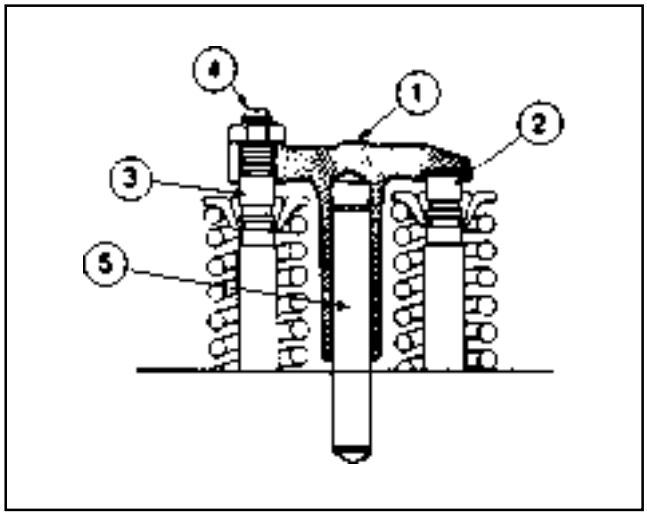


Fig. 7-9. Valve crosshead

3. Turn down the crosshead adjusting screw until it touches the valve stern (3).

4. Using ST-669 Torque Wrench Adapter, tighten the locknut to 22 to 26 ft-lbs (30 to 35 N•m). If ST-669 is not available, hold the screws with a screwdriver and tighten the locknuts to 25 to 30 ft lbs (34 to 41 N•m).

5 Check tne clearance between the crosshead and the valve spring retainer with a wire gauge. There must be a minimum of 0.020 Inch (0.51 mm) clearance at this point.

Valve Adjustment

The same engine position used in adjusting the injectors is used for setting the intake and exhaust valves.

1. While adjusting the valves, make sure that the compression release on those engines so equipped, is in the running position.
2. Loosen the locknut and back off the adjusting screw. Insert a feeler gauge between the rocker lever and crosshead. Turn the screw down until the lever just touches the gauge and lock the adjusting screw in this position with the locknut. Tighten the locknut to 40 to 45 ft-lbs (54 to 61 N•m). torque. When using ST-669 torque to 30 to 35 ft-lbs (41 to 47 N•m).
3. Always make final valve adjustment at stabilized engine lubricating oil temperature. See Table 7-8 for the appropriate valve clearances.
4. Discard old rocker cover gaskets and use new gaskets. Mount rocker covers and tighten capscrews to 45 N•m (35 ft-lb).

Table 7-8 : Valve Clearances — Inch (mm)

Intake Valves Cold Set	Exhaust Valves Cold Set
V-1710 Engines	
0.014 (0.36)	0.027 (0.69)

INJECTOR AND VALVE ADJUSTMENT USING 3375004 DIAL INDICATOR KIT FOR KT/KTA 1150 ENGINES

This method involves adjusting the injector plunger travel with an accurate dial indicator. A check can be made of the adjustment without disturbing the locknut or screw setting. The valves can also be checked or set while adjusting the injectors by this method. See Table 7-9.

3375004 Injector Adjustment Kit is used to adjust the injectors with or without Jacobs Brake units installed.

Table 7-9 : Injector and Valve Set Position for KT/ KTA 1150 Engines.

Bar in Direction	Pulley Position	Set Cylinder Injector	Valve
Start	A	3	5
Adv. To	B	6	3
Adv. To	C	2	6
Adv To	A	4	2
Adv. To	B	1	4
Adv To	C	5	1
Firing Order 1-5-3-6-2-4			

It is essential that 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.

Operating adjustments must be made using the correct values as stated.

Injector and Valve Adjustment

Note : Do not use the fan to rotate the engine. Remove the shaft retainer clip. Fig. 7-9, and press the shaft inward until the barring gear engages the drive gear; then advance. After the adjustments are complete, retract the shaft and install the retainer clip into the safety lock groove.

Fig. 7-9. Engine barring arrangement — KV Engine

Caution : The barring mechanism gear must be completely engaged when barring the engine to avoid damage to the teeth of the gear.

1. Bar the engine in the direction of rotation until “B” mark on the pulley, Fig. 7-10, is aligned with pointer on the gear case cover. In this position, both valve rocker levers for cylinder No. 3 must be free (valves closed). The injector plunger for cylinder No. 6 must be at the top of travel; if not, bar the engine through 360 degrees, realign the marks with the pointer.

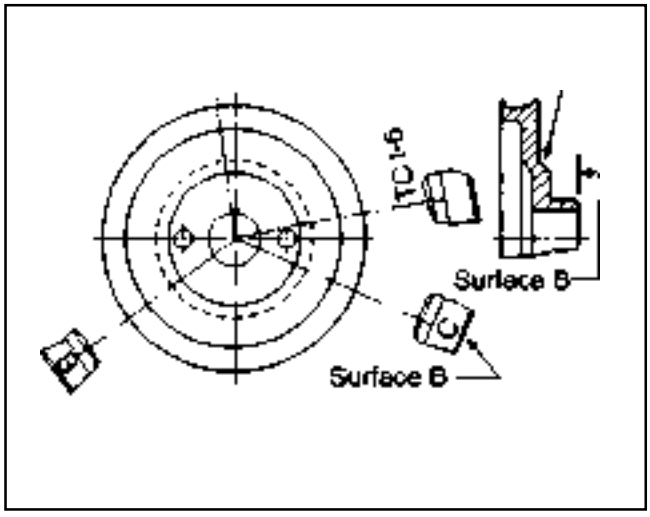


Fig 7-10. Accessory drive pulley marking KT/KTA 1150

Note : The injector and valves on any one (1) cylinder can not be set at the same valve set position. Example: If the rocker levers on No. 3 cylinder are free (valves closed) the injector plunger travel on No. 6 cylinder is a starting point. See Table 7-9.

2. Install 3375004 Dial Indicator Assembly to the rocker housing, (3375005) extension must contact the injector plunger top, Fig. 7-11.

3. Screw the injector lever adjusting screw down until the plunger is bottomed in the cup, back off approximately 1/2 turn then bottom again, set the dial indicator at zero (0).

Note : Care must be taken to assure the injector plunger is correctly bottomed in the cup, without overtightening the adjusting screw, before setting the dial indicator.

4. Back the adjusting screw out until a reading of 0.304 inch (7.72 mm), reference Table 7-10, is obtained on the dial indicator. Snug tighten the locknut.

Fig. 7-11. Dial indicator in place — extension in contact with plunger

5. Using 3375009 Rocker Lever Actuator Assembly and (3375007) Support Plate, bottom the injector plunger, check the zero (O) setting. Fig. 7-11. Allow the plunger to rise slowly; the indicator must show the plunger travel to be within the range indicated in Table 7-10.

Table 7-10 : Adjustment Limits Using Dial Indicator Method Inch (mm) KT/KTA 1150 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
0.304 ± 0.001 (7.72 ± 0.03)	0.014 (0.36)	0.027 (0.69)

Fig. 7-12. Actuating rocker lever

6. Using ST-669 Torque Wrench Adapter to hold the adrusting screw in position, torque the locknut to 30 to 35 ft-lbs (41 to 47 N•m). If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver, torque the locknuts to 40 to 45 ft-lbs (54 to 61 N•m).

7. Actuate the injector plunger several times as a check of the adjustment. Remove the dial indicator assembly.

Caution: Be sure the crossheads are adjusted before setting the valves. See Crosshead Adjustment following.

Valve Adjustment

1. Insert the correct thickness feeler gauge between the rocker lever and the crosshead for the valves being adjusted. See Table 7-10 for valve clearance.

2. If adjustment is required, loosen the locknut and turn the adjusting screw down until the rocker

Fig. 7-13. Adjusting crosshead clearance

lever just touches the feeler gauge; lock the adjusting screw in this position with the locknut.

3. Tighten the locknut to 40 to 45 ft-lb (54 to 61 N•m) torque. When using ST-669 Torque Wrench Adapter tighten the locknuts to 30 to 35 ft-lb (41 to 47 N•m) torque.
4. Repeat the adjustment procedure for each cylinder. See Table 7-9 for firing order and injector and valve set positions.
5. Discard old rocker cover gaskets and use new gaskets. Mount rocker covers and tighten capscrews to 40 N•m (30 ft-lb).

Crosshead Adjustment

Crossheads are used to operate two valves with one rocker lever. The crosshead adjustment is provided to assure equal operation of each pair of valves and prevent strain from misalignment.

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

1. Loosen the valve crosshead adjusting screw locknut and back off the screw (4, Fig. 7-14) one turn.

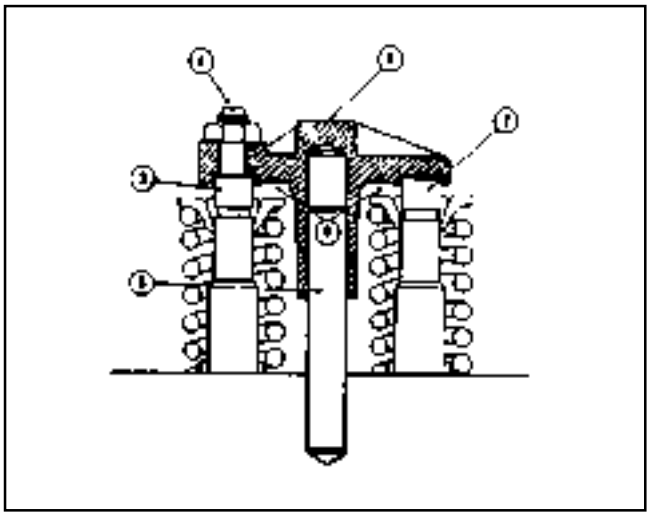


Fig. 7-14. Valve Crosshead

2. Use light finger pressure at the rocker lever contact surface (1) to hold the crosshead in contact with the valve stem (2) The adjusting screw should not touch the valve stem (3) at this point
3. Turn down the crosshead adjusting screw until it touches the valve stem (3).
4. Using ST-669 Torque Wrench Adapter, tighten the locknuts to 22 to 26 ft-lbs (30 to 35 N-m). If ST-669 is not available, hold the screws with a screwdriver and tighten the locknuts to 25 to 30 ft-lbs (34 to 41 N.m).
5. Check the clearance (6) between the crosshead and valve spring retainer with a wire gauge. There must be a minimum of 0.025 inch (0.64 mm) clearance at this point.

INJECTOR AND VALVE ADJUSTING USING 3375004 DIAL INDICATOR KIT (KT/KTA 2300 AND KTA : 3067 ENGINES)

Valve Set Mark Alignment

Note: KT/KTA 2300 and KTA 3067 injectors, crossheads and valves are adjusted to the same values. Refer to Fig's. 7-15 and 7-16 for specific cylinder arrangement and engine firing order.

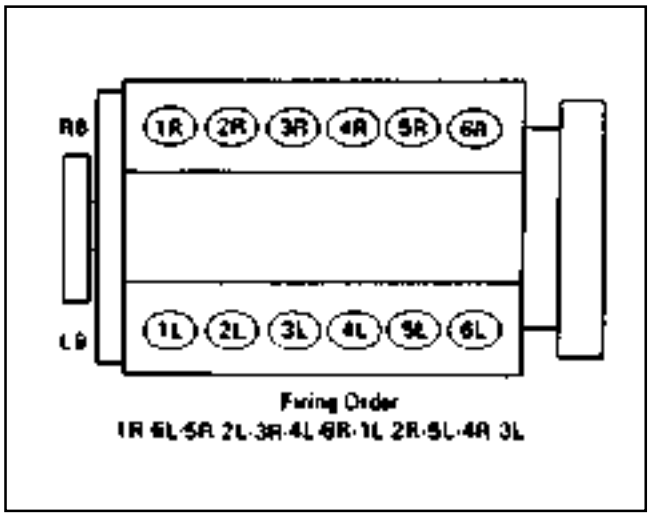


Fig. 7-15. Cylinder arrangement and firing order — KT/KTA 2300

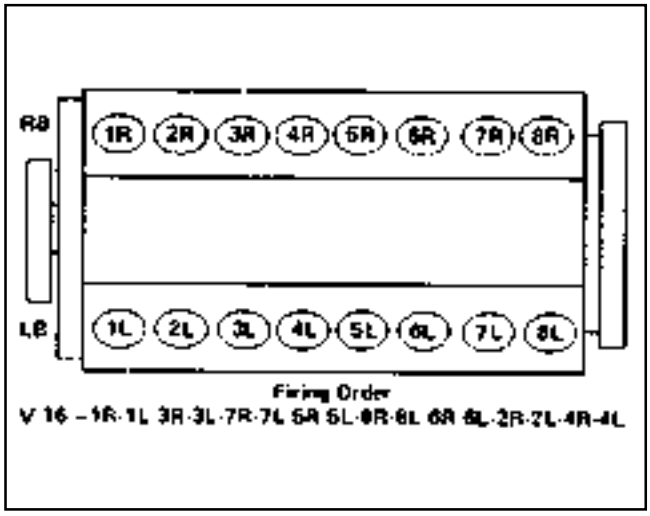


Fig. 7-16. Cylinder arrangement and firing order — KTA 3067

Three locations are provided where valve and injector alignment marks may be viewed. Injector plunger travel and valves both may be set on one cylinder at the

same valve set location. The crankshaft must be turned through two (2) complete revolutions to properly set all injector plunger travel and valves.

Note : The barring mechanism may be located on either the left bank or right bank at the flywheel housing. The cover plate on opening “A” or “C” directly above the barring rnechanism must be removed when viewing the timing marks at the flywheel housing.

1. When viewing the engine at the vibration damper, Fig. 7-17, align the timing marks on the damper with the pointer on the gear case cover.

Fig. 7-17. Valve set marks on vibratlon damper KT/KTA 2300

2. When barring the engine from the right bank at the flywheel housing “A” VS timing marks on the flywheel (1, Fig. 7-18) must align with the scribe mark (2) when viewed through the opening marked “A” on the flywheel housing.

Fig 7-18. Valve set marks on right bank flywheel and housing — KT/KTA 2300

3. When barring the engine from the left bank at the flywheel housing “C” VS timing marks on the flywheel (1, Fig. 7-19) must align with the scribe mark (2) when viewed through the opening marked “C” on the flywheel housing.

Caution: When aligning valve set marks at either flywheel housing location, care must be taken to assure that “A” or “C” valve set marks on the flywheel match “A” or “C” marks on the flywheel housing opening.

Fig. 7-19. Engine barring device.

Injector Plunger Adjustment

1. Bar the engine in the direction of rotation until the appropriate valve set mark is aligned with the scribe mark on the flywheel housing or until a valve set mark on the vibration damper is aligned with the pointer on the gear case cover

Note : Any valve set position may be used as a starting point when adjusting the injectors, crossheads and valves. Determine which of the two (2) cylinder indicated have both valves closed (rocker levers free). This cylinder is in position for injector plunger travel, crosshead and valve adjustment.

2. Set up 3375007 Support Block on the rocker lever housing, of the cylinder selected, with the 3375005 dial indicator extension on the injector plunger top. Fig. 7-20.

Note : Make sure that 3375008 Dial Indicator extension is secured in the indicator stem and is not touching the rocker lever.

3. Using the rocker lever actuator, Fig. 7-21, depress the lever toward the injector until the plunger is

Fig. 7-20. Dial medicator in place – extension in contact with plunger

Fig. 7-21. Bottoming injector plunger in cup

bottomed in the cup to squeeze the oil film from the cup. Allow the injector plunger to rise, bottom again, hold in the bottom position and set the indicator zero (0). Check the extension contact with the plunger top.

4. Allow the plunger to rise then bottom the plunger again, release the lever, the indicator must show travel as indicated in Table 7-12 Adjust as necessary.

Table 7-12 : Adjustment Limits Using Dial Indicator Method Inch (mm) for KT/KTA 2300 and KTA 3067 Engines

Injector Plunger Travel	Valve Clearance Intake	Exhaust
0.308 ± 0.001 (7.82 ± 0.03)	0.014 (0.36)	0.027 (0.69)

5. If the adjusting screw locknuts were loosened for adjustment, tighten to 40 to 45 ft-lbs (54 to 61 N•m) torque and actuate the plunger several times as a check of the adjustment. Tighten the locknuts to 30 to 35 ft-lbs (41 to 47 N•m) torque when using ST-669 Torque Wrench Adapter.

6. Remove 3375004 Kit.

Crosshead Adjustment

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

Crossheads are used to operate two valves with one rocker lever, an adjusting screw is provided to assure equal operation of each pair of valves and prevent strain from misalignment. Crosshead adjustment changes as a result of valve and seat wear during engine operation.

1. Loosen the adjusting screw locknut, back off the screw (4, Fig. 7-14) one turn.

2. Use light finger pressure at the rocker lever contact surface (1) to hold the crosshead in contact with the valve stem (2). The adjusting screw should not touch the valve stem (3) at this point.

3. Turn down the adjusting screw until it touches the valve stem (3).

4. Using 3375008 Torque Wrench Extension to hold the adjusting screw in position, tighten the locknut to 22 to 26 ft-lb (30 to 35 N•m) torque. If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver, tighten the locknut to 25 to 30 ft-lb (34 to 41 N•m) torque.

5. Check the clearance (6) between the crosshead and the valve spring retainer with a gauge. There must be a minimum of 0.025 inch (0.64 mm) clearance at this point.

Valve Adjustment

1. Insert the correct thickness feeler gauge between the rocker lever and the crosshead for the valves being adjusted. See Table 7-12 for valve clearance.

Note : Exhaust valves are toward the front of the engine in each cylinder head on the LB side and are toward the rear of the engine in each cylinder head on the RB side.

2. If adjustment is required, loosen the locknut and turn the adjusting screw down until the rocker

lever just touches the feeler gauge; lock the adjusting screw in this position with the locknut.

3. Tightn the locknut to 40 to 45 ft-lb (54 to 61 N.m) torque. When using ST-669 Torque Wrench Adapter tighten the locknuts to 30 to 35 ft-lb (41 to 47 N.m) torque.

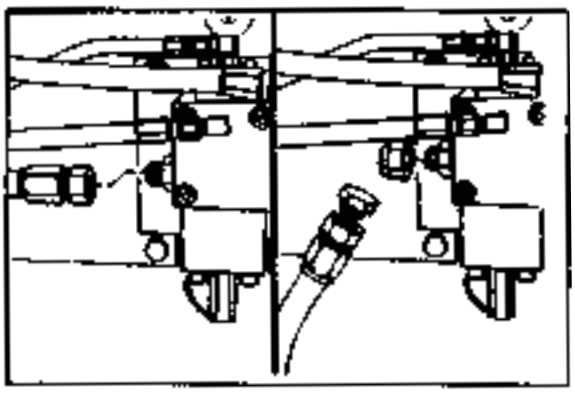
After completing the injector plunger travel, crosshead and valve adjustment on this cylinder bar the engine in the direction of rotation until the next valve set mark is aligned with the scribe mark at the flywheel housing or the pointer on the gear case cover; repeat the procedure. See Fig's. 7-15 and 7-16 for cylinder arrangement and engine firing order.

Discard old rocker cover gaskets and use new gaskets. Mount rocker covers and tighten capscrews to 40 N•m (30 ft-lb).

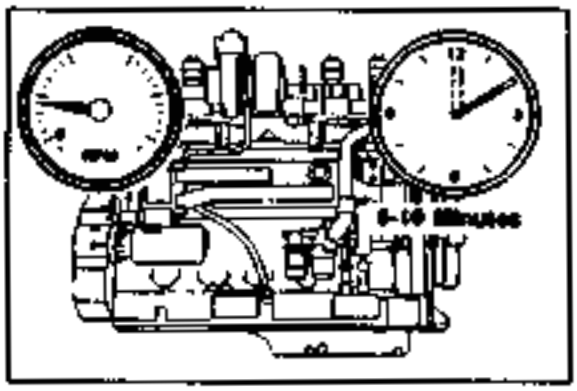
OBC Injector Set Procedure - K19 Engines (with STC injectors)

Clean the engine to avoid dust entry inside the engine.

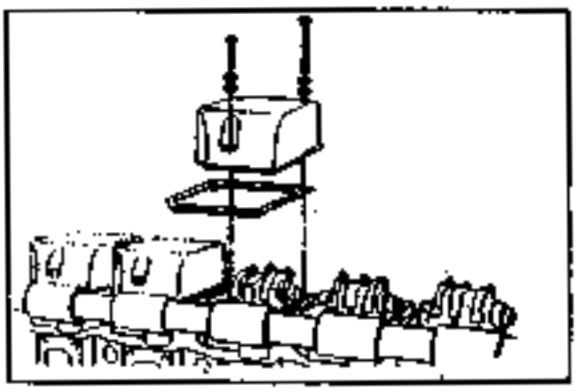
On engines with a **hydromechanical STC valve,** remove the oil supply hose from the oil control valve. Plug the hose, cap, and fitting. This prevents the engine from going into advance timing.

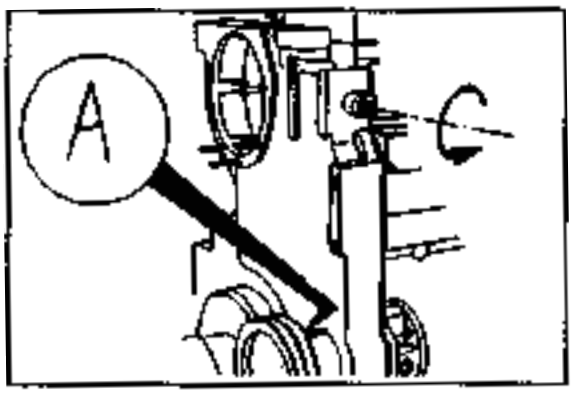


Operate the engine at high idle for 5 minutes (in normal timing mode). This will allow all of the oil to pump out of the injector tappets so a correct injector adjustment can be made.



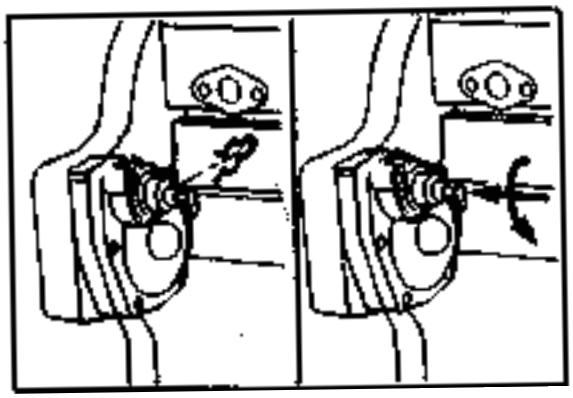
Shut the engine off. Remove the rocker lever covers and all related components.





NOTE : The barring device shaft turns approximately two revolutions before the engine begins to turn. The device will **not** turn the engine opposite the direction of normal rotation.

Push the shaft in and turn the barring device until the **A** mark on the pulley is aligned with the mark that is cast into the boss for the accessory drive seal on the front gear cover.



On engines with a two-piece front cover.

- remove the clip,
- push the shaft in to engage the gears,
- rotate the device shaft **counterclockwise** to turn the engine in the direction of normal rotation.

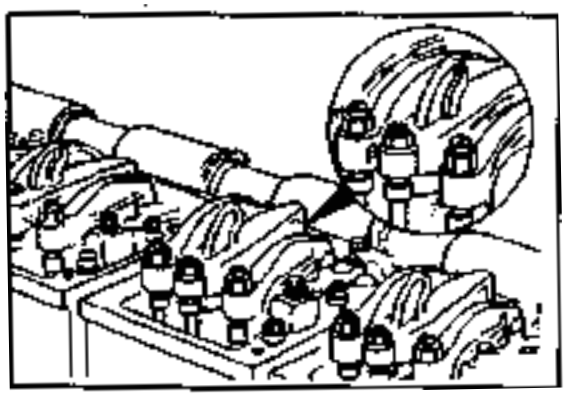
The alignment mark is also on the boss for the accessory drive seal.

K19 OBC PROCEDURE
WITH STC OR HVT VALVE AND INJECTOR ADJUSTMENT CHART

VS MARK	VALVES CLOSED ON CYLINDER NO.	ADJUST VALVES ON CYLINDER NO.	INJECTORS ON CYLINDER NO.
A	1	5	4
B	5	3	1
C	3	6	5
A	6	2	3
B	2	4	6
C	4	1	2

Determine the Cylinder in Position for Valve Set

The crossheads and valves will be adjusted on the cylinder that has all the valves closed. Use the table to determine the cylinders to check for valve position.



Wiggle the valve rocker levers on the two cylinders in question. The crossheads and valves on the cylinder where both levers feel loose are ready to adjust.

Use the chart to determine the injector that is ready to adjust.

NOTE : Adjustment can begin on any valve set mark.

In our example, assume the **A** mark is aligned and the adjusting screw height indicates that the valves on cylinder No. 6 are closed. The chart shows adjust the valves on cylinder No. 2 and the injector on cylinder No. 3.

After adjusting the crossheads, valves and injector, bar the engine to the **B** set mark. Adjust the crossheads and valves on cylinder No. 4 and adjust the injector on cylinder No. 6.

K19 OBC PROCEDURE
WITH STC OR HVT VALVE AND INJECTOR ADJUSTMENT CHART

VS MARK	VALVES CLOSED ON CYLINDER NO.	ADJUST VALVES ON CYLINDER NO.	ADJUST INJECTORS ON CYLINDER NO.
A	1	5	4
B	5	3	1
C	3	6	5
(A)	(6)	(2)	(3)
B	2	4	6
C	4	1	2

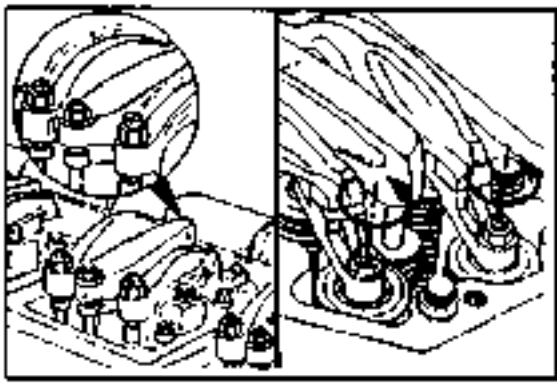
Adjust the Crossheads

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 locknuts on the intake and exhaust valve crossheads.

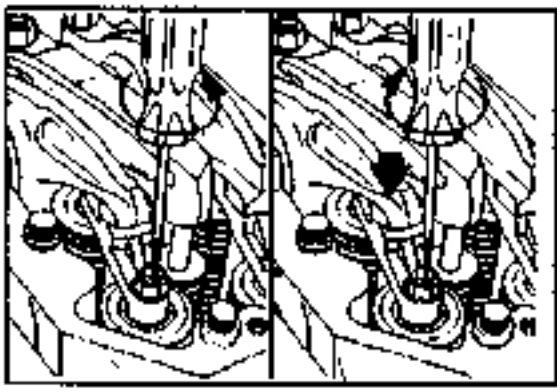


NOTE : Use the following procedure to adjust both the intake and the exhaust crossheads.

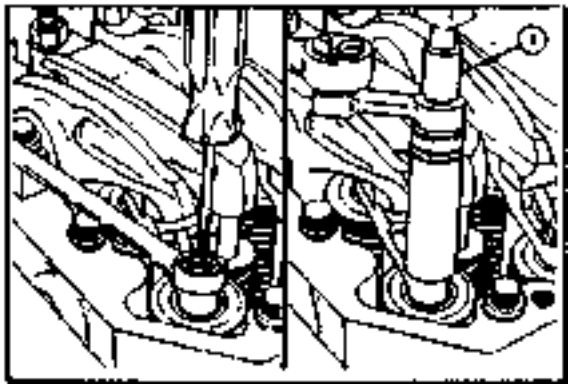
Turn the adjusting screw out at least one turn.

Hold the crosshead down against its guide.

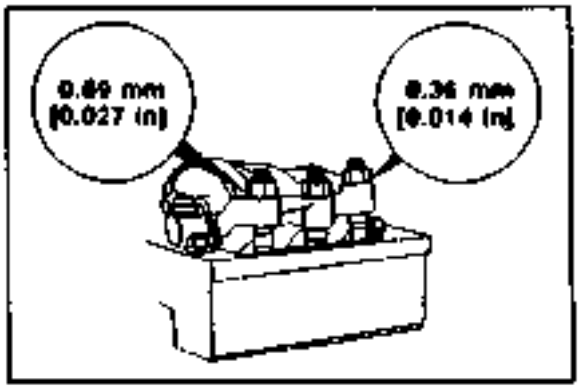
Turn the adjusting screw in until it touches the top of the valve stem but does **not** raise the crosshead.



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) :

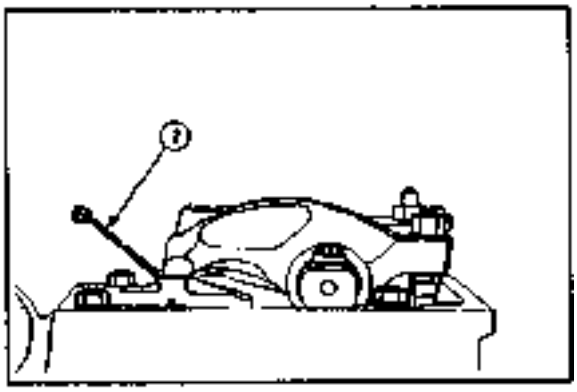


	Torque Values N•m	ft-lb
With Adapter	35	25
Less Adapter	40	30

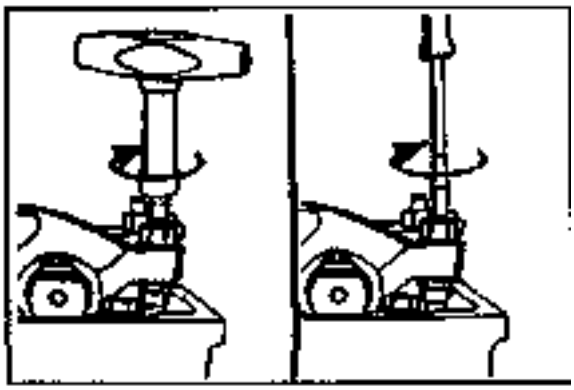


Adjust the Valves

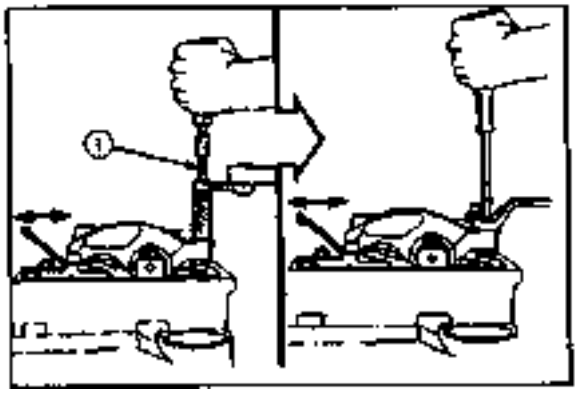
Valve Adjustment (Initial Set)		
mm		In
0.69	Exhaust	0.027
0.36	Intake	0.014



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.



NOTE : The adjusting screw **must not** turn when the lock nut is tightened.

Tighten the locknut to the value indicated below.

With Toruqe Wrench Adapter, Part No. ST-669 (1) — 45 N•m [35 ft-lb]

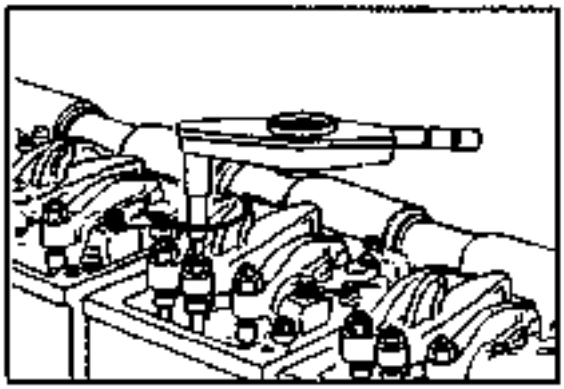
Without Adapter — 60 N•m [45 ft-lb]

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 inch] 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.

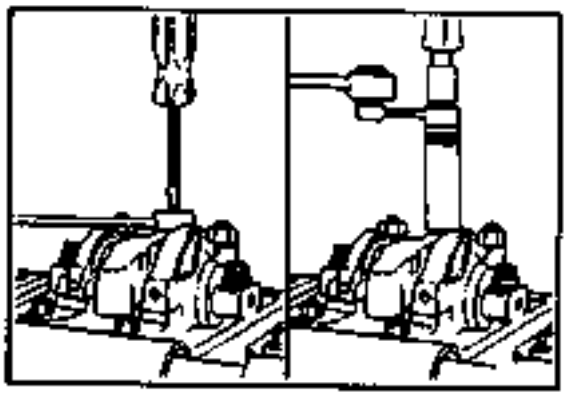
Hold the torque wrench in a position that allows you to look in a direct line at the dial. This is to make sure the dial will be read accurately.

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 [2.6 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.

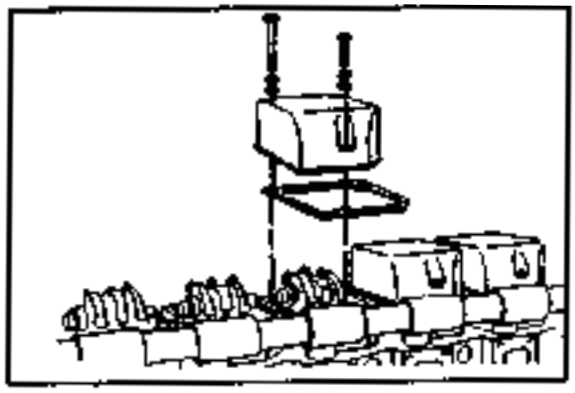


Hold the adjusting screw in this position. The adjusting screws **must not** turn when the lock nut is tightened.

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.

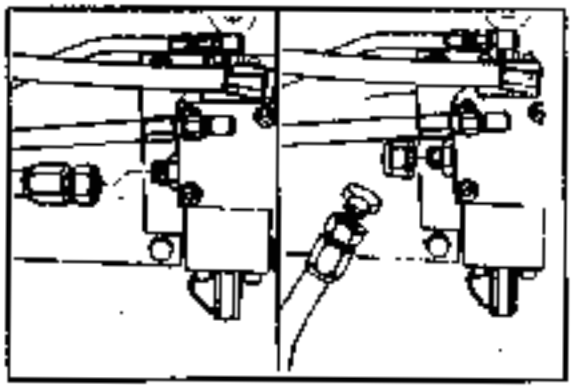
Install the rocker lever cover and all related components.

Torque Value : 40 N•m (30 ft-lb)

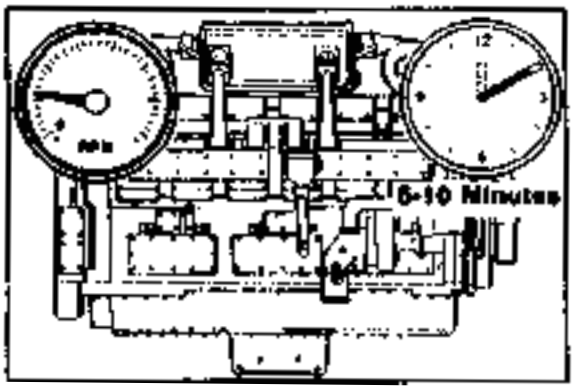
OBC Injector Set Procedure - on K38 and KTA-50 G3 (1 MW) Engines with STC injectors

Clean the engine to avoid dust entry inside the engine.

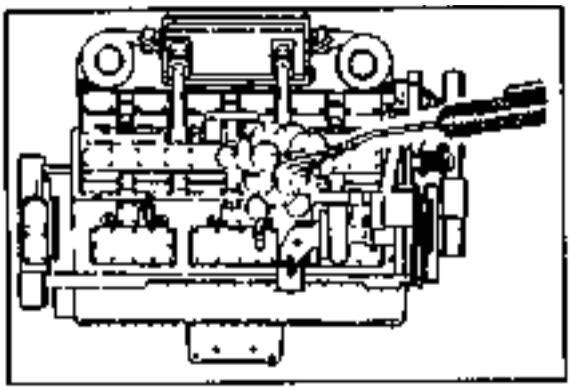
On engines with a **hydromechanical STC valve,** remove the oil supply hose from the oil control valve. Plug the hose, cap, and fitting. This prevents the engine from going into advance timing.



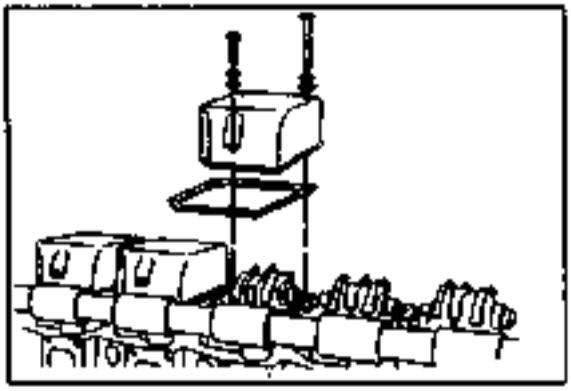
Operate the engine at high idle for 5 minutes (in normal timing mode). This will allow all of the oil to pump out of the injector tappets so a correct injector adjustment can be made.



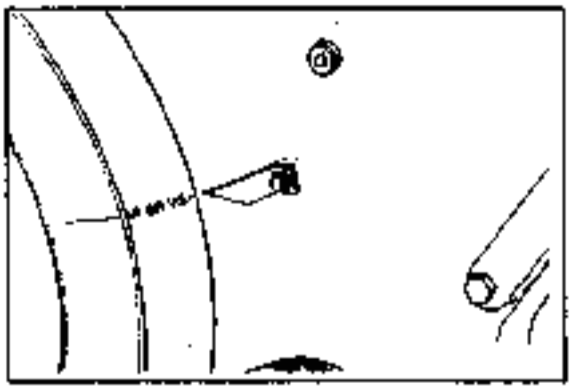
Shut the engine off.



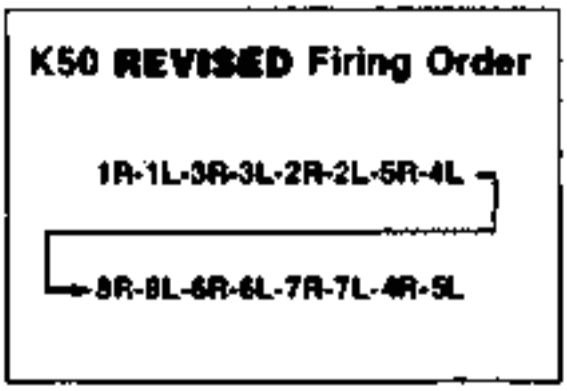
If you have not previously cleaned the engine, clean the engine now to prevent dirt from entering the engine when the valve covers are removed.



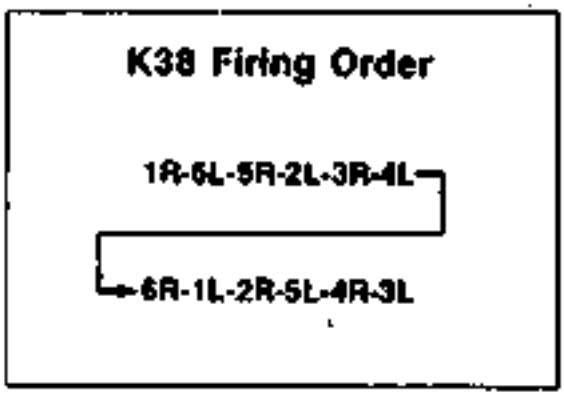
Remove the rocker lever covers and all related components.



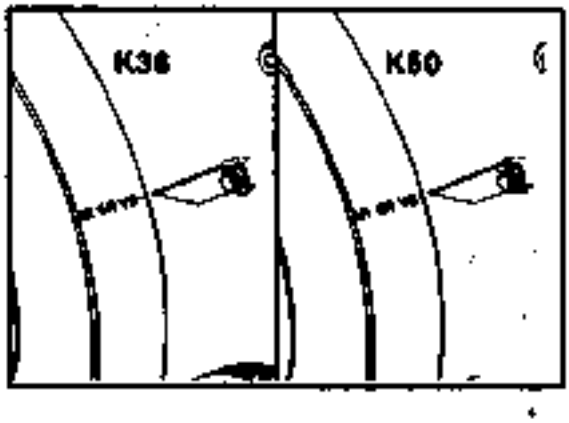
Valve and injector adjustment marks are on the vibration damper. The marks must be aligned with the pointer.



This artwork displays the revised firing order for KTA-50-G3 (STC injectors) engine model.



This artwork displays the tiring order for K38 engines



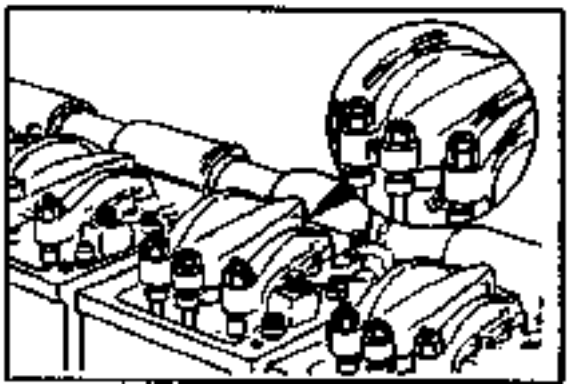
Direction of normal rotation for K38 and KTA-50-G3 engine is **clockwise** when viewing the **front** of the engine.

VS represents the valve set. Ignore any TC (top center) marks while setting the valves and injectors.

Determine the Cylinder in Position for Valve Set

The crossheads and valves are ready to be adjusted on the cylinder that has all the valves closed.

Check the two cylinders shown on the VS mark.



Wiggle the valve rocker levers on the two cylinders in question. The crossheads and valves on the cylinder where both levers feel loose are ready to adjust.

Caution : Use the correct chart for the engine being serviced or the parts will be damaged.

After identifying the cylinder with the valves ready to be adjusted, use the following charts for the sequence. The procedure and specifications for adjusting the crossheads, valves and injectors are after the charts.

The following charts give the crosshead, valve and injector adjustment sequence.

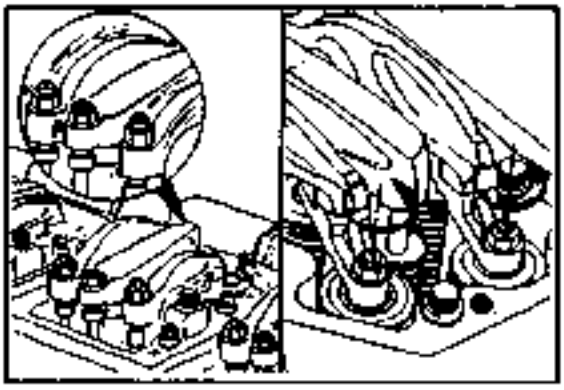
NOTE : Adjustment can begin on any valve set mark. In our example, assume the **1R-6R** or **1R-8R** marks are aligned and the adjusting screw height for the valves on the cylinder no. 1 right bank are closed and ready to adjust.

K38 OUTER BASE CIRCLE SET PROCEDURE (with STC injectors)
Valve and Injector Adjustment Chart

VS MARK	VALVES CLOSED ON CYLINDER NUMBER	ADJUST VALVES ON CYLINDER NUMBER	ADJUST INJECTORS ON CYLINDER NUMBER
1R-6R VS	1R	1R	2R
6L-1L VS	6L	6L	5L
5R-2R VS	5R	5R	4R
2L-5L VS	2L	2L	3L
3R-4R VS	3R	3R	1R
4L-3L VS	4L	4L	6L
1R-6R VS	6R	6R	5R
6L-1L VS	1L	1L	2L
5R-2R VS	2R	2R	3R
2L-5L VS	5L	5L	4L
3R-4R VS	4R	4R	6R
4L-3L VS	3L	3L	1L

KTA-50-G3 (with STC injectors) OUTER BASE CIRCLE SET PROCEDURE - REVISED FIRING ORDER
Valve and Injector Adjustment Chart

VS MARK	VALVES CLOSED ON CYLINDER NUMBER	ADJUST VALVES ON CYLINDER NUMBER	ADJUST INJECTORS ON CYLINDER NUMBER
1R-8R VS	1R	1R	6R
1L-8L VS	1L	1L	6L
3R-6R VS	3R	3R	7R
3L-6L VS	3L	3L	7L
2R-7R VS	2R	2R	4R
2L-7L VS	2L	2L	5L
4R-5R VS	5R	5R	1R
4L-5L VS	4L	4L	1L
1R-8R VS	8R	8R	3R
1L-8L VS	8L	8L	3L
3R-6RVS	6R	6R	2R
3L-6L VS	6L	6L	2L
2R-7R VS	7R	7R	5R
2L-7L VS	7L	7L	4L
4R-5R VS	4R	4R	8R
4L-5L VS	5L	5L	8L



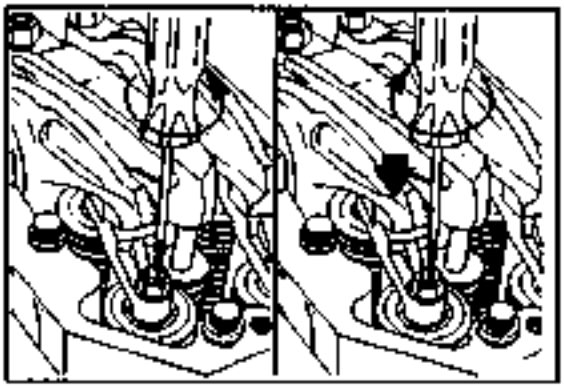
Crossheads - Adjustment

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.

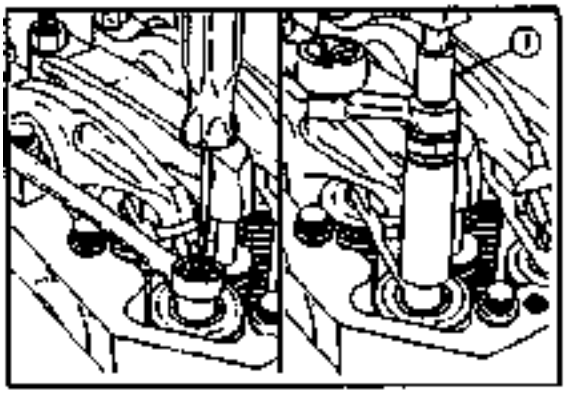


Use the following procedure to adjust both the intake and the exhaust crossheads.

Turn the adjusting screw out at least on turn.

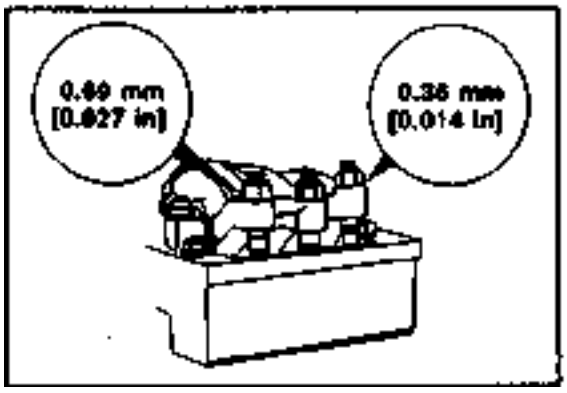
Hold the crosshead down against its guide.

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



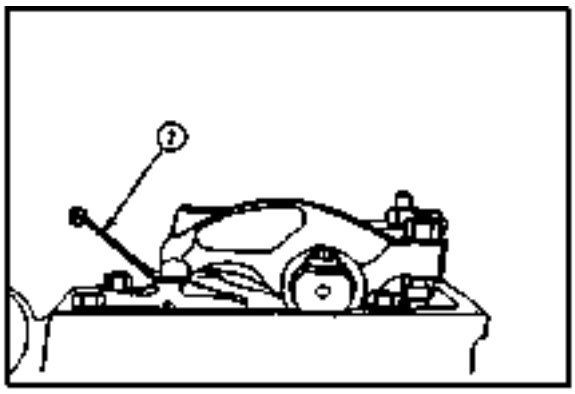
Hold the adjusting screw in this position. The adjusting screw **must not** turn when the lock nut is tightened to its torque value. Tighten the lock nut. The following torque values are given with and without Part No. ST-669, Torque Wrench Adapter (1) :

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

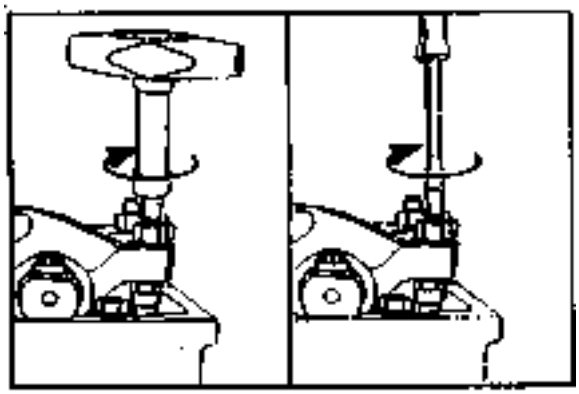


Valves - Adjustment

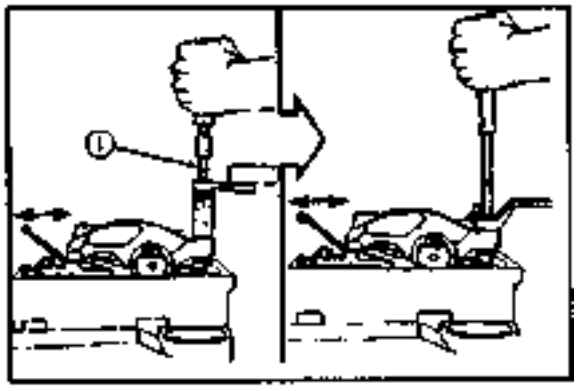
Valve Adjustment (Initial Set)		
mm		In
0.69	Exhaust	0.027
0.36	Intake	0.014



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.



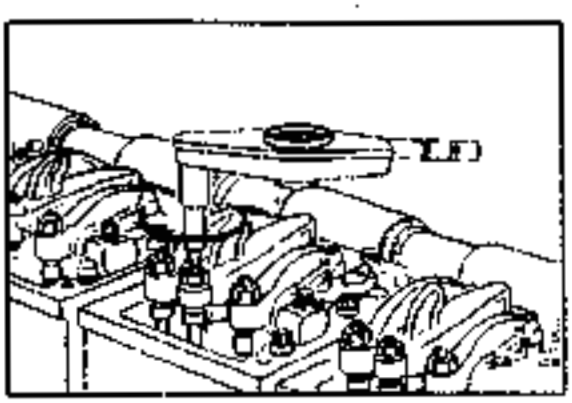
The adjusting screw **must not** turn when the lock nut is tightened. Tighten the lock nut to the value indicated below.

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 torward 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

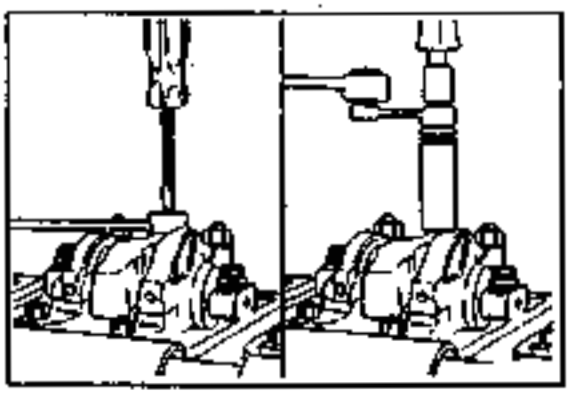
Use a dial type torque wrench to tighten the injector rocker lever adjusting screw. If the screw causes chattering during setting, repair the screw and lever as required.

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].

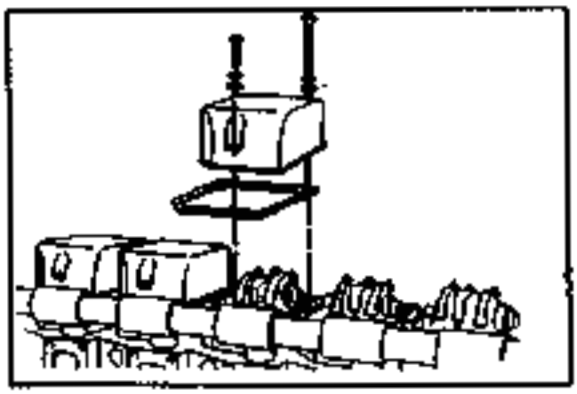
The torque wrench **must** be calibrated, have a resolution of 0.28 N•m [2.5 in-lb], and have a range of 17 to 23 N¥m [150 to 200 in-lb]. Do **not** use a clicker-type torque wrench.



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)

Injector Adjustment - Top Stop Zero Lash (IBC) Method (for NT-855-G5 Big Cam III Non STC Engines)

The adjustment sequence here is identical to the dial indicator method.

The valves and the injectors on the same cylinder are **not** adjusted at the same set mark on the accessory drive pulley.

One pair of valves and one Injector are adjusted at each pulley set mark **before** rotating the accessory drive to the next mark.

Two crankshaft revolutions are required to adjust all the valves and injectors

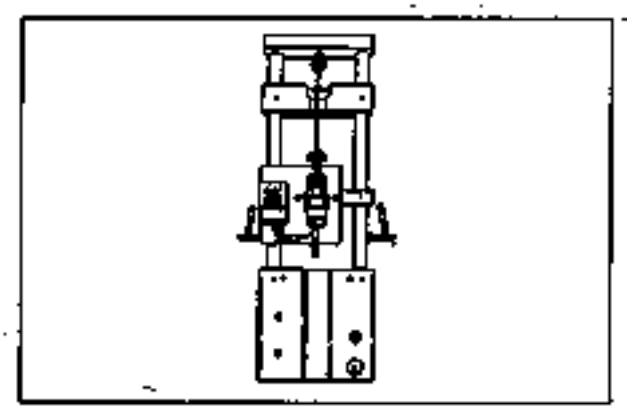
With this method, the injector plunger travel **must** be set on an injector stand with the injectors removed from the engine.

Caution : Top stop injector plunger travel can only be adjusted when the injectors are removed from the engine. Part No. 3822696, Adjusting Tool, must be used to make this adjustment.

Injector and Valve Adjustment Sequence

Bar Engine In Direction of Rotation	Pulley Position	Set Cylinder Injector	Valve
Start	A	3	5
Advance to	B	6	3
Advance to	C	2	6
Advance to	A	4	2
Advance to	B	1	4
Advance to	C	5	1

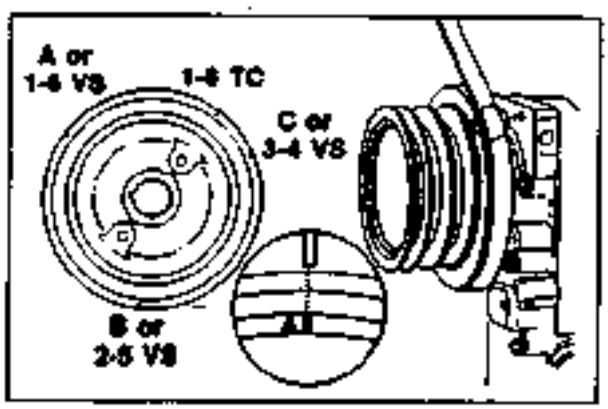
Firing Order : 1-5-3-6-2-4

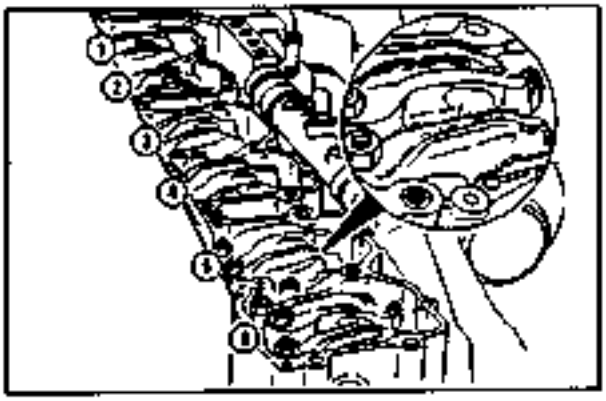


Rotate the accessory drive **clockwise until the** “A” valve set mark on the accessory drive pulley is aligned with the cast-in pointer.

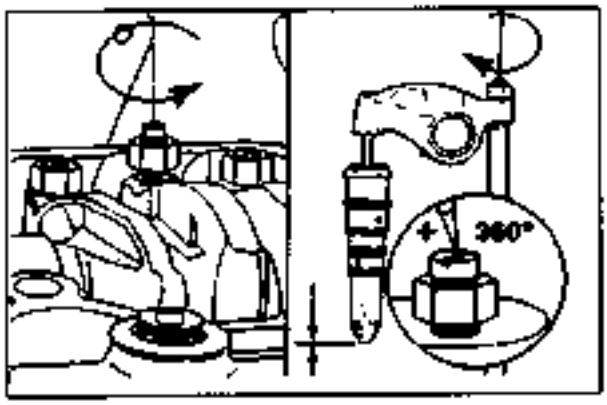
Check the valve rocker levers on cylinder No. 5 to see if both valves are closed.

Note : Both valves are closed when both rocker levers are loose and can be moved from side to side. If both valves are **not** closed, rotate the accessory drive one complete revolution; and align the “A” mark with the cast-in pointer again.



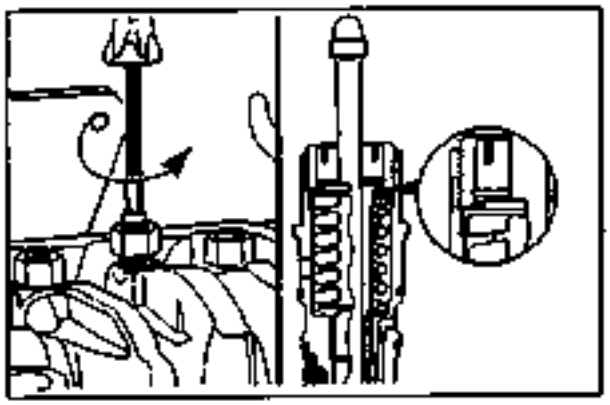


If the valve rocker lever adjusting screws have been loosened and **not** yet adjusted, watch the valve push tubes as the engine rolls upon the “A” mark. Both valve push tubes will move to the downward (valve closed) position if the engine is on the correct stroke.

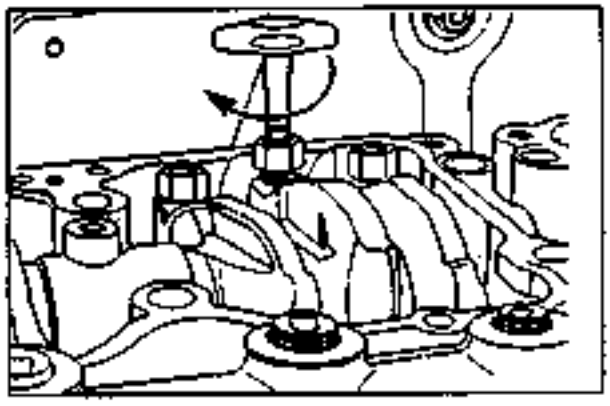


Loosen the lock nut on the injector adjusting screw on cylinder No. 3. Tighten the adjusting screw until all the clearance is removed between the rocker lever and injector link.

Tighten the adjusting screw one additional turn to correctly seat the link.



Loosen the injector adjusting screw until the injector spring retainer washer touches the top stop screw.



Caution : An overtightened setting on the injector adjusting screw will produce increased stress on the injector train and the camshaft injector lobe which can result in engine damage.

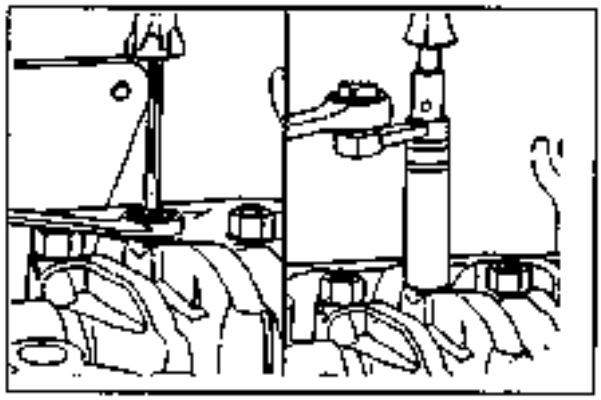
Use torque wrench, Part No. 3376592, to tighten the adjusting screw.

Torque Value : 0.6 to 0.7 N•m [5 to 6 in-lb]

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

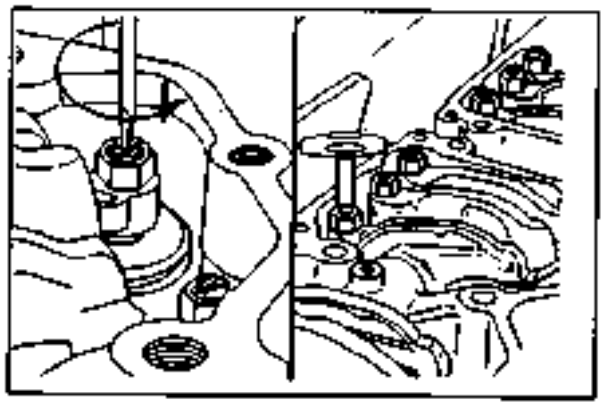
Torque Values :

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

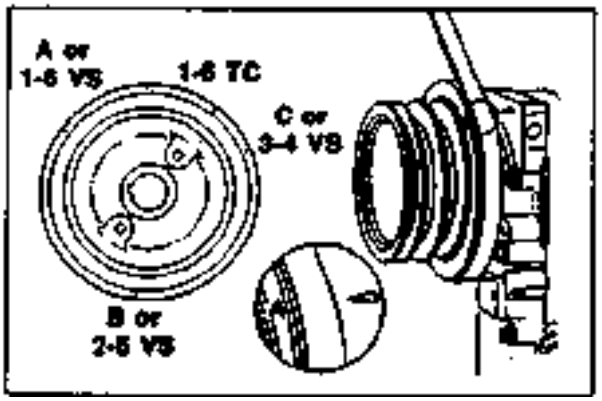


Adjust the crossheads and the valves on cylinder No. 5 **before** rotating the accessory drive to the next valve set mark.

Refer to "Crosshead Adjustment Procedures" and "Valve Adjustment Procedures."



After adjusting the crossheads and the valves on cylinder No. 5, rotate the accessory drive and align the next valve set mark (B) on the accessory drive pulley with the cast-in pointer on the gear cover.



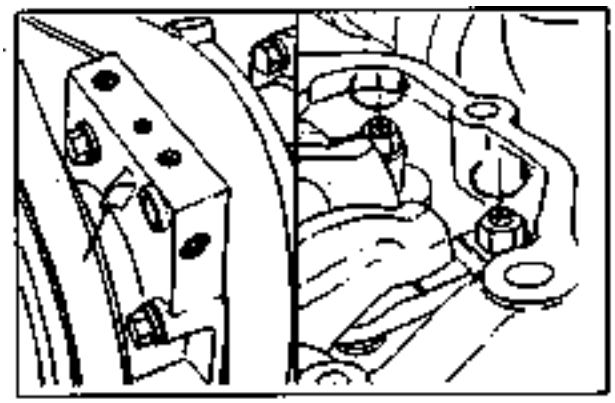
Adjust injector No. 6 and the crossheads and the valves on cylinder No. 3.

Repeat the process following the Injector and Valve Adjustment Sequence Chart to adjust all injectors, crossheads, and valves correctly.

Injector and Valve Adjustment Sequence

Bar Engine In Direction of Rotation	Pulley Position	Set Cylinder Injector	Valve
Start	A	3	5
Advance to	B	6	3
Advance to	C	2	6
Advance to	A	4	2
Advance to	B	1	4
Advance to	C	5	1

Firing Order : 1-5-3-6-2-4

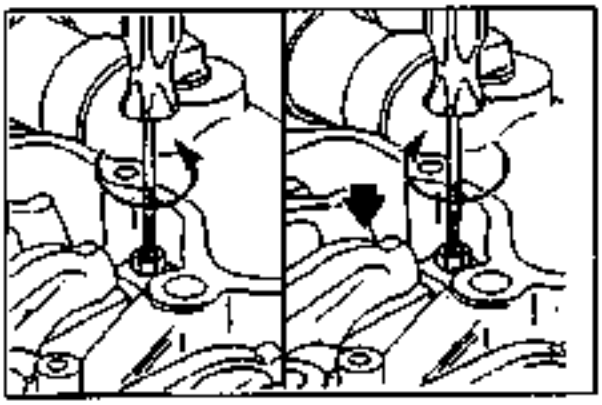


Crosshead Adjustment Procedure

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.

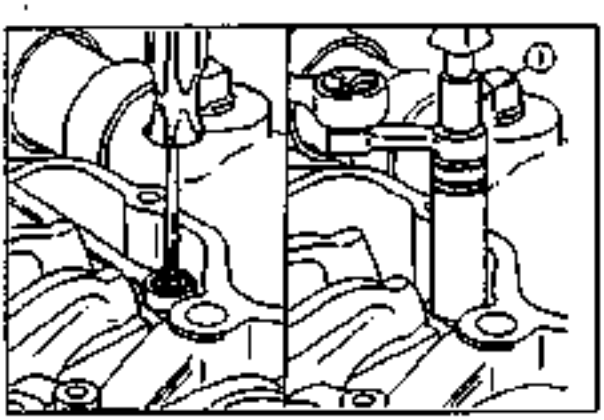
NOTE : Use the following procedure to adjust both the intake and the exhaust crossheads :



Turn the adjusting screw out at least one turn.

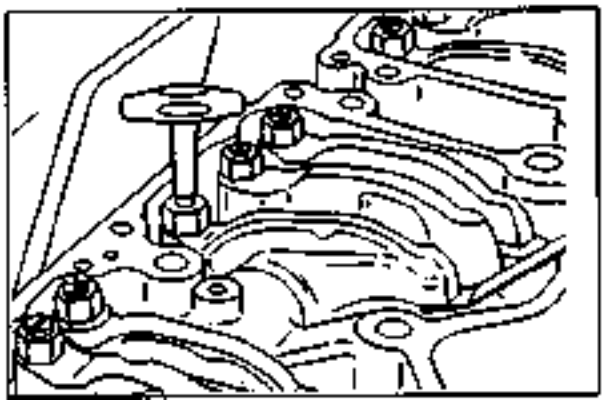
Hold the crosshead down against its mating valve stems.

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 toruqe value. Tighten the lock nut. The following torque values are given with and without toruqe 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

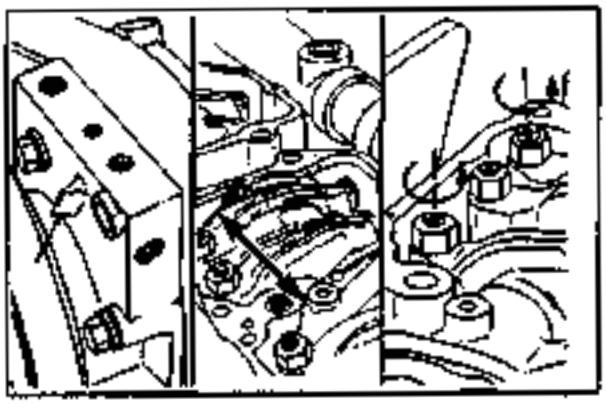


Adjust the intake and the exhaust valves on No. 5 cylinder **before** rotating the accessory drive to the next valve set mark.

Refer to “Valve Adjustment Procedures.”

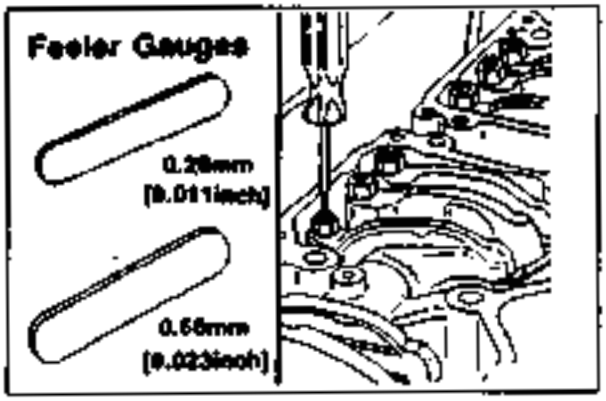
Valve Adjustment Procedure

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.



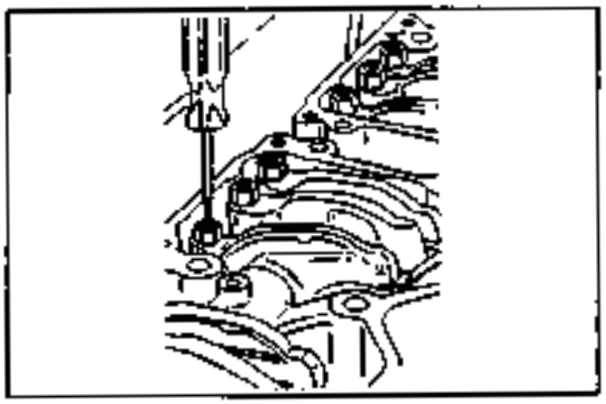
Select a feeler gauge for the correct valve lash specification.

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.

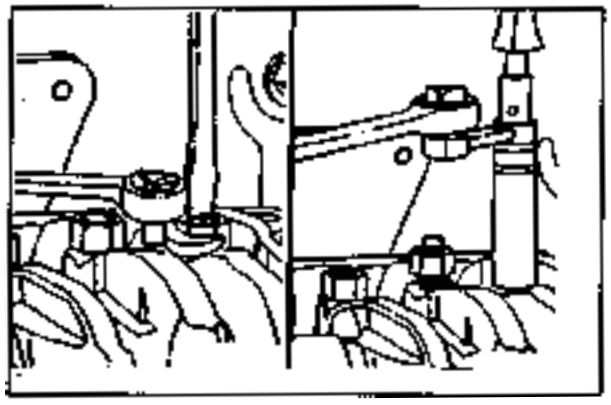


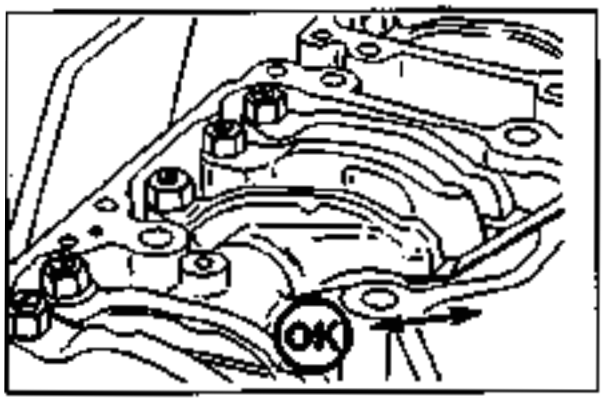
Hold the adjusting screw in this position. The adjusting screw **must not** turn when the lock nut is tightened. Tighten the lock nut.

Torque Values :

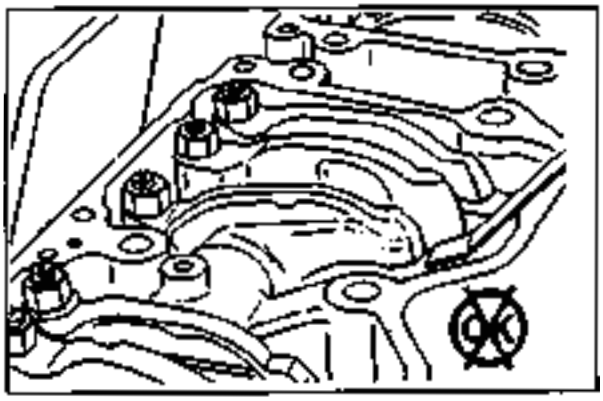
With torque wrench adapter, Part No. ST-669 — 47 N•m [35 ft-lb]

Without adapter — 61 N•m [45 ft-lb]

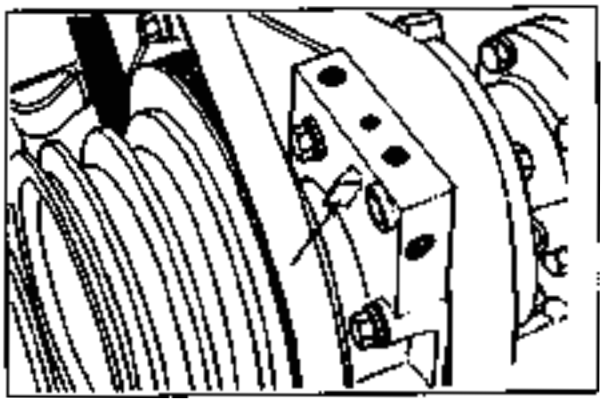




After tightening the lock nut to the correct torque value, check to make sure the feeler gauge will slide backward and forward between the crosshead and the rocker lever with only a slight drag.



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.

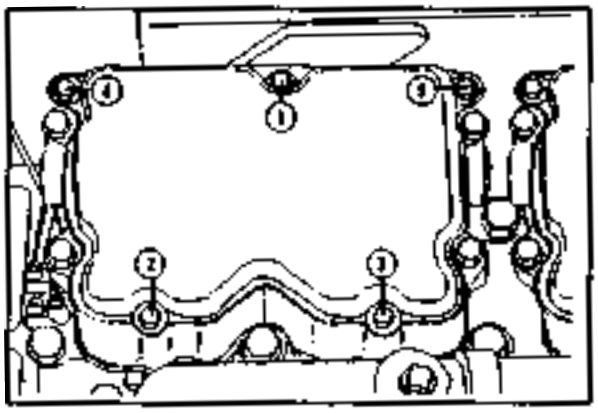
Injector and Valve Adjustment Sequence

Bar Engine In Direction of Rotation	Pulle Position	Set Cylinder Valve
Start	A	5
Advance to	B	3
Advance to	C	6
Advance to	A	2
Advance to	B	4
Advance to	C	1

Firing Order : 1-5-3-6-2-4

Adjust the appropriate crossheads and the valves following the Valve Adjustment Sequence Chart.

Repeat the process to adjust all injectors, crossheads, and valves correctly.



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 Value : 20 N•m [15 ft-lb]

NOTES

“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, Fig. 7-22) 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 aneriod with clean engine lubricating oil. Replace the fill plug (1).

Replace Aneroid Breather

Remove and replace the aneroid breather (3, Fig. 7-22).

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.

For Tapered Roller Bearings —

Engine Model	End Clearance
V-28	0.003"-0.010"
K-19	0.003"-0.016"
KV-38	0.001"-0.008"

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.

NOTES

“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.

After removing the injectors from KT/KTA 1150, KT/KTA 2300 or KTA 3067 Engines for cleaning the seal seat should be removed from the injector (Fig. 8-1) or injector “well” for cleaning, examination and/or replacement as necessary.

Fig. 8-1. Injector seal seat — all KT Engines

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 flatwashers, lockwashers 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 prelubricated 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
T-50, ST-50, VT-50	0.006 to 0.018 inch (0.15 to 0.46 mm)	0.003 to 0.033 inch (0.08 to 0.84 mm)
H2A	0.004 to 0.006 inch (0.10 to 0.15 mm)	0.0125 to 0.0185 inch (0.31 to 0.47 mm)
H1E	0.004 to 0.006 inch (0.010 to 0.15 mm)	0.012 to 0.018 inch (0.30 to 0.46 mm)
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

Rubber Damper

The damper hub (1), (Fig. 8-2) and the inertia member (2) are stamped with an index mark (3) to permit the detection of movement between the two components.

Fig. 8-2. Vibration damper alignment marks

There should be no relative rotation between the hub and the inertia member resulting from engine operation.

Check for extrusion or rubber particles between the hub and the inertial member.

If there is evidence of inertia member movement and rubber extrusion, replace the damper.

Viscous Dampers

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.

Table 8-2 : Viscous Vibration Damper Thickness Specifications — Inch (mm)

Damper Part No.	Maximum Allowable Thickness	Recommended Change Interval — Hours
3037156	1.635 (41.53)	15000
207531	2.574 (65.38)	15000
211915	1.550 (39.37)	15000
217321	1.663 (42.24)	15000
217322	1.663 (42.24)	15000
217323	1.663 (42.24)	15000
3873899	2.574 (65.38)	24000
3015464	2.574 (65.38)	24000
3628651	2.574 (65.38)	24000
3628649	2.574 (65.38)	24000
3628650	2.574 (65.38)	24000

Air Compressor

All air compressors have a small amount of oil carryover 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. 8-3) 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.

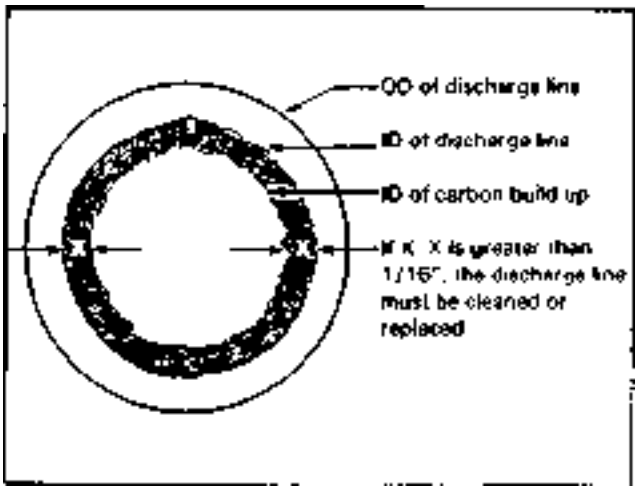


Fig. 8-3. Air discharge line

Intake Inspection

1. Remove the capscrews, flat washers and lockwashers securing the unloader valve assembly to the cylinder head cover. Remove the unloader valve assembly and spring from the cylinder head and cover, Fig. 8-4.
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.

Clean Crankcase Breathers (KT/KTA 2300 and KTA 3067 Engines)

Remove the crankcase breathers from the right bank and left bank. Clean in an approved cleaning solvent, dry with compressed air & install.

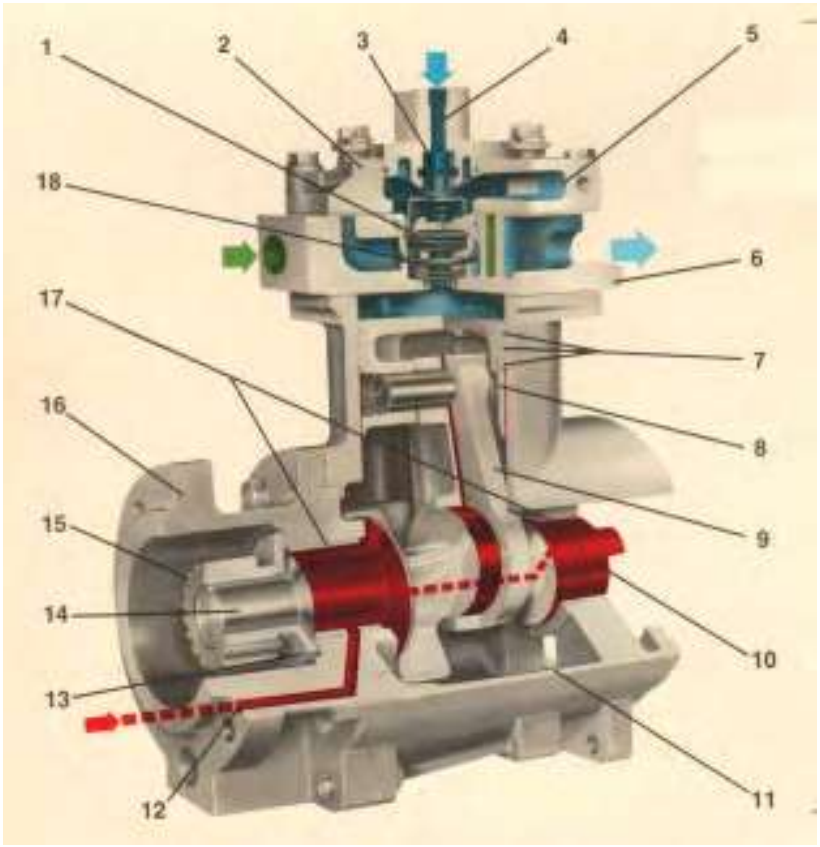


Fig. 8-4. Air Compressor

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 7-1).

NOTES

Seasonal Maintenance Checks

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.

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 Preheater Cold-Starting Aid

Remove the 1/8 inch pipe plug from the manifold, near the glow plug and check the operation of the preheater 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 170° to 185°F (77° to 85°C) or low 160° to 175°F (71° to 79°C) and in a few cases high-range 180° to 195°F (82° to 91°C) 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.

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 9-1 : 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)
V-1710/ V28	0.006 (0.15)	0.013 (0.33)	0.018 (0.46)
KT/KTA19	0.004 (0.10)	0.016 (0.40)	0.022 (0.56)
KT/KTA38 KTA50	0.005 (0.13)	0.015 (0.38)	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 Heat Exchanger Zinc Plugs

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

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.

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

Specifications and Torque

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

Lubricant, Fuel and Coolant

The Functions of Lubricating Oil

The Lubricating oil used in a Cummins engine must be multifunctional. It must perform the primary functions of:

Lubrication by providing a film between the moving parts to reduce wear and friction.

Cooling by serving as a heat transfer media to carry heat away from critical areas.

Sealing by filling in the uneven surfaces in the cylinder wall, valve stems and turbocharger oil seals. Cleaning by holding contaminants in suspension to prevent a build up of deposits on the engine surfaces.

In addition, it must also provide:

Dampening and cushioning of components that operate under high stress, such as gears and push tubes.

Protection from oxidation and corrosion.

Engine lubricating oil must be changed when it can no longer perform its functions within an engine. Oil does not wear out, but it becomes contaminated to the point that it can no longer satisfactorily protect the engine. Contamination of the oil is a normal result of engine operation. During engine operation a wide variety of contaminants are introduced into the oil. Some of these are:

Byproducts of Engine Combustion—asphaltenes, soot and acids from partially burned fuel.

Acids, varnish and sludge which are formed as a result of the oxidation of the oil as it breaks down or decomposes.

Dirt entering the engine through the combustion air, fuel, while adding or changing lubricating oil.

The oil must have an additive package to combat these contaminants. The package generally consists of :

Detergents/Dispersants which keep insoluble matter in suspension until they are filtered from the oil or are removed with the oil change. This prevents sludge and carbon deposits from forming in the engine.

Inhibitors to maintain the stability of the oil, prevent acids from attacking metal surfaces and prevent rust during the periods the engine is not operating.

Other Additives that enable the oil to lubricate highly loaded areas, prevent scuffing and seizing, control foaming and prevent air retention in the oil.

Oil Performance Classification System

The American Petroleum Institute (API), The American Society of Testing and Materials (ASTM) and the Society of Automotive Engineers (SAE) have jointly developed and maintained a system for classifying lubricating oil by performance categories. The following is brief description of the API'categories used in the Cummins Lubricating oil recommendations.

CF4 Oils of this category are formulated for service of high speed, four stroke cycle diesel engines. API CF4 oils exceeds the requirements for API CE Category, providing improved control of oil consumption and piston deposits.

Break-in Oils

Special "break-in" lubricating oils are not recommended for new or rebuilt Cummins engines. Use the same lubricating oils used in normal engine operation.

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 [0°F (–18°C)] 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.

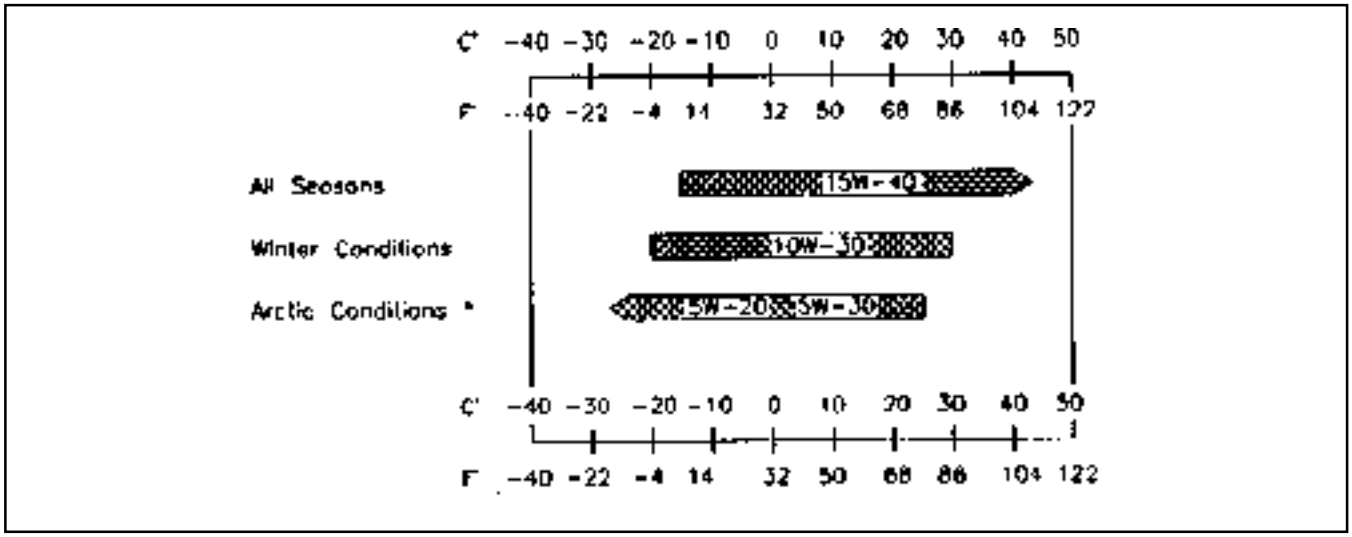
Multigraded oils are generally produced by adding viscosity index improver additives to retard the thinning effects, a low viscosity base oil will experience at engine operating temperatures. Multigraded oils that meet the requirements of the API classifications, are recommended for use in Cummins engines.

Cummins recommends the use of multigraded lubricating oil with the viscosity grades shown in Tahle 11-1 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 oii 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 ternperature 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 11-1.

Table 11-1 : Cummins Recommended SAE Oil Viscosity Grades vs Ambient Temperatures



Note : For temperature consistantly 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, CF4 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.

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.

Hence Cummins India Limited strongly recommends the use of SAE 15W40 Lub oil with API ,CF4 classification for all Cummins engines to get the various advantages and optimum performance from the Cummins engine.

This oil should 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 topup. 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 100 Hours 500 Hours Copper, Corrosion	ASTM D 942 10 max. 25 max. *FTM 5309 Pass
Dirt Count, Particles/cc 25 Microns + 75 Microns + 125 Microns + Rubber Swell	*FTM 3005 5,000 max. 1,000 max. None *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 11-3 : 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 104°F (40°C)
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 1 .0 mass percent.
Active Sulfur (ASTM D130)	Copper Strip Corrosion not to exceed No. 2 rating after three hours at 122°F (50°C).
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 60°F (0.816 to 0.876 g/cc at 15°C).
Cloud Point (ASTM D97)	10°F (6°C) 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.

TABLE 11-4: REQUIREMENTS FOR HIGH SPEED DIESEL FUEL AS PER IS 1460: 1974

Sr. No.	Characteristics	Requirement	Method of test Ref. to Appendix (P : of IS 1448)	
1	Acidity, Inorganic	nil	—	P : 2
2	Acidity, total mg. of KOH/g max.	0.50	—	P : 2
3	Ash, percent by mass max.	0.01	—	P : 4
4	Carbon residue (Ramsbottom) percent by mass, max.	0.20	—	P : 8
5	Cetane Number, min.	42	—	P : 9
6	Pour point, max.	6°C (42.8°F)	—	P : 10
7	Copperstrip corrosion for 3 hours at 212°F (100°C)	Not worse than No. 1	—	P : 15
8	Distillation percent recovery at 366°C min.	90	—	P : 18
9	Flash point : (a) Abel, °C min.	38	—	P : 20
10	Kinematic viscosity CS at 38°C (100.4°F)	2.0 to 7.5	—	P : 25
11	Sediment, percent by mass max.	0.05	—	P : 30
12	Total sulphur, percent by mass max.	1.0	—	P : 33 or P : 35
13.	Water content, percent by volume, max.	0.05	—	P : 40
14	Total sediments, mg. per 100 ml. max.	1.0	A	—

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 coolent is added and requires no change in schedule of element replacement.

2. Coolant Additive Concentrate (CAC)

A. Coolant Additive Concentrate

It is supplied in plastic red colour containors 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. Premixed 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.
3167221	Premixed Coolant	5 lt.
3167222	Premixed Coolant	10 lt.
3167223	Premixed Coolant	20 lt.
3167224	Premixed Coolant	205 lt.

C. Test strip

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

Part Number	Description
3167225	Test strip

D. Test Kit

This consists of 2 test strips, a clear plastic beaker and a dropper to collect the coolant. Test kits are supplied in cardboard boxes.

Part Number	Description
3167226	Test Kit

Test Kit

IMPORTANT NOTE

Shelf life for Coolant Additive Concentrate & Premixed Coolant is 5 years & that of test strip/kit is 18 months.

INSTRUCTIONS FOR USE

The Coolant Additive Concentrate and premixed coolant is supplied with each engine as,

- Required quantity of Coolant Addative Concentrate as per engine model.
- Coolant test kit 3167226
- Premixed coolant for top up.

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

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

Picture 1

b) Fill the remaining system by water till the system is completely filled. (Ref. Picture 2).

Picture 2

Industrial Applications

The total coolant capacity varies for different engine models and applications. Hence following procedure to be followed to maintain concentration level of CAC.

a) Prepare coolant mixture by mixing 15 parts of water with 1 part of Coolant Additive Concentrate supplied in kit and stir for thorough mixing.

b) Fill the system completely with this coolant. Measure and note down the system capacity for further reference purpose.

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 premixed coolant only and not by water.

To facilitate top up, premixed coolant is made available. This premixed coolant is to be used as supplied. Do not dilute.

If premixed 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.

Salient Features of CAC

- Safe / environmental & user friendly
- Easy operation, time saving at 'B' check.
- To be filled in through Radiator / 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 1:15 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.

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 hrs./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 radiator/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.

Following action is required after checking CAC level.

Units/Lit.	Action Required
Below 0.4	Add precharge quantity. i.e. quantity of Coolant Additive Concentrate liquid as required for initial commissioning.
Between 0.4 to 0.6	Continue adding Coolant Additive Concentrate as per service treatment chart at B check.
Above 0.6	OK, No action required.

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 hrs. of operation or after two years, it is necessary to replace the coolant.

Important Note :

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

Hardness	(as CaCO3)	-	170 ppm max
Chlorides	(as Cl)	-	40 ppm max
Sulfate	(as SO4)	-	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.

Conversion of field engines :

The engines working in field using Corrosion Resistor can be converted to use CAC with following method. **Cummins India Limited** encourages the field conversions to provide customers benefit of the new improvement.

1. Drain coolant and remove Corrosion Resistor housing.

2. Disconnect and remove Corrosion Resistor connections. Plug the connections in block / water pump inlet. Use following plugs as required :

Description	Part No.
1/4" NPTF	S-910-B
1/2" NPTF	S-915-A
3/4" NPTF	S-995
1" NPTF	S-962

ANNEXURE

Requirements of Coolant Additive Concentrate for Genset Application Engines

System capacity (lt.)	Present Genset Engine Models	Coolant Additive Concentrate requirement (lt.) *	'B' check requirement for CAC (lt.) *
40-60	495-H/E & Radiator	4 (2+2)	0.5
61-80	743 -H/E & Radiator 855 - H/E cooled	5	1
81-120	855 Rad- Cooled & K6 Rad / H/E	7 (5+2)	1
121-175	No genset model at present	10	1.5 (1+0.5)
176-225	1710 -H/E	15 (10+5)	2
226-300	V1710 - Radiator KV12&16/ 1MW - H/E	20	3 (2+1)
301-400	KV12 & 16 Radiator Cooled	25 (10+10+5)	4 (2+2)
401-500	1MW -Radiator Cooled	30 (10+10+10)	5

* Figures in bracket indicate combination of can sizes.

3. Flush the coolant system with plain water twice to remove chromate from cooling system. This is required as chromate has yellow colour & new coolant has pink colour.

4. Follow instructions 1 to 4 as given above for first fill.

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

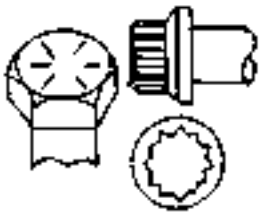
- Calcium Magnesium (Hardness) 170 PPM as ($CaCO_3$ + $MgCO_3$)
- Chloride 40 PPM as (Cl)
- Sulpher (Sulphates) 100 PPM as (SO_4)

To ensure adequate corrosion protection check engine coolant per procedure under Check Engine Coolant in section 6.

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

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 specifid in another section of the manual.

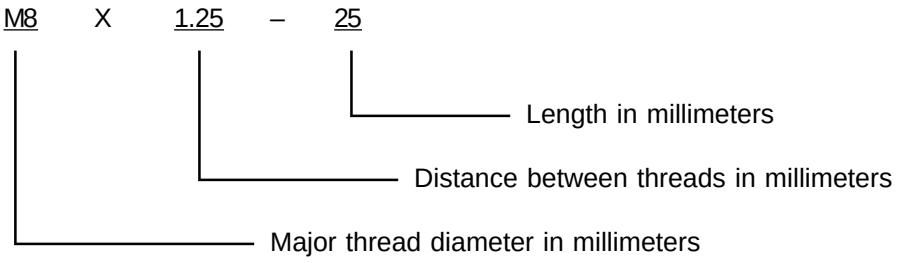
2. These values are based on clean, dry threads. Reduce the value by 10% when a lubricant is used. Reduce the value by 20% if new plated capscrews are used.

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



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 throughly. 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.

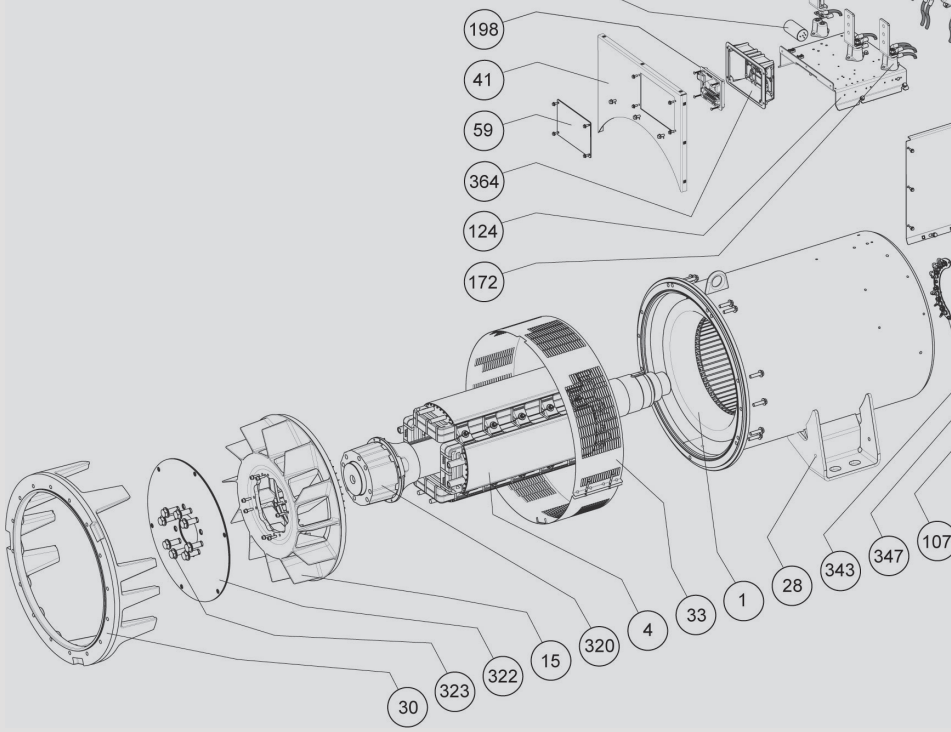
Electronic Governor Controller (EFC) :

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 Governed 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 Sludge	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 Ald/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	●					●	●			●																				●	
Demaged/Worn AFC Pluger Seal/Barrel										●																					
Fuel Pump Calibration Incorrect					●	●	●	●		●	●	●	●	●																●	
Injector Flow incorrect		●			●	●	●	●		●	●																				
AFC Air Leak, Beloows							●			●																					
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						●																						●		●	



LSA 49.3

Low Voltage Alternator - 4 pole

Installation and maintenance

LEROY-SOMER™

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LSA 49.3
Low Voltage Alternator - 4 pole

This manual concerns the alternator which you have just purchased.
We wish to draw your attention to the contents of this maintenance manual.

SAFETY MEASURES

Before using your machine for the first time, it is important to read the whole of this installation and maintenance manual.

All necessary operations and interventions on this machine must be performed by a qualified technician.

Our technical support service will be pleased to provide any additional information you may require.

The various operations described in this manual are accompanied by recommendations or symbols to alert the user to potential risks of accidents. It is vital that you understand and take notice of the following warning symbols.

WARNING

Warning symbol for an operation capable of damaging or destroying the machine or surrounding equipment.

Warning symbol for general danger to personnel.

Warning symbol for electrical danger to personnel.

SAFETY INSTRUCTIONS

We wish to draw your attention to the following 2 safety measures which must be complied with:

a) During operation, do not allow anyone to stand in front of the air outlet guards, in case anything is ejected from them.

b) Do not allow children younger than 14 to go near the air outlet guards.

A set of self-adhesive stickers depicting the various warning symbols is included with this maintenance manual. They should be positioned as shown in the drawing below once the machine has been fully installed.

WARNING

The alternators must not be put into service until the machines in which they are to be incorporated have been declared compliant with Directives EC and plus any other directives that may be applicable.
This manual is to be given to the end user.

The range of electric alternators and their derivatives, manufactured by us or on our behalf, comply with the technical requirements of the customs Union directives (EAC).

LSA 49.3
Low Voltage Alternator - 4 pole

CONTENTS

LSA 49.3
Low Voltage Alternator - 4 pole

1 - RECEIPT

1.1 - Standards and safety measures

Our alternators comply with most international standards.
See the EC Declaration of Incorporation on the last page.

1.2 - Inspection

On receipt of your alternator, check that it has not suffered any damage in transit. If there are obvious signs of knocks, contact the transporter (you may be able to claim on their insurance) and after a visual check, turn the machine by hand to detect any malfunction.

1.3 - Identification

The alternator is identified by means of a nameplate fixed on the machine (see drawing).
Make sure that the nameplate on the machine conforms to your order.
So that you can identify your alternator quickly and accurately, we suggest you fill in its specifications on the nameplate below.

1.4 - Storage

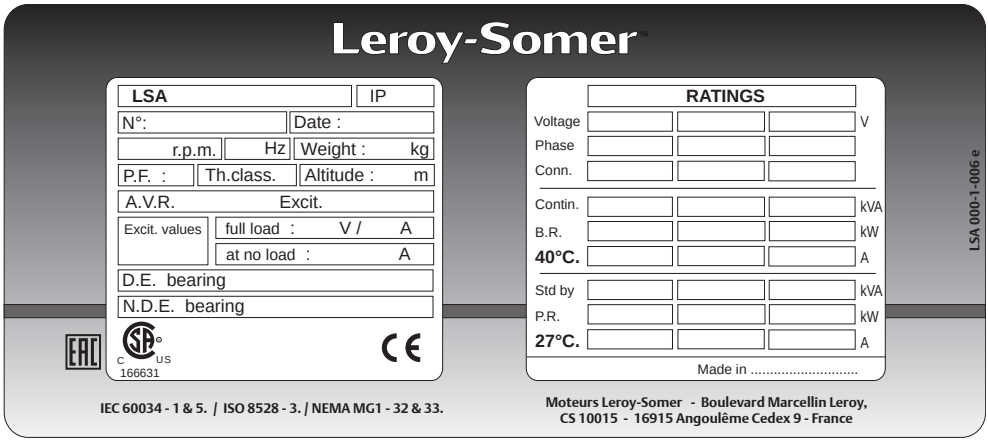
Prior to commissioning, machines should be stored :
- away from humidity (< 90%); after a long period of storage, check the machine insulation. To prevent the bearings from becoming marked, do not store in an environment with significant vibration.

1.5 - Application

These alternators are mainly designed to produce electricity in the context of applications involving the use of generators.

1.6 - Usage restrictions

Use of the machine is restricted to operating conditions (environment, speed, voltage, power, etc) compatible with the characteristics indicated on the nameplate.



LSA 49.3
Low Voltage Alternator - 4 pole

2 - TECHNICAL CHARACTERISTICS

2.1 - Electrical characteristics

This alternator is a machine without sliprings or revolving field brushes, wound as “2/3 pitch” ; 6 or 12-wire, with class H insulation and a field excitation system available in either AREP or PMG version (see diagrams and AVR maintenance manual).

• Electrical options

- Stator temperature detection sensors
- Space heaters
- Terminal box with mounting kit for protection or measurement C.T.

In order to conform to standard EN 61000-6.3, EN 61000-6.2, EN 55011, the R 791 interference suppression kit is needed.

2.2 - Mechanical characteristics

- Steel frame
- Cast iron end shields
- Protected ball bearings, greased for life (greasable as an option)
- Mounting arrangement: single-bearing with feet and SAE flanges/coupling discs, twin-bearing with SAE flange and standard cylindrical shaft extension
- Drip-proof machine, self-cooled
- Degree of protection: IP 23

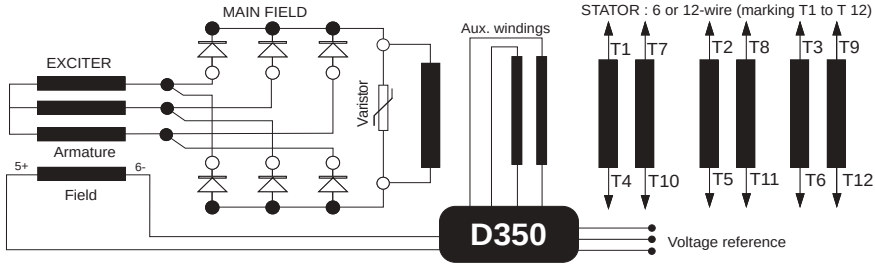
• Mechanical options

- Protection against harsh environments
- Air inlet filter, air outlet filter: IP 44

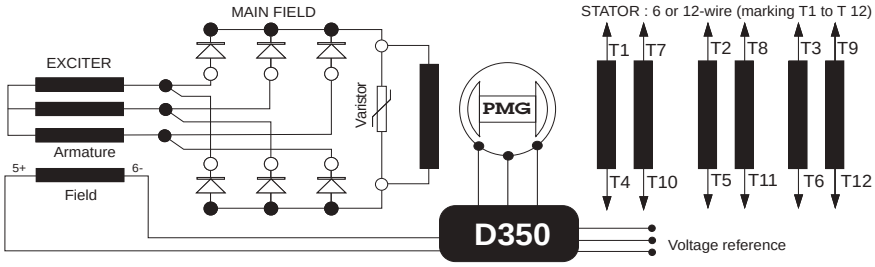
To prevent excessive temperature rise caused by clogged filters, it is advisable to monitor the stator winding with thermal sensors (CTP or PT100).

- Bearing temperature detection sensors

• AREP three-phase 6 or 12-wire



• PMG three-phase 6 or 12-wire



LSA 49.3
Low Voltage Alternator - 4 pole

3 - INSTALLATION

Personnel undertaking the various operations indicated in this section must wear personal protective equipment appropriate for mechanical and electrical hazards.

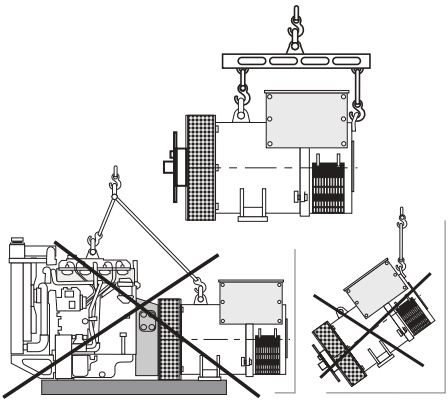
3.1 - Assembly

All mechanical handling operations must be undertaken using suitable equipment and the machine must be horizontal. Check how much the machine weighs before choosing the lifting tool.
During this operation, do not allow anyone to stand under the load.

• Handling

The generously-sized lifting eyes are for handling the alternator only. They must not be used to lift the genset. The choice of lifting hooks or handles should be determined by the shape of the lifting eyes. Choose a lifting system which respects the integrity and the environment of the machine.

During this operation, do not allow anyone to stand under the load.



• Single-bearing coupling

Before coupling, check the compatibility between the alternator and the engine by performing:
- undertaking a torsional analysis of the transmission (alternators data are available on request),
- checking the dimensions of the flywheel and its housing, the flange, coupling discs and offset.

WARNING

When coupling the alternator to the prime mover, do not use the fan to turn the alternator or rotor.
The holes of the coupling discs should be aligned with the flywheel holes by cranking the engine.
Make sure the machine is securely bedded in position during coupling.

Check that there is lateral play on the crankshaft.

• Double-bearing coupling

- Semi-flexible coupling

Careful alignment of the machines is recommended, checking that the lack of concentricity and parallelism of both parts of the coupling do not exceed 0.1 mm.

This alternator has been balanced with a 1/2 key.

• Location

The room where the alternator is placed must be ventilated to ensure that the ambient temperature cannot exceed the data on the nameplate.

3.2 - Checks prior to first use

• Electrical checks

Under no circumstances should an alternator, new or otherwise, be operated if the insulation is less than 1 megohm for the stator and 100,000 ohms for the other windings.

There are 2 possible methods for restoring the above minimum values.
a) Dry out the machine for 24 hours in a drying oven at a temperature of 110 °C (without the regulator).
b) Blow hot air into the air intake, having made sure that the machine is rotating with the exciter field disconnected.

Note : Prolonged standstill
In order to avoid these problems, we recommend the use of space heaters, as well as turning over the machine from time to time. Space heaters are only really effective if they are working continuously while the machine is stopped.

WARNING

Ensure that the alternator has the degree of protection matching the defined environmental conditions.

• Mechanical checks
Before starting the machine for the first time, check that:
- all fixing bolts are tight,
- the length of bolt and the tightening torque are correct,
- the cooling air is drawn in freely,
- the protective grills and housing are correctly in place,
- the standard direction of rotation is clockwise as seen from the drive end (phase rotation in order 1 - 2 - 3).
For anti-clockwise rotation, swap 2 and 3.
- the winding connection corresponds to the site operating voltage (see section 3.3).

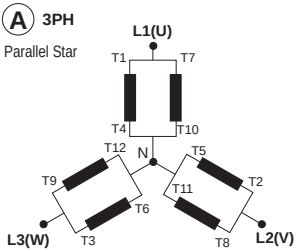
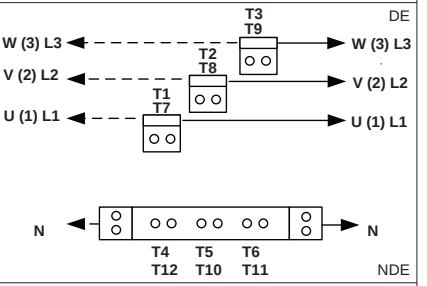
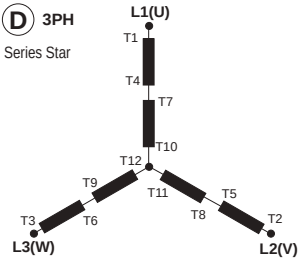
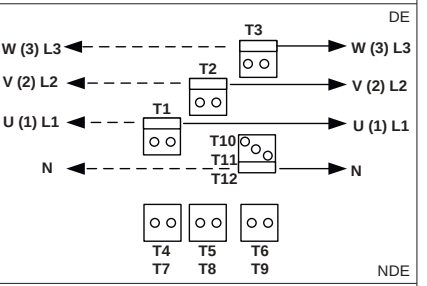
3.3 - Terminal connection diagrams

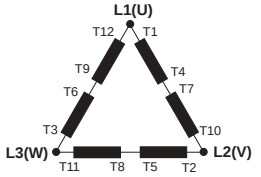
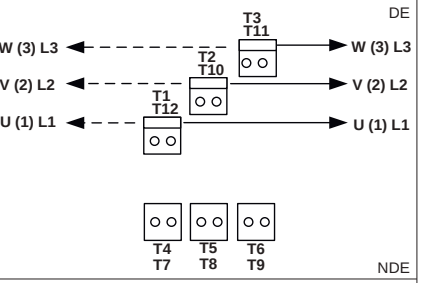
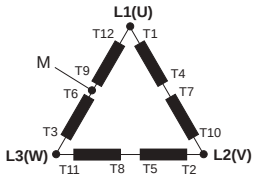
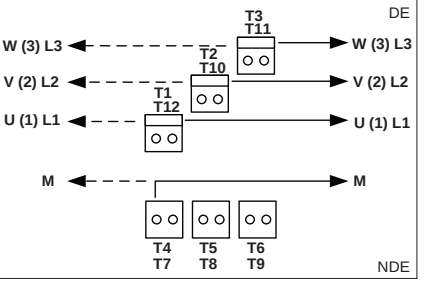
To modify the connection, change the position of the stator cables on the terminals. The winding code is specified on the nameplate.

Any intervention on the alternator terminals during reconnection or checks should be performed with the machine stopped. In no case should the internal connections in the terminal box be subjected to stresses due to cables connected by the user.

LSA 49.3
Low Voltage Alternator - 4 pole

• AREP or PMG three-phase 12-wire

Connection codes	Voltage			**OPTION:** Outputs to right / **STANDARD:** Outputs to left
A 3PH Parallel Star 	Winding	50 Hz	60 Hz	
	6	190 200 208	190 208 220 240	
	7	208 200 230		
	8		190 200 208	
D 3PH Series Star 	Winding	50 Hz	60 Hz	
	6	380 400 460	380 416 440 480	
	7	415 440 460		
	8		380 400 416	

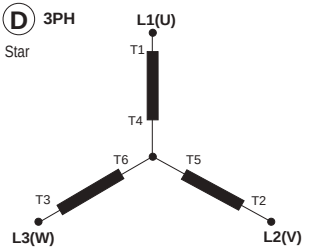
Connection codes	Voltage / Detection			Factory connection 12 wires
F Series Delta  Note: // alternator: CT -> L1 (In)	Winding	50 Hz	60 Hz	
	6	220 230 240	220 240 255	
	7	240 255		
	8		220 230 240	
DELTA + MIDDLE POINT DELTA EDISON 	Winding	50 Hz	60 Hz	
	6	220 230 240	220 240 255	
	7	240 255		
	8		220 230 240	

LSA 49.3
Low Voltage Alternator - 4 pole

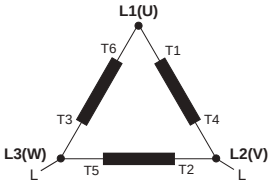
• AREP or PMG three-phase 6-wire

Connection codes

D **3PH** Star



F Delta **1PH** or **3PH**



Voltage / Detection

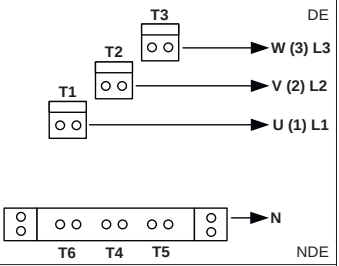
Winding	50 Hz	60 Hz
6S	380 - 415	380 - 480
7S	440	-
8S	-	380 - 416

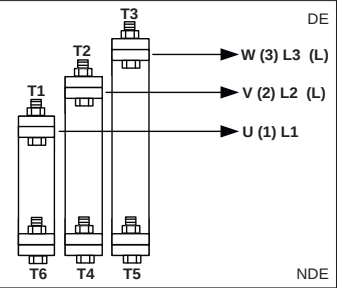
D350:
U => T1, V => T2, W => T3

Winding	50 Hz	60 Hz
6S	220 - 240	220 - 240
7S	250 - 260	-
8S	200	220 - 240

D350:
U => T1, V => T2, W => T3

Factory connection 6 wires

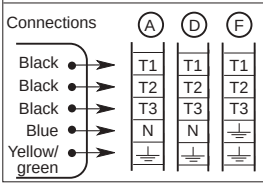




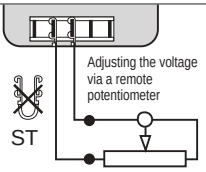
In case of reconnection, ensure that AVR voltage detection is correct !
We can supply a set of flexible shunts and special connection links as an option for making these connections.

• Option connection diagram

R 791 T interference suppression kit (standard for CE marking)

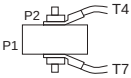


External voltage potentiometer or ext. source 1V (resistance 1.5 KΩ)

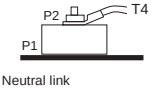


Connection of the optional current transformer

D connection In/2 12-wire
Secondary 1 A



D connection In/4 6-wire
A connection In/4 12-wire
Secondary 1 A



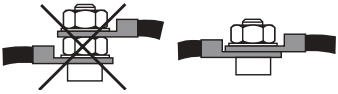
Neutral link

• Connection checks

Electrical installations must comply with the current legislation in force in the country of use.
Check that:
- The residual circuit-breaker conforms to legislation on protection of personnel, in force in the country of use, and has been correctly installed on the alternator power output as close as possible to the alternator. (In this case, disconnect the wire of the interference suppression module linking the neutral).
- Any protection devices in place have not been tripped.
- If there is an external AVR, the connections between the alternator and the cabinet are made in accordance with the connection diagram.
- There is no short-circuit phase-phase or phase-neutral between the alternator output terminals and the generator set control cabinet (part of the circuit not protected by circuitbreakers or relays in the cabinet).
- The machine should be connected with the busbar separating the terminals as shown in the terminal connection diagram.

- The alternator earth terminal inside the terminal box is connected to the electrical earth circuit
- The earth terminal is connected to the frame.

The connections inside the terminal box must never be subjected to stress due to cables connected by the user.



Diameter	M6	M8	M10	M12
Torque	4 Nm	10 Nm	20 Nm	35 Nm
Tolerance	± 15%			

3.4 - Commissioning

The machine can only be started up and used if the installation is in accordance with the regulations and instructions defined in this manual.

The machine is tested and set up at the factory. When first used with no load, make sure that the drive speed is correct and stable (see the nameplate). With the regreasable bearing option, we recommend greasing the bearings at the time of commissioning (see section 4.3).
On application of the load, the machine should achieve its rated speed and voltage; however, in the event of abnormal operation, the machine setting can be altered (follow the adjustment procedure in section 3.5). If the machine still operates incorrectly, the cause of the malfunction must be located (see section 4.5).

3.5 - Setting up

The various adjustments during tests must be made by a qualified engineer.
Ensure that the drive speed specified on the nameplate is reached before commencing adjustment.
After operational testing, replace all access panels or covers.
The AVR is used to make any adjustments to the machine.

4 - SERVICING - MAINTENANCE

4.1 - Safety measures

Servicing or troubleshooting must be carried out strictly in accordance with instructions so as to avoid the risk of accidents and to maintain the machine in its original state.

All such operations performed on the alternator should be undertaken by personnel trained in the commissioning, servicing and maintenance of electrical and mechanical components, who must wear personal protective equipment appropriate for mechanical and electrical hazards.

Before any intervention on the machine, ensure that it cannot be started by a manual or automatic system and that you have understood the operating principles of the system.

Warning : During and after running, the alternator will reach temperatures hot enough to cause injury, such as burns.

4.2 - Routine maintenance

• Checks after start-up

After approximately 20 hours of operation, check that all fixing bolts on the machine are still tight, plus the general state of the machine and the various electrical connections in the installation.

• Electrical servicing

Commercially-available volatile degreasing agents can be used.

WARNING

Do not use: trichlorethylene, perchlorethylene, trichloroethane or any alkaline products.

These operations must be performed at a cleaning station, equipped with a vacuum system that collects and flushes out the products used.

The insulating components and the impregnation system are not at risk of damage from solvents. Avoid letting the cleaning product run into the slots.

Apply the product with a brush, sponging frequently to avoid accumulation in the housing. Dry the winding with a dry cloth. Let any traces evaporate before reassembling the machine.

• Mechanical servicing

WARNING

Cleaning the machine using water or a highpressure washer is strictly prohibited. Any problems arising from such treatment are not covered by our warranty.

Degreasing: Use a brush and detergent (suitable for paintwork).

Dusting: Use an air gun.

If the machine is fitted with air inlet and outlet filters, the maintenance personnel should clean them routinely at regular intervals. In the case of dry dust, the filter can be cleaned using compressed air and/or replaced if it is clogged.

After cleaning the alternator, it is essential to check the winding insulation (see sections 3.2 and 4.5).

4.3 - Bearings

The bearings are permanently greased	Approximate life of the grease (depending on use) = 20,000 hours or 3 years.
As an option, the bearings are regreasable	Regreasing interval: 4500 hrs of operation DE bearing: Amount of grease: 60 gr NDE bearing: Amount of grease: 50 gr
Standard grease	LITHIUM - standard - NLGI 3
Grease used in the factory	ESSO - Unirex N3

It is imperative to lubricate the alternator during operation and on first use. Before using another grease, check for compatibility with the original one.

4.4 - Mechanical defects

Fault		Action
Bearing	Excessive overheating of one or both bearings (bearing temperature 80°C above the ambient temperature)	- If the bearing has turned blue or if the grease has turned black, change the bearing. - Bearing not fully locked (abnormal play in the bearing cage) - End shields incorrectly aligned
Abnormal temperature	Excessive overheating of alternator frame (more than 40° C above the ambient temperature)	- Air flow (inlet-outlet) partially clogged or hot air is being recycled from the alternator or engine - Alternator operating at too high a voltage (>105% of Un on load) - Alternator overloaded
Vibrations	Too much vibration	- Misalignment (coupling) - Defective mounting or play in coupling - Rotor balancing fault (Engine - Alternator)
	Excessive vibration and humming noise coming from the machine	- Phase imbalance - Stator short-circuit
Abnormal noise	Alternator damaged by a significant impact, followed by humming and vibration	- System short-circuit - Misparalleling Possible consequences - Broken or damaged coupling - Broken or bent shaft end - Shifting and short-circuit of main field - Fan fractured or coming loose on shaft - Irreparable damage to rotating diodes/AVR, surge suppressor

4.5 - Electrical faults

Fault	Action	Effect	Check/Cause
No voltage at no load on start-up	Connect a new battery of 4 to 12 volts to terminals E- and E+, respecting the polarity, for 2 to 3 seconds	The alternator builds up and its voltage is still correct when the battery is removed	- Lack of residual magnetism
		The alternator builds up but its voltage does not reach the rated value when the battery is removed	- Check the connection of the voltage reference to the AVR - Faulty diodes - Armature short-circuit
		The alternator builds up but its voltage disappears when the battery is removed	- Faulty AVR - Field windings disconnected - Main field winding open circuit (check the resistance)
Voltage too low	Check the drive speed	Correct speed	Check the AVR connections (AVR may be faulty) - Field windings short-circuited - Rotating diodes burnt out - Main field winding short-circuited - Check the resistance
		Speed too low	Increase the drive speed (Do not touch the AVR voltage pot. (P2) before running at the correct speed.)
Voltage too high	Adjust AVR voltage potentiometer	Adjustment ineffective	- Faulty AVR - 1 faulty diode
Voltage oscillations	Adjust AVR stability potentiometer	If no effect : try normal / fast recovery modes (ST2)	- Check the speed : possibility of cyclic irregularity - Loose connections - Faulty AVR - Speed too low when on load (or LAM set too high)
Voltage correct at no load and too low when on load	Run at no load and check the voltage between E+ and E- on the AVR	Voltage between E+ and E- AREP / PMG < 10V	- Check the speed (or LAM set too high)
		Voltage between E+ and E- AREP / PMG > 15V	- Faulty rotating diodes - Short-circuit in the main fiel (check the resistance) - Faulty exciter armature
Voltage disappears during operation	Check the AVR, the surge suppressor, the rotating diodes, and replace any defective components	The voltage does not return to the rated value	- Exciter winding open circuit - Faulty exciter armature - Faulty AVR - Main field open circuit or short-circuited

LSA 49.3
Low Voltage Alternator - 4 pole

• Checking the winding

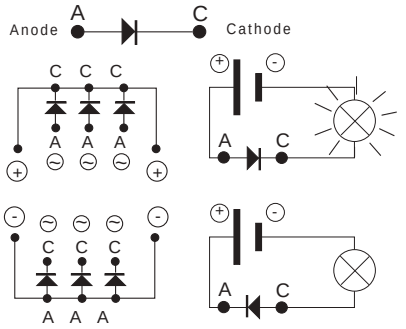
You can check the winding insulation by performing a high voltage test. In this case, you must disconnect all AVR wires.

WARNING

Damage caused to the AVR in such conditions is not covered by our warranty.

• Checking the diode bridge

A diode in good working order should allow the current to flow only in the anode-to-cathode direction.



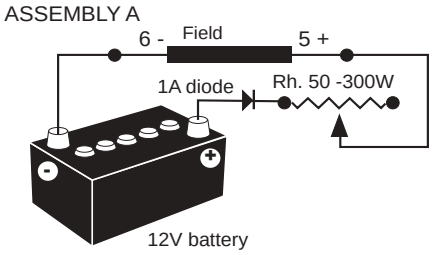
• Checking the windings and rotating diodes using separate excitation

During this procedure, make sure that the alternator is disconnected from any external load and inspect the terminal box to check that the connections are fully tightened.

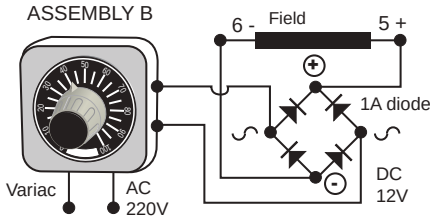
1) Stop the unit, disconnect and isolate the AVR wires.

2) There are two ways of creating an assembly with separate excitation.

Assembly A: Connect a 12 V battery in series with a rheostat of approximately 50 ohms - 300 W and a diode on both exciter field wires (5+) and (6-).



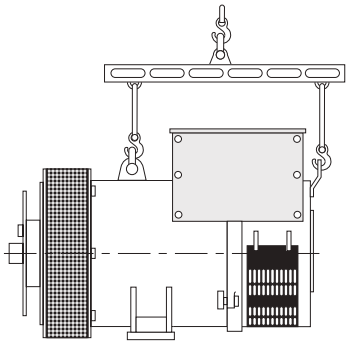
Assembly B: Connect a “Variac” variable power supply and a diode bridge on both exciter field wires (5+) and (6-).
Both these systems should have characteristics which are compatible with the field excitation power of the machine (see the nameplate).
3) Run the unit at its rated speed.
4) Gradually increase the exciter field current by adjusting the rheostat or the variac and measure the output voltages on L1 - L2 - L3, checking the excitation voltage and current at no load (see the machine nameplate or ask for the factory test report). When the output voltage is at its rated value and balanced within 1% for the rated excitation level, the machine is in good working order. The fault therefore comes from the AVR or its associated wiring (ie. sensing, auxiliary windings).



4.6 - Dismantling, reassembly

WARNING

During the warranty period, this operation should only be carried out in an approved workshop or in our factory, otherwise the warranty may be invalidated.
Whilst being handled, the machine should remain horizontal (rotor not locked in position). Check how much the machine weighs before choosing the lifting method.



• Tools required

To fully dismantle the machine, we recommend using the tools listed below:
- 1 ratchet spanner + extension
- 1 torque wrench
- 1 set of flat spanners: 8 mm, 10 mm, 18 mm
- 1 socket set: 8, 10, 13, 16, 18, 21, 24, 30 mm
- 1 puller (U35) / (U32/350)

• Bolt tightening torque

See section 5.4.

• Access to diodes

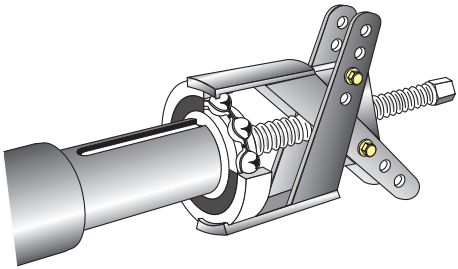
- Open the air intake grille (51).
- Disconnect the diodes.
- Disconnect the diodes using an ohmmeter or a battery lamp.
- Remove the surge suppressor (347) + 6 copper shunts.
- Remove the 6 “H” mounting nuts for the diode bridges on the support.
- Change the fitted caps, respecting the polarity.

• Access to connections and the regulation system

Access directly by removing the terminal box lid (48) or the AVR access door (59).

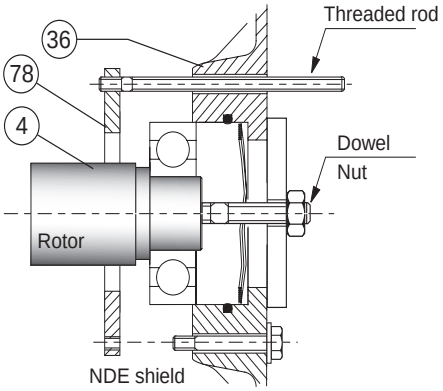
• Replacing the NDE bearing

- Remove the air intake grille (51).
- Remove the terminal box lid (48), the NDE panel (365) and the side panels (367).
- Disconnect the exciter wires (5+,6-).
- Disconnect the stator connections T4 to T6 (and T7 to T9 for versions 12 wires).
- Remove the neutral link (278).
- Remove the 4 bolts of bearing thrust (78).
- Remove the bolts and take out the bearing (36).
- Remove the ball bearing (70) using a puller with a central threaded bar (see fig. below).



- Fit the new antifriction bearing onto the shaft after heating it by induction to approximately 80 °C.
- Mount the new preloading (wavy) washer (79) + the new “O” ring seal (349) in the shield (36).
- Screw a threaded rod into the thrust bearing (78).
- Refit the end shield on the machine using a dowel and nut in the shaft extension (see drawing).

- Slide the threaded rod into the shield hole to make it easier to assemble (see basic diagram).



- Fit the thrust bearing bolts (78), remove the threaded rod, fit the other bolt and tighten up the assembly.
- Tighten the bearing bolts (37).
- Connect the stator connections and mount the neutral link (278).
- Reconnect exciter wires E+, E-.
- Finish reassembling the cover.

WARNING

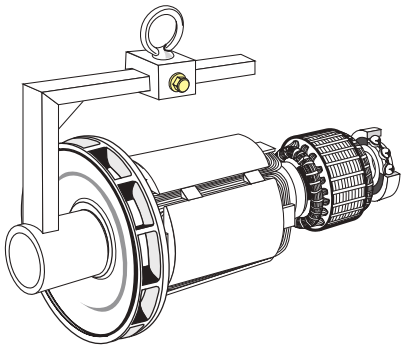
When dismantling the shields, you will need to change the antifriction bearings, the "O" ring seal, the preloading (wavy) washer and adhesive paste.

• Replacing the DE bearing

- Remove the air outlet grill (33).
- Remove the bolts from the DE shield and the 4 bolts from the inner bearing retainer.
- Remove the shield (30).
- Take out the ball bearing (60) using a puller with a central bolt.
- Fit the new bearing, after heating it by induction to approximately 80 °C.
- Screw a threaded rod into the thrust bearing (68).
- Refit the shield (30) on the machine.
- Slide the threaded rod into the shield hole to make it easier to assemble (see basic diagram).
- Tighten the bottom thrust bearing bolts (68), remove the threaded rod and fit the other bolts.
- Tighten the shield bolts.
- Refit the air outlet grill (33), respecting the initial angular position.

• Dismantling the rotor assembly

- Remove the NDE shield (36).
- Remove the DE shield (30) if it is a double-bearing machine.
- Support the DE rotor (4) with a strap or with a support constructed in accordance with the following drawing.
- Move the strap as the rotor moves in order to distribute the weight over it.



WARNING

When dismantling the rotor involves changing parts or rewinding, the rotor must be rebalanced.

• Reassembling the machine

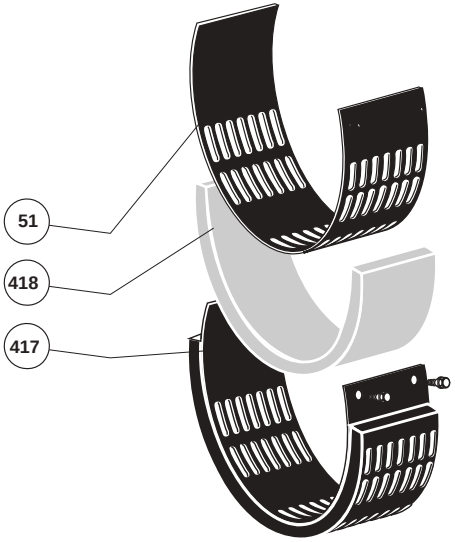
- Mount the rotor (4) in the stator (1) (see drawing above) taking care not to knock the windings.
- Slide the threaded rod into the shield hole to make it easier to assemble (see diagram).
- Fit the thrust bearing bolts (78), remove the threaded rod, fit the other screw and tighten up the assembly.
- Tighten the bearing bolts (37).

- Connect the stator connections and mount the neutral link (278).
- Reconnect exciter wires E+, E-.
- Finish reassembling the cover.
- Refit the flange (30) on the stator (1).
- Tighten the shield bolts.

If using a double-bearing machine:
- Finish reassembling the cover.
- Screw a threaded rod into the thrust bearing (68).
- Refit the shield (30) on the machine.
- Slide the threaded rod into the shield hole to make it easier to assemble (see basic diagram).
- Fit the thrust bearing bolts (68), remove the threaded rod, fit the other bolt and tighten up the assembly.
- Tighten the shield bolts.
- Refit the air outlet grill (33).
- Check that the machine assembly is correctly mounted and that all bolts are tightened.

• Dismantling and reassembly of the filters

- Remove the grille (417) then take out the filter (418) as shown below. Change the filter, if necessary, please refer to section 4.2 for cleaning the filter. To replace follow instructions in reverse order.



4.7 - Installation and maintenance of the PMG

The PMG reference is PMG 8.
See the PMG manual ref : 4211.

4.8 - Table of characteristics

Table of average values
Alternator - 4 poles - 50 Hz - Standard winding No. 6 (12-wire)
(400V for the excitation values)
The voltage and current values are given for no-load operation and operation at rated load with separate field excitation. All values are given at ± 10% and may be changed without prior notification (for exact values, consult the test report).

• Three-phase: 4-pole
SHUNT/AREP excitation
Resistances at 20 °C (Ω)

Type	Stator L/N	Rotor	Exciter field	Exciter armature
S4 (6-wire)	0.0037	0.333	11.55	0.069
S4 (12-wire)	0.0020	0.381	11.55	0.069
M6	0.0031	0.369	11.55	0.069
M8	0.0029	0.436	11.55	0.069
L9	0.0020	0.472	11.55	0.069
L10	0.0020	0.485	11.55	0.069

Resistances of auxiliary windings AREP at 20 °C (Ω)

Type	X1, X2	Z1, Z2
S4 (6-wire)	0.249	0.297
S4 (12-wire)	0.257	0.312
M6	0.201	0.260
M8	0.205	0.268
L9	0.204	0.262
L10	0.208	0.269

LSA 49.3
Low Voltage Alternator - 4 pole

Field excitation current i exc (A)
SHUNT/AREP - 400V - 50 Hz

"i exc": excitation current of the exciter field

Type	No load	At rated load
S4	1.1	4.2
M6	1	4.1
M8	1	3.8
L9	1	3.7
L10	1	3.8

For 60 Hz machines, the "i exc" values are approximately 5 to 10 % lower.

• Voltage of auxiliary windings at no load

Type	X1, X2	Z1, Z2
S4 (6-wire)	112	11
S4 (12-wire)	120	12
M6	100	12
M8	100	12
L9	122	17
L10	120	17

• Table of weights
(values given for information only)

Type	Total weight (kg)	Rotor (kg)
S4	1480	541
M6	1622	604
M8	1683	630
L9	1835	686
L10	1884	703

After operational testing, it is essential to replace all access panels or covers.

5 - SPARE PARTS

5.1 - First maintenance parts

Emergency repair kits are available as an option.
They contain the following items :

Emergency kit AREP/PMG	5163978
AVR D350	-
Diode bridge assembly	-
Surge suppressor	-

Single-bearing kit	4996460
Non drive end bearing	-
«O» ring	-
Preloading (wavy) washer	-

Double-bearing kit	4996457
Non drive end bearing	-
Drive end bearing	-
«O» ring	-
Preloading (wavy) washer	-

5.2 - Technical support service

Our technical support service will be pleased to provide any additional information you may require.

For all spare parts orders or technical support requests, send your request to service.epg@leroy-somer.com or your closest contact, whom you will find at www.lrsm.co/support indicating the complete type of machine, its number and the information indicated on the nameplate.

Part numbers should be identified from the exploded views and their description from the parts list.

To ensure that our products operate correctly and safely, we recommend the use of original manufacturer spare parts.
In the event of failure to comply with this advice, the manufacturer cannot be held responsible for any damage.

After operational testing, it is essential to replace all access panels or covers.

5.3 - Accessories

• Space heater when stopped

The space heater must run as soon as the alternator stops. It is installed at the rear of the alternator. Its standard power is 250W with 220V or 250W with 110V on request.

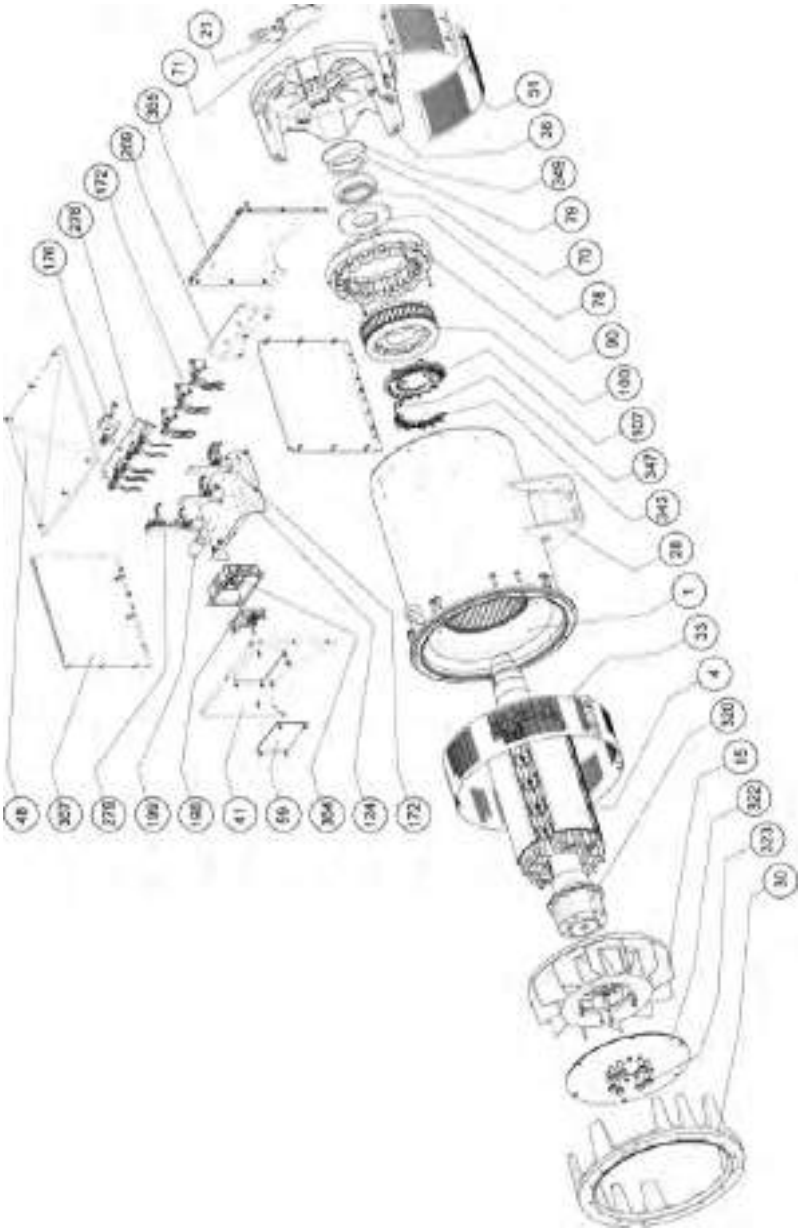
Caution : the power supply is present when the alternator has stopped.

• Temperature probes with thermistors (CTP)

These are thermistor triplets with a positive temperature coefficient installed in the stator winding (1 per phase). There can be a maximum of 2 triplets in the winding (at 2 levels : warning and trip) and 1 thermistor in the rear bearing.
These sensors must be linked to adapted sensing relays (supplied optionally).
Cold resistance of cold thermistor sensors : 100 to 250 Ω per probe.

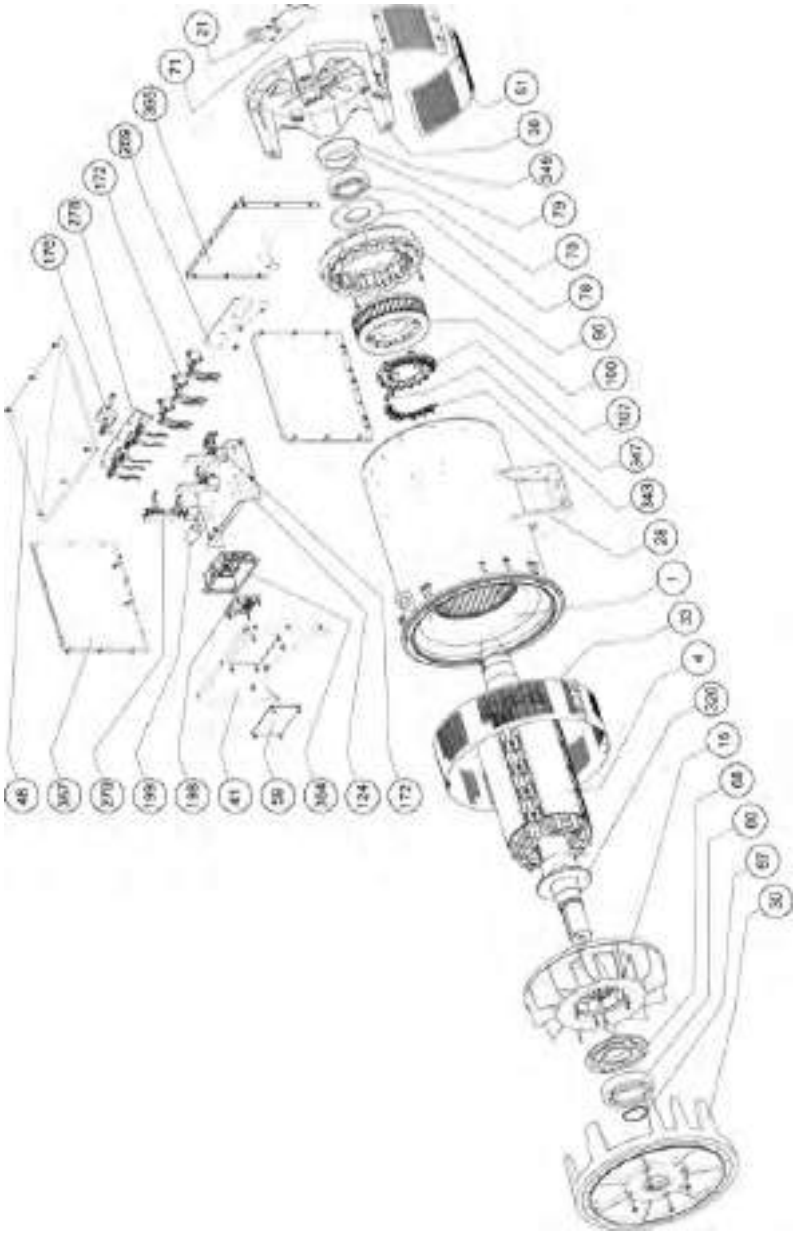
5.4 - Exploded views, parts list and tightening torque

• Single-bearing



LSA 49.3
Low Voltage Alternator - 4 pole

• Two-bearing



LSA 49.3
Low Voltage Alternator - 4 pole

Ref.	Qty	Description	Screw Ø	Torque N.m	Ref.	Qty	Description	Screw Ø	Torque N.m
1	1	Stator assembly	-	-	100	1	Exciter armature (rotor)	-	-
4	1	Rotor assembly	-	-	107	1	Diode support ring	-	-
15	1	Fan	-	-	124	1	Terminal block	M8	26
21	1	Lifting eye	-	-	172	-	Isolator	M8	26
28	1	Earth terminal	M12	69	176	1	Current transformer	-	-
30	1	Drive end (DE) shield	-	-	198	1	Voltage regulator (AVR)	M5	6
33	1	Protective guard	M6	8.3	199	1	Interference suppression module (RFI kit)	-	-
36	1	Non drive end (NDE) shield	-	-	269	1	Non drive end (NDE) cross-member	M8	26
41	1	Terminal box front panel	M8	20	278	1	Neutral bar	M12	35
48	1	Terminal box lid	M6	8.3	279	3	Connection bar	M12	35
51	1	Air intake guard	M6	8.3	320	1	Coupling sleeve	-	-
59	1	AVR access panel	M6	8.3	322	3	Coupling discs	-	-
60	1	Drive end (DE) bearing	-	-	323	8	Fixing bolts	M20	340
67	1	Circlips	-	-	343	1	Diode bridge assembly	M6	4
68	4	Inner bearing retainer	M10	40	347	1	Surge suppressor (+ PCB)	-	-
70	1	Non drive end (NDE) bearing	-	-	349	1	O ring seal	-	-
71	1	Outer bearing retainer	-	-	364	1	AVR support	-	-
78	1	Inner bearing retainer	M10	40	365	1	Terminal box rear panel	M8	20
79	1	Preloading (wavy) washer	-	-	367	1	Terminal box side panel	M8	20
90	1	Exciter field (stator)	M8	20					

Disposal and recycling instructions

We are committed to limiting the environmental impact of our activity. We continuously monitor our production processes, material sourcing and product design to improve recyclability and minimise our environmental footprint.

These instructions are for information purposes only. It is the user's responsibility to comply with local legislation regarding product disposal and recycling.

Recyclable materials

Our alternators are mainly constructed from iron, steel and copper materials, which can be reclaimed for recycling purposes.

These materials can be reclaimed through a combination of manual dismantling, mechanical separation and melting processes. Our technical support department can provide detailed directions on how to dismantle products on request.

Waste & hazardous materials

The following components and materials require special treatment and must be separated from the alternator before the recycling process:

- electronic materials found in the terminal box, including the automatic voltage regulator (198), current transformers (176), interference suppression module (199) and other semi-conductors.

- diode bridge (343) and surge suppressor (347), found on the alternator rotor.

- major plastic components, such as the terminal box structure on some products. These components are usually marked with information concerning the type of plastic.

All materials listed above need special treatment to separate waste from reclaimable materials and should be entrusted to specialist recycling companies.

The oil and grease from the lubrication system should be treated as hazardous waste and must be treated in accordance with local legislation.

LSA 49.3
Low Voltage Alternator - 4 pole

Declaration of EC compliance and incorporation

This Declaration applies to the generators designed to be incorporated into machines complying with the Machinery Directive Nr 2006/42/EC dated 17 May 2006.

MOTEURS LEROY-SOMER
Boulevard Marcellin Leroy
16015 ANGOULEME
FRANCE

MLS HOLICE STLO.SRO
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DIVISION LEROY-SOMER
STREET EMERSON
Nr4 Parcul Industrial Tetarom 2
4000641 CLUJ NAPOCA
ROMANIA

Declares hereby that the electric generators of the types:

LSA40, LSA42.3, LSA44.2, LSA44.3, LSA46.2, LSA46.3, LSA47.2, LSA49.1, LSA49.3, LSA50.1, LSA50.2, LSA51.2, LSA52.2, LSA52.3, LSA53.1, LSA53, LSA53.2, LSA54, LSA54.2, TAL040, TAL042, TAL044, TAL046, TAL047, TAL049, as well as their derivatives, manufactured by Leroy-Somer or on Leroy-Somer's behalf, comply with the following International Standards and Directive:

- EN and IEC 60034-1, 60034-5 and 60034-22
- ISO 8528-3 “Reciprocating internal combustion engine driven alternating current generating sets. Part 3. Alternating current generators for generating sets”
- Low Voltage Directive Nr 2014/35/UE dated 26 February 2014

Furthermore, these generators, designed in compliance with the Machine Directive Nr 2006/42, are therefore able to be incorporated into Electrical Gen-Sets complying with the following International Directives:

- Machinery Directive Nr 2006/42/EC dated 17 May 2006
- EMC Directive Nr 2014/30/UE dated 26 February 2014, as intrinsic levels of emissions and immunity are concerned

WARNING:

The here mentioned generators should not be commissioned until the corresponding Gen-Sets have been declared in compliance with the Directives Nr 2006/42/EC and 2014/30/UE, as well as with the other relevant Directives.

Leroy-Somer undertakes to transmit, in response to a reasoned request by the national authorities, relevant information on the generator.

Technical Managers
J.P. CHARPENTIER Y. MESSIN

4152 en - 2017.05 / m

The contractual EC Declaration of Conformity and Incorporation can be obtained from your contact on request.

LSA 49.3
Low Voltage Alternator - 4 pole

Service & Support

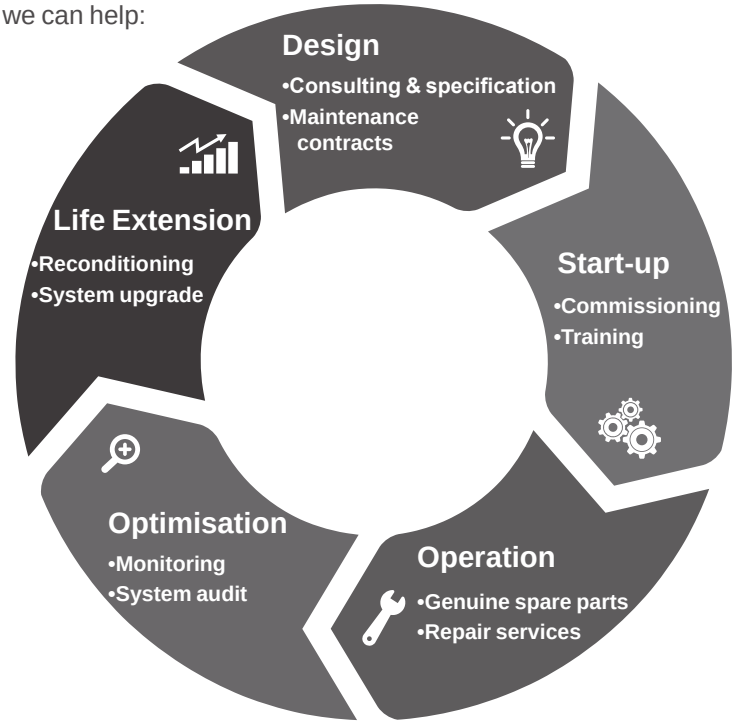
Our worldwide service network of over 80 facilities is at your service.

This local presence is our guarantee for fast and efficient repair, support and maintenance services.

Trust your alternator maintenance and support to electric power generation experts. Our field personnel are 100% qualified and fully trained to operate in all environments and on all machine types.

We have a deep understanding of alternator operation, providing the best value service to optimise your cost of ownership.

Where we can help:



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All for dreams

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DEEP SEA ELECTRONICS PLC
DSE8610 Control Module

Document number 057-115

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DSE Model 8610 series Control and Instrumentation System Operators Manual

Amendments since last publication

Issue no.	Comments
1	First Release
2	Added ROCOF & Vector shift
3	Added Ethernet
4	Added 'MSC OLD UNITS ON BUS' alarm description
5	Added Data logging

Clarification of notation used within this publication.

NOTE:	Highlights an essential element of a procedure to ensure correctness.
CAUTION!	Indicates a procedure or practice, which, if not strictly observed, could result in damage or destruction of equipment.
WARNING!	Indicates a procedure or practice, which could result in injury to personnel or loss of life if not followed correctly.

TABLE OF CONTENTS

Section Page

1 BIBLIOGRAPHY

This document refers to and is referred to by the following DSE publications which can be obtained from the DSE website www.deepseaplc.com

1.1 INSTALLATION INSTRUCTIONS

Installation instructions are supplied with the product in the box and are intended as a 'quick start' guide only.

DSE PART	DESCRIPTION
053-xxx	DSE8600 Installation Instructions
053-032	DSE2548 LED Expansion Annunciator Installation Instructions
053-033	DSE2130 Input Expansion Installation Instructions
053-034	DSE2157 Output Expansion Installation Instructions

1.2 TRAINING GUIDES

Training Guides are produced to give 'handout' sheets on specific subjects during training sessions.

DSE PART	DESCRIPTION
056-005	Using CTs With DSE Products
056-010	Overcurrent Protection
056-022	Breaker Control
056-019	Earth Fault Protection
056-024	GSM Modem
056-029	Smoke Limiting
056-030	Module PIN Codes

1.3 MANUALS

DSE PART	DESCRIPTION
057-004	Electronic Engines And DSE Wiring Manual
057-082	DSE2130 Input Expansion Manual
057-083	DSE2157 Output Expansion Manual
057-084	DSE2548 Annunciator Expansion Manual
057-119	DSE8600 Series Configuration Software Manual
057-120	DSE866 Operator Manual

2 INTRODUCTION

This document details the installation and operation requirements of the DSE8610 Series modules, part of the DSEPower® range of products.
The manual forms part of the product and should be kept for the entire life of the product. If the product is passed or supplied to another party, ensure that this document is passed to them for reference purposes.
This is not a *controlled document.* You will not be automatically informed of updates. Any future updates of this document will be included on the DSE website at www.deepseaplc.com

The **DSE8600 series** is designed to provide differing levels of functionality across a common platform. This allows the generator OEM greater flexibility in the choice of controller to use for a specific application.

The **DSE8600 series** module has been designed to allow the operator to start and stop the generator, and if required, transfer the load to the generator either manually (via fascia mounted push-buttons) or automatically.

Synchronsing and Load Sharing features are included within the controller, along with the necessary protections for such a system.

The user also has the facility to view the system operating parameters via the LCD display.

The **DSE8600** module monitors the engine, indicating the operational status and fault conditions, automatically shutting down the engine and giving a true first up fault condition of an engine failure by a COMMON AUDIBLE ALARM. The LCD display indicates the fault.

The powerful ARM microprocessor contained within the module allows for incorporation of a range of complex features:

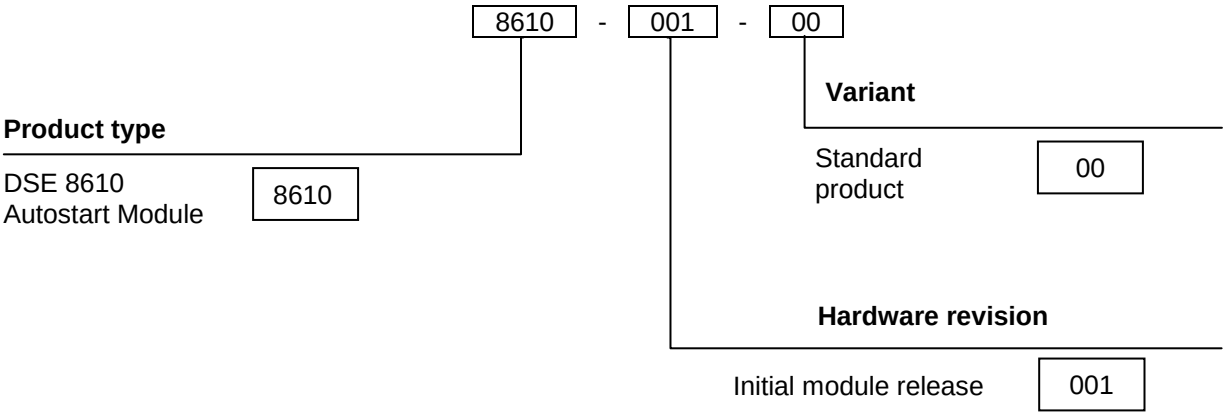
- *Text based LCD display (supporting multiple languages).*
- ***True RMS** Voltage, Current and Power monitoring.*
- *Engine parameter monitoring.*
- *Fully configurable inputs for use as alarms or a range of different functions.*
- *Engine ECU interface to **electronic engines**.*
- *Direct connection to governor / AVR for synchronising and load sharing*
- *R.O.C.O.F. and Vector shift for detection of mains failure when in parallel with the mains supply.*

Using a PC and the Configuration Suite software allows alteration of selected operational sequences, timers and alarms.

Additionally, the module's integral fascia configuration editor allows adjustment of a subset of this information.
A robust plastic case designed for front panel mounting houses the module. Connections are via locking plug and sockets.

3 SPECIFICATIONS

3.1 PART NUMBERING



At the time of this document production, there are no variants of this product.

3.1.1 SHORT NAMES

Short name	Description
DSE8600, DSE86xx	All modules in the DSE8600 Series

3.2 TERMINAL SPECIFICATION

Connection type	Two part connector. • Male part fitted to module • Female part supplied in module packing case - Screw terminal, rising clamp, no internal spring.	 Example showing cable entry and screw terminals of a 10 way connector
Minimum cable size	0.5mm² (AWG 24)	
Maximum cable size	2.5mm² (AWG 10)	

NOTE: For purchasing additional connector plugs from DSE, please see the section entitled *Maintenance, Spares, Repair and Servicing* elsewhere in this document.

3.3 POWER SUPPLY REQUIREMENTS

Minimum supply voltage	8V continuous
Cranking dropouts	Able to survive 0V for 50mS providing the supply was at least 10V before the dropout and recovers to 5V afterwards. This is more than sufficient to allow the module to operate during engine cranking where the battery supply often falls as low as 4V (on a 12V system!) This is achieved without the need for internal batteries or other external requirements.
Maximum supply voltage	35V continuous (60V protection for surges)
Reverse polarity protection	-35V continuous
Maximum operating current	300mA at 24V 600mA at 12V
Maximum standby current	190mA at 24V 390mA at 12V

Plant supply instrumentation display

Range	0V-70V DC (note Maximum continuous operating voltage of 35V DC)
Resolution	0.1V
Accuracy	±1% full scale (±0.7V)

3.4 GENERATOR AND BUS VOLTAGE / FREQUENCY SENSING

Measurement type	True RMS conversion
Sample Rate	5KHz or better
Harmonics	Up to 10th or better
Input Impedance	300K Ω ph-N
Phase to Neutral	15V (minimum required for sensing frequency) to 333V AC (absolute maximum) Suitable for 110V to 277V nominal (±20% for under/overvoltage detection)
Phase to Phase	26V (minimum required for sensing frequency) to 576V AC (absolute maximum) Suitable for 190V ph-ph to 479V ph-ph nominal (±20% for under/overvoltage detection)
Common mode offset from Earth	100V AC (max)
Resolution	1V AC phase to neutral 2V AC phase to phase
Accuracy	±1% of full scale phase to neutral (±3.33V ph-N) ±2% of full scale phase to phase (±11.52V ph-ph)
Minimum frequency	3.5Hz
Maximum frequency	75.0Hz
Frequency resolution	0.1Hz
Frequency accuracy	±0.2Hz

3.5 GENERATOR CURRENT SENSING

Measurement type	True RMS conversion
Sample Rate	5KHz or better
Harmonics	Up to 10th or better
Nominal CT secondary rating	1A or 5A (5A recommended)
Maximum continuous current	5A
Overload Measurement	3 x Nominal Range setting
Absolute maximum overload	50A for 1 second
Burden	0.5VA (0.02Ω current shunts)
common mode offset	±2V peak plant ground to CT common terminal
Resolution	0.5% of 5A
Accuracy	±1% of Nominal (1A or 5A) (excluding CT error)

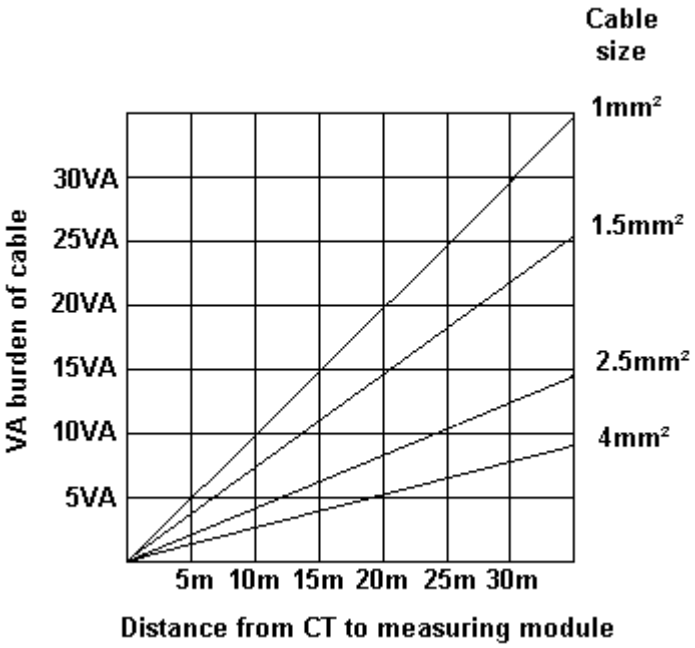
3.5.1 VA RATING OF THE CTS

The VA burden of the DSE8610 module on the CTs is 0.5VA. However depending upon the type and length of cabling between the CTs and the DSE8610 module, CTs with a greater VA rating than the module are required.

The distance between the CTs and the measuring module should be estimated and cross-referenced against the chart opposite to find the VA burden of the cable itself.

If the CTs are fitted within the alternator top box, the star point (common) of the CTs should be connected to system ground (earth) as close as possible to the CTs. This minimises the length of cable used to connect the CTs to the DSE module.

Example.
If 1.5mm² cable is used and the distance from the CT to the measuring module is 20m, then the burden of the cable alone is approximately 15VA. As the burden of the DSE controller is 0.5VA, then a CT with a rating of at least 15+0.5V = 15.5VA must be used. If 2.5mm² cables are used over the same distance of 20m, then the burden of the cable on the CT is approximately 7VA. CT's required in this instance is at least 7.5VA (7+0.5).

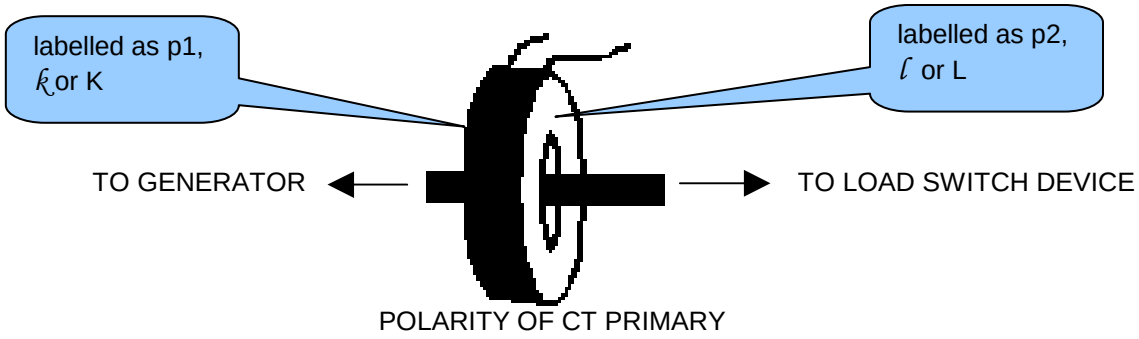


NOTE: - Details for 4mm² cables are shown for reference only. The connectors on the DSE modules are only suitable for cables up to 2.5mm².

NOTE: - CTs with 5A secondary windings are recommended with DSE modules. 1A CTs can be used if necessary however, the resolution of the readings is 5 times better when using 5A CTs.

3.5.2 CT POLARITY

Take care to ensure the correct polarity of the CTs. Incorrect CT orientation will lead to negative kW readings when the set is supplying power. Take note that paper stick-on labels on CTs that show the orientation are often incorrectly placed on the CT (!). It is more reliable to use the labelling in the case moulding as an indicator to orientation (if available).
To test orientation, run the generator in island mode (not in parallel with any other supply) and load the generator to around 10% of the set rating. Ensure the DSE module shows positive kW for all three individual phase readings.



NOTE:- Take care to ensure correct polarity of the CT primary as shown above. If in doubt, check with the CT supplier.

3.5.3 CT PHASING

Take particular care that the CTs are connected to the correct phases. For instance, ensure that the CT on phase 1 is connected to the terminal on the DSE module intended for connection to the CT for phase 1.
Additionally ensure that the voltage sensing for phase 1 is actually connected to generator phase 1.
Incorrect connection of the phases as described above will result in incorrect power factor (pf) measurements, which in turn results in incorrect kW measurements.
One way to check for this is to make use of a single-phase load. Place the load on each phase in turn, run the generator and ensure the kW value appears in the correct phase. For instance if the load is connected to phase 3, ensure the kW figure appears in phase 3 display and not in the display for phase 1 or 2.

3.5.4 CT CLASS

Ensure the correct CT type is chosen. For instance if the DSE module is providing overcurrent protection, ensure the CT is capable of measuring the overload level you wish to protect against, and at the accuracy level you require. For instance, this may mean fitting a protection class CT (P10 type) to maintain high accuracy while the CT is measuring overload currents.
Conversely, if the DSE module is using the CT for instrumentation only (current protection is disabled or not fitted to the controller), then measurement class CTs can be used. Again, bear in mind the accuracy you require. The DSE module is accurate to better than 1% of the full-scale current reading. To maintain this accuracy you should fit Class 0.5 or Class 1 CTs.

You should check with your CT manufacturer for further advice on selecting your CTs

3.6 INPUTS

3.6.1 DIGITAL INPUTS

Number	11 configurable inputs
Arrangement	Contact between terminal and ground
Low level threshold	2.1V minimum
High level threshold	6.6V maximum
Maximum input voltage	+50V DC with respect to plant supply negative
Minimum input voltage	-24V DC with respect to plant supply negative
Contact wetting current	7mA typical
Open circuit voltage	12V typical

3.6.2 ANALOGUE INPUTS

Oil Pressure (Configurable if engine ECU link provides oil pressure measurement)

Measurement type	Resistance measurement by measuring voltage across sensor with a fixed current applied
Arrangement	Differential resistance measurement input
Measurement current	15mA
Full scale	240Ω
Over range / fail	270Ω
Resolution	0.1 Bar (1-2 PSI)
Accuracy	±2% of full scale resistance (±4.8Ω) excluding transducer error
Max common mode voltage	±2V
Display range	13.7 bar (0-200 PSI) subject to limits of the sensor

Coolant Temperature (Configurable if engine ECU link provides coolant temp measurement)

Measurement type	Resistance measurement by measuring voltage across sensor with a fixed current applied
Arrangement	Differential resistance measurement input
Measurement current	10mA
Full scale	480Ω
Over range / fail	540Ω
Resolution	1°C (2℉)
Accuracy	+/-2% of full scale resistance (±9.6Ω) excluding transducer error
Max common mode voltage	±2V
Display range	0°C -140°C (32℉ - 284℉) subject to limits of the sensor

Flexible sensor

Number	2
Measurement type	Resistance measurement by measuring voltage across sensor with a fixed current applied
Arrangement	Differential resistance measurement input
Measurement current	10mA
Full scale	480Ω
Over range / fail	540Ω
Resolution	1%
Accuracy	±2% of full scale resistance (±9.6Ω) excluding transducer error
Max common mode voltage	±2V
Display range	0-250%

3.6.3 CHARGE FAIL INPUT

Minimum voltage	0V
Maximum voltage	35V (plant supply)
Resolution	0.2V
Accuracy	±1% of max measured voltage (±0.35V)
Excitation	Active circuit constant power output
Output Power	2.5W Nominal @12V and 24V
Current at 12V	210mA
Current at 24V	104mA

The charge fail input is actually a combined input and output.
Whenever the generator is required to run, the terminal provides excitation current to the charge alternator field winding.
When the charge alternator is correctly charging the battery, the voltage of the terminal is close to the plant battery supply voltage. In a failed charge situation, the voltage of this terminal is pulled down to a low voltage. It is this drop in voltage that triggers the *charge failure* alarm. The level at which this operates and whether this triggers a warning or shutdown alarm is configurable using the DSE Config Suite Software.

3.6.4 MAGNETIC PICKUP

Type	Differential input
Minimum voltage	0.5V RMS
Max common mode voltage	±2V
Maximum voltage	Clamped to ±70V by transient suppressors
Maximum frequency	10,000Hz
Resolution	6.25 RPM
Accuracy	±25 RPM
Flywheel teeth	10 to 500

NOTE : DSE can supply a suitable magnetic pickup device, available in two body thread lengths :
DSE Part number 020-012 - Magnetic Pickup probe 5/8 UNF 2½" thread length
DSE Part number 020-013 - Magnetic Pickup probe 5/8 UNF 4" thread length

Magnetic Pickup devices can often be 'shared' between two or more devices. For example, one device can often supply the signal to both the DSE8600 series module and the engine governor. The possibility of this depends upon the amount of current that the magnetic pickup can supply.

3.7 OUTPUTS

Ten (10) digital outputs are fitted to the DSE8610 controller. Additional outputs are provided for by adding up to ten (10) external relay boards (DSE2157). This allows for up to 80 additional digital outputs.

3.7.1 OUTPUTS A & B

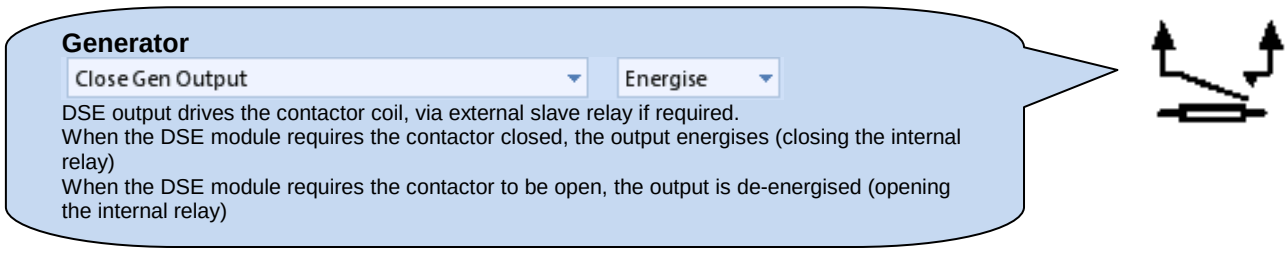
Type	Normally used for Fuel / Start outputs. Fully configurable for other purposes if the module is configured to control an electronic engine. Supplied from Emergency Stop terminal 3.
Rating	15A resistive @ 35V

3.7.2 OUTPUTS C & D

Type	Voltage free relays, fully configurable, normally used for generator / mains load switch control.
Rating	8A resistive @ 250 V AC

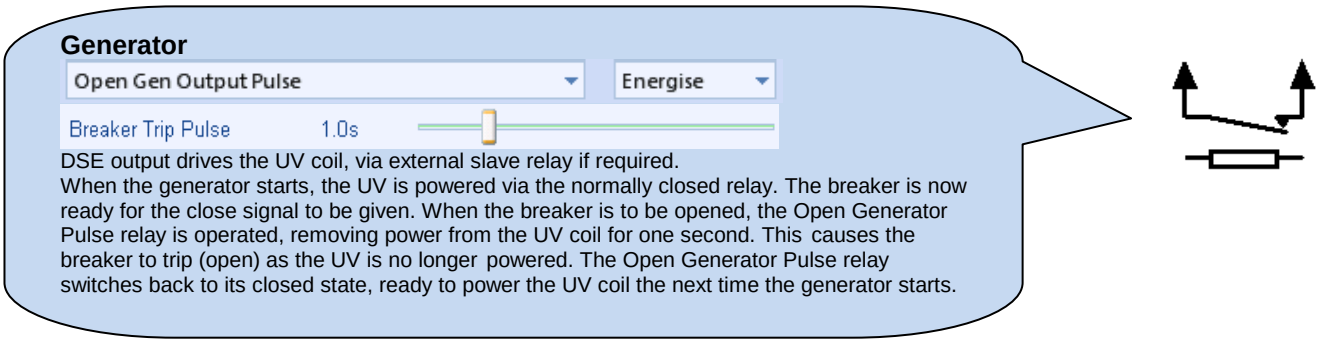
3.7.2.1 CONTACTOR COILS

Use output D, the normally open relay:



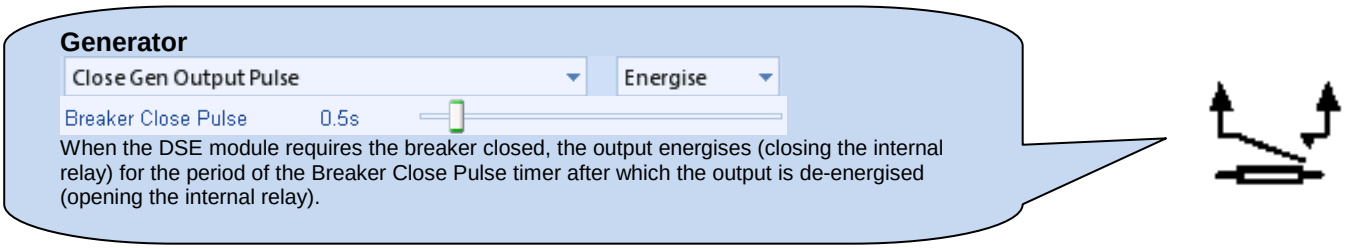
3.7.2.2 UNDERVOLTAGE (UV COILS)

Use output C, the normally closed relay :



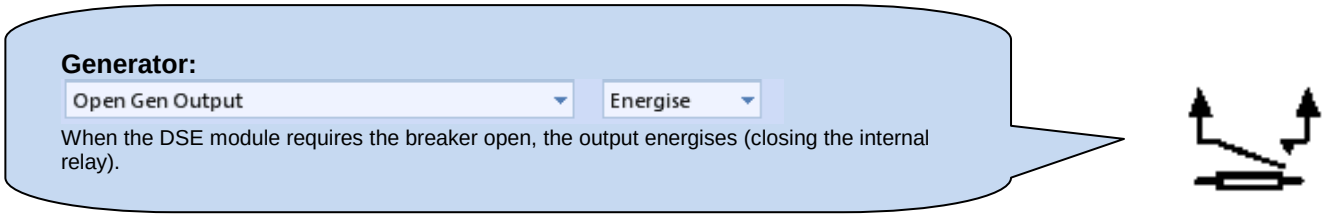
3.7.2.3 CLOSING COILS

For continuous closing signals (close signal is present continuously when the breaker is closed), follow the instructions above as for *Contactor Coils*.
For momentary (pulsed) closing signals, use OUTPUT D, the normally open relay:

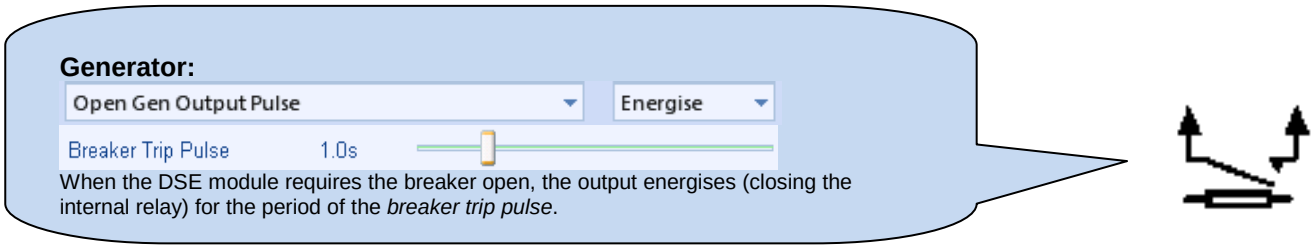


3.7.2.4 OPENING COILS / SHUNT TRIP COILS

For Continuous opening signal, use output D, the normally open relay:



For momentary (pulsed) closing signals, use a normally open relay:



3.7.3 OUTPUTS E,F,G,H, I & J

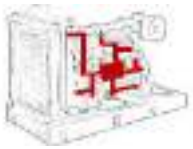
Number	6
Type	Fully configurable, supplied from DC supply terminal 2.
Rating	3A resistive @ 35V

3.8 COMMUNICATION PORTS

USB Port	USB2.0 Device for connection to PC running DSE configuration suite only Max distance 6m (yards)
Serial Communication	RS232 and RS485 are both fitted but and provide independent operation
RS232 Serial port	Non – Isolated port Max Baud rate 115K baud subject to S/W TX, RX, RTS, CTS, DSR, DTR, DCD Male 9 way D type connector Max distance 15m (50 feet)
RS485 Serial port	Isolated Data connection 2 wire + common Half Duplex Data direction control for Transmit (by s/w protocol) Max Baud Rate 19200 External termination required (120Ω) Max common mode offset 70V (on board protection transorb) Max distance 1.2km (¾ mile)
CAN Port	Engine CAN Port Standard implementation of 'Slow mode', up to 250K bits/s Non-Isolated. Internal Termination provided (120Ω) Max distance 40m (133 feet)
Ethernet	Auto detecting 10/100 Ethernet port.

3.9 COMMUNICATION PORT USAGE

3.9.1 CAN INTERFACE



Modules are fitted with the CAN interface as standard and are capable of receiving engine data from engine CAN controllers compliant with the CAN standard.
CAN enabled engine controllers monitor the engine's operating parameters such as engine speed, oil pressure, engine temperature (among others) in order to closely monitor and control the engine. The industry standard communications interface (CAN) transports data gathered by the engine controller interface. This allows generator controllers such as the DSE8600 series to access these engine parameters with no physical connection to the sensor device.

NOTE:- For further details for connections to CAN enabled engines and the functions available with each engine type, refer to the manual *Electronic Engines and DSE Wiring.* Part No. 057-004

3.9.2 USB CONNECTION

The USB port is provided to give a simple means of connection between a PC and the DSE8600 series controller. Using the DSE Configuration Suite Software, the operator is then able to control the module, starting or stopping the generator, selecting operating modes, etc.
Additionally, the various operating parameters (such as output volts, oil pressure, etc.) of the remote generator are available to be viewed or changed.

To connect a DSE8600 series module to a PC by USB, the following items are required:

- DSE8600 series module

- DSE 8600 series configuration software
  (Supplied on configuration suite software CD or available from www.deepseaplc.com).

- USB cable Type A to Type B.
  (This is the same cable as often used between a PC and a USB printer)

  DSE can supply this cable if required :
  PC Configuration interface lead (USB type A – type B) DSE Part No 016-125

NOTE:- The DC supply must be connected to the module for configuration by PC.

NOTE:- Refer to DSE8600 series Configuration Suite Manual (DSE part 057-119) for further details on configuring, monitoring and control.

3.9.3 USB HOST-MASTER (USB DRIVE CONNECTION)

Capability to add USB Host facility for USB ‘Pendrive’ type interface for data recording
Connector Type A.
For data logging max maximum size 16Gb.(see viewing the instrument pages)

NOTE:- Refer to DSE8600 series Configuration Suite Manual (DSE part 057-119) for further details on configuring, monitoring and control.

3.9.4 RS232

The RS232 port on the DSE8600 series controller supports the Modbus RTU protocol.
The Gencomm register table for the controller is available upon request from the DSE Technical Support Department.

RS232 is for short distance communication (max 15m) and is typically used to connect the DSE86xx series controller to a telephone or GSM modem for more remote communications.

Many PCs are not fitted with an internal RS232 serial port. DSE DOES NOT recommend the use of USB to RS232 convertors but can recommend PC add-ons to provide the computer with an RS232 port.

Recommended PC Serial Port add-ons (for computers without internal RS232 port):
Remember to check these parts are suitable for your PC. Consult your PC supplier for further advice.

- Brainboxes PM143 PCMCIA RS232 card (for laptop PCs)

- Brainboxes VX-001 Express Card RS232 (for laptops and nettops PCs)

- Brainboxes UC246 PCI RS232 card (for desktop PCs)

- Brainboxes PX-246 PCI Express 1 Port RS232 1 x 9 Pin (for desktop PCs)

Supplier:
Brainboxes
Tel: +44 (0)151 220 2500
Web: http://www.brainboxes.com
Email: Sales:sales@brainboxes.com

NB DSE Have no business tie to Brainboxes. Over many years, our own engineers have used these products and are happy to recommend them.

RECOMMENDED EXTERNAL MODEMS:

- Multitech Global Modem – MultiModem ZBA (PSTN)
  DSE Part Number 020-252
  (Contact DSE Sales for details of localisation kits for these modems)

- Wavecom Fastrak Supreme GSM modem kit (PSU, Antenna and modem)*
  DSE Part number 0830-001-01

- Brodersen GSM Industrial Modem*
  DSE Part number 020-245

NOTE: *For GSM modems a SIM card is required, supplied by your GSM network provider :

- For SMS only, a ‘normal’ voice SIM card is required. This enables the controller to send SMS messages to designated mobile phones upon status and alarm conditions.
- For a data connection to a PC running DSE Configuration Suite Software, a ‘special’ CSD (Circuit Switched Data) SIM card is required that will enable the modem to answer an incoming data call. Many ‘pay as you go’ services will not provide a CSD (Circuit Switched Data) SIM card.

3.9.5 RS485

The RS485 port on the DSE8600 series controller supports the Modbus RTU protocol.
The DSE Gencomm register table for the controller is available upon request from the DSE Technical Support Department.

RS485 is used for point-to-point cable connection of more than one device (maximum 32 devices) and allows for connection to PCs, PLCs and Building Management Systems (to name just a few devices).

One advantage of the RS485 interface is the large distance specification (1.2km when using Belden 9841 (or equivalent) cable. This allows for a large distance between the DSE8600 series module and a PC running the DSE Configuration Suite software. The operator is then able to control the module, starting or stopping the generator, selecting operating modes, etc.
The various operating parameters (such as output volts, oil pressure, etc.) of the remote generator can be viewed or changed.

NOTE:- For a single module to PC connection and distances up to 6m (8yds) the USB connection method is more suitable and provides for a lower cost alternative to RS485 (which is more suited to longer distance connections).

Recommended PC Serial Port add-ons (for computers without internal RS485 port).
Remember to check these parts are suitable for your PC. Consult your PC supplier for further advice.

- Brainboxes PM154 PCMCIA RS485 card (for laptops PCs)
  Set to ‘Half Duplex, Autogating” with ‘CTS True’ set to ‘enabled’

- Brainboxes VX-023 ExpressCard 1 Port RS422/485 (for laptops and nettop PCs)

- Brainboxes UC320 PCI Velocity RS485 card (for desktop PCs)
  Set to ‘Half Duplex, Autogating” with ‘CTS True’ set to ‘enabled’

- Brainboxes PX-324 PCI Express 1 Port RS422/485 (for desktop PCs)

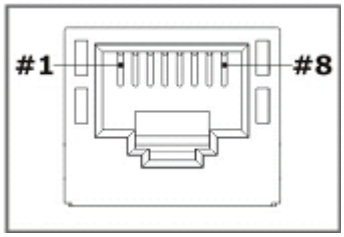
Supplier:
Brainboxes
Tel: +44 (0)151 220 2500
Web: http://www.brainboxes.com
Email: Sales:sales@brainboxes.com

NB DSE Have no business tie to Brainboxes. Over many years, our own engineers have used these products and are happy to recommend them.

3.9.6 ETHERNET

The DSE8610 is fitted with ETHERNET socket for connection to LAN (local area networks)

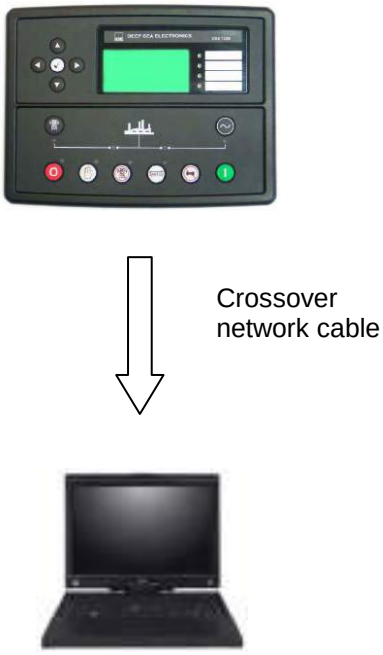
	Description
1	TX+
2	TX-
3	RX+
4	Do not connect
5	Do not connect
6	RX-
7	Do not connect
8	Do not connect



3.9.6.1 DIRECT PC CONNECTION

Requirements

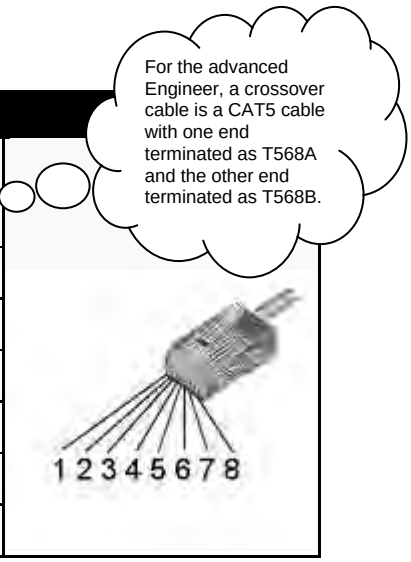
- DSE8610
- Crossover Ethernet cable (see Below)
- PC with Ethernet port and Windows Internet Explorer 6 or above, Firefox



Crossover cable wiring detail

Two pairs crossed, two pairs uncrossed
10baseT/100baseTX crossover

Pin	Connection 1 (T568A)	Connection 2 (T568B)
1	white/green stripe	white/orange stripe
2	green solid	orange solid
3	white/orange stripe	white/green stripe
4	blue solid	blue solid
5	white/blue stripe	white/blue stripe
6	orange solid	green solid
7	white/brown stripe	white/brown stripe
8	brown solid	brown solid

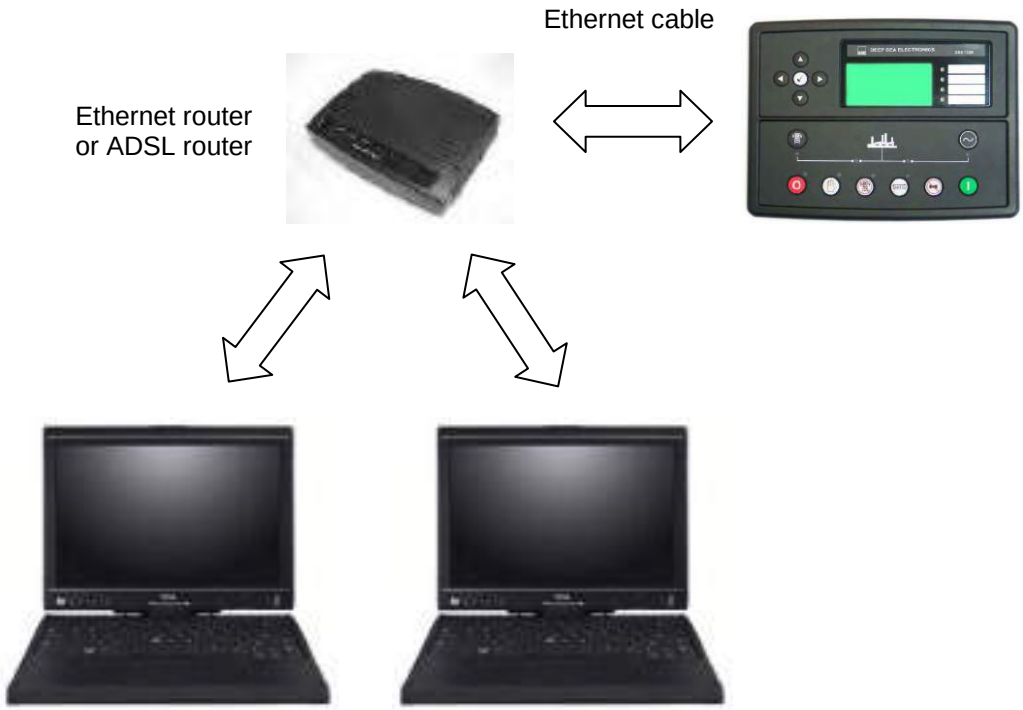


NOTE:- This cable can be purchased from any good PC or IT store.

3.9.6.2 CONNECTION TO BASIC ETHERNET

Requirements

- DSE8610
- Ethernet cable (see below)
- Working Ethernet (company or home network)
- PC with Ethernet port and Windows Internet Explorer 6 or above, Firefox

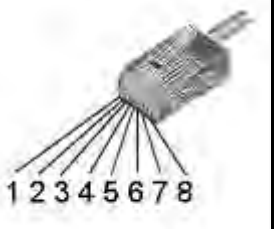


Ethernet cable wiring detail

10baseT/100baseT

Pin	Connection 1 (T568A)	Connection 2 (T568A)
1	white/green stripe	white/green stripe
2	green solid	green solid
3	white/orange stripe	white/orange stripe
4	blue solid	blue solid
5	white/blue stripe	white/blue stripe
6	orange solid	orange solid
7	white/brown stripe	white/brown stripe
8	brown solid	brown solid

For the advanced Engineer, this cable has both ends terminated as T568A (as shown below) or T568B.

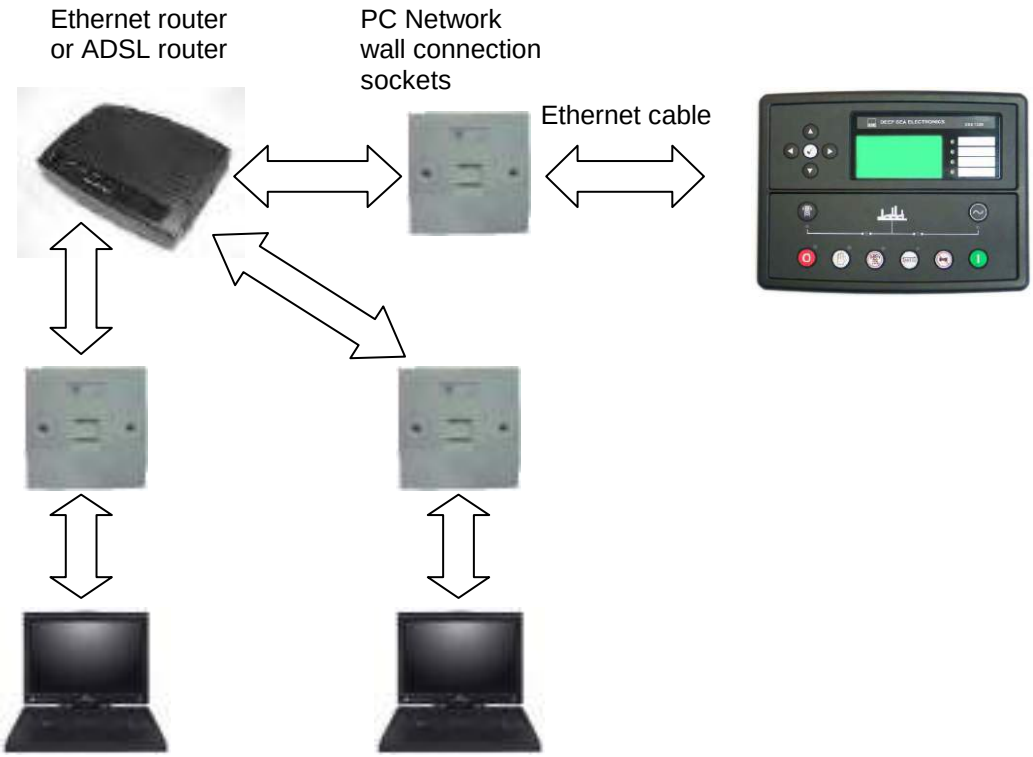


NOTE:- DSE Stock a 2m (2yds) Ethernet Cable – Part number 016-137. Alternatively they can be purchased from any good PC or IT store.

3.9.6.3 CONNECTION TO COMPANY INFRASTRUCTURE ETHERNET

Requirements

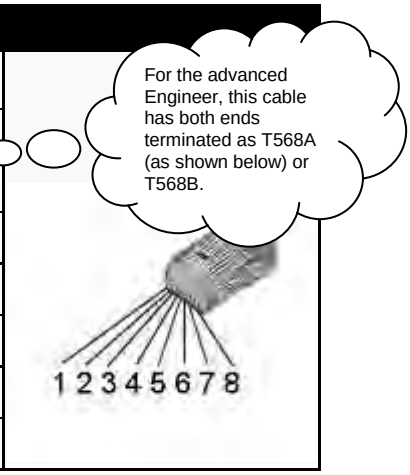
- DSE8610
- Ethernet cable (see below)
- Working Ethernet (company or home network)
- PC with Ethernet port and Windows Internet Explorer 6 or above, Firefox



Ethernet cable wiring detail

10baseT/100baseT

Pin	Connection 1 (T568A)	Connection 2 (T568A)
1	white/green stripe	white/green stripe
2	green solid	green solid
3	white/orange stripe	white/orange stripe
4	blue solid	blue solid
5	white/blue stripe	white/blue stripe
6	orange solid	orange solid
7	white/brown stripe	white/brown stripe
8	brown solid	brown solid

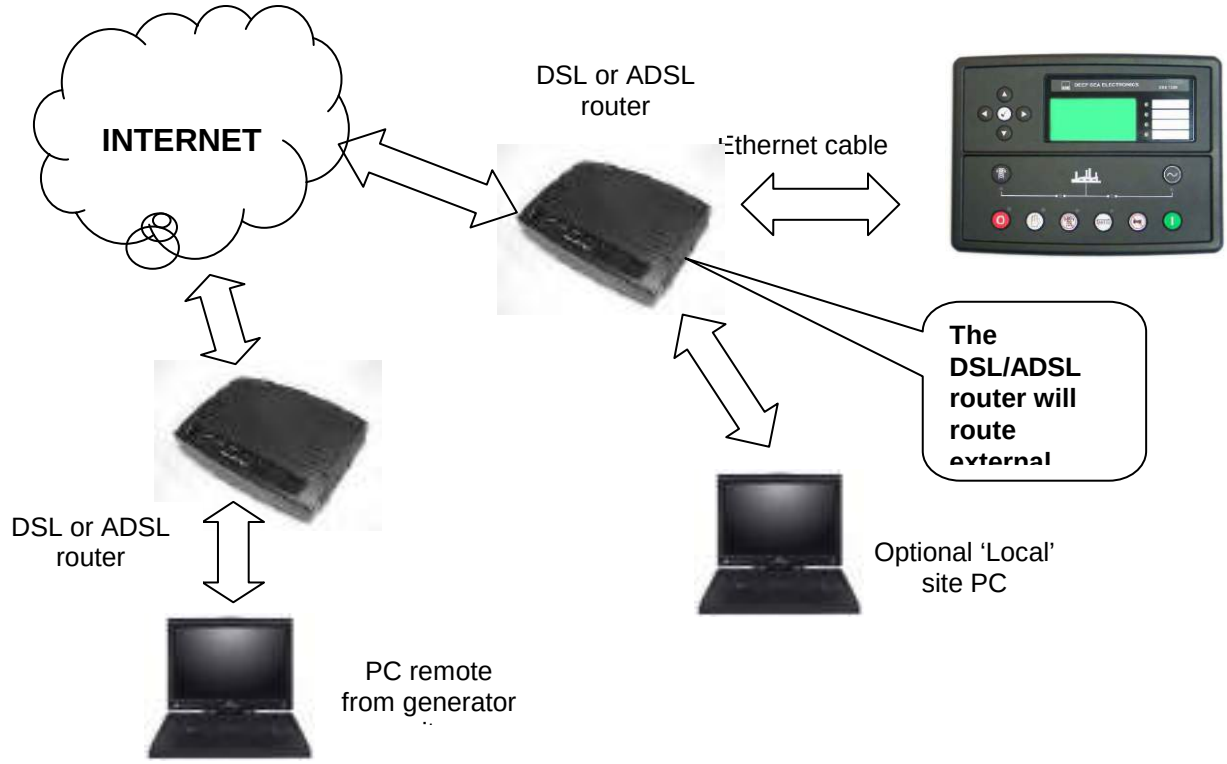


NOTE:- DSE Stock a 2m (2yds) Ethernet Cable – Part number 016-137. Alternatively they can be purchased from any good PC or IT store.

3.9.6.4 CONNECTION TO THE INTERNET

Requirements

- Ethernet cable (see below)
- Working Ethernet (company or home network)
- Working Internet connection (ADSL or DSL recommended)

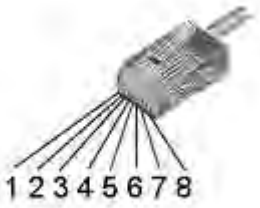


Ethernet cable wiring detail

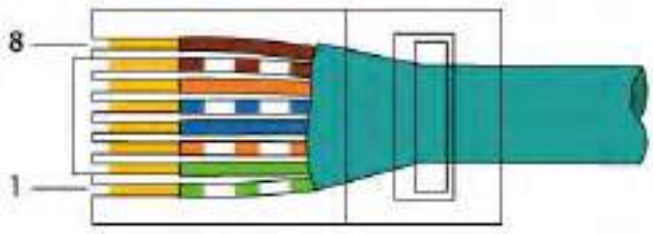
10baseT/100baseT

Pin	Connection 1 (T568A)	Connection 2 (T568A)
1	white/green stripe	white/green stripe
2	green solid	green solid
3	white/orange stripe	white/orange stripe
4	blue solid	blue solid
5	white/blue stripe	white/blue stripe
6	orange solid	orange solid
7	white/brown stripe	white/brown stripe
8	brown solid	brown solid

For the advanced Engineer, this cable has both ends terminated as T568A (as shown below) or T568B.



NOTE:- DSE Stock a 2m (2yds) Ethernet Cable – Part number 016-137. Alternatively they can be purchased from any good PC or IT store.



EIA/TIA-568A

Firewall configuration for internet access

As modem/routers differ enormously in their configuration, it is not possible for DSE to give a complete guide to their use with the DSE8610. However it is possible to give a description of the requirements in generic terms. For details of how to achieve the connection to your modem/router you are referred to the supplier of your modem/router equipment.

The DSE8610 makes its data available over Modbus TCP and as such communicates over the Ethernet using a Port configured via the DSE config suite software..

You must configure your modem/router to allow inbound traffic on this port. For more information you are referred to your WAN interface device (modem/router) manufacturer.

It is also important to note that if the port assigned (setting from software “Modbus Port Number”) is already in use on the LAN, the DSE8610 cannot be used and another port must be used .

Outgoing Firewall rule

As the DSE8610 makes its user interface available to standard web browsers, all communication uses the chosen port. It is usual for a firewall to make the same port outgoing open for communication.

Incoming traffic (virtual server)

Network Address and Port Translation (NAPT) allows a single device, such as the modem/router gateway, to act as an agent between the Internet (or "public external network") and a local (or "internal private") network. This means that only a single, unique IP address is required to represent an entire group of computers.

For our DSE8610 application, this means that the WAN IP address of the modem/router is the IP address we need to access the site from an external (internet) location.

When requests reaches the modem/router, we want this passed to a ‘virtual server’ for handling, in our case this is the DSE8610 module.

R**esult :** Traffic arriving from the WAN (internet) on port xxx is automatically sent to IP address set within the configuration software on the LAN (DSE8610) for handling.

NOTE:- Refer to DSE8600 series Configuration Suite Manual (DSE part 057-119) for further details on configuring, monitoring and control.

3.10 DSENET® FOR EXPANSION MODULES

DSENet® is the interconnection cable between the host controller and the expansion module(s) and must not be connect to any device other than DSE equipment designed for connection to the DSENet®

Cable type	Two core screened twisted pair
Cable characteristic impedance	120Ω
Recommended cable	Belden 9841 Belden 9271
Maximum cable length	1200m (¾ mile) when using Belden 9841 or direct equivalent. 600m (666 yds) when using Belden 9271 or direct equivalent.
DSENet® topology	"Daisy Chain" Bus with no stubs (spurs)
DSENet® termination	120Ω. Fitted internally to host controller. Must be fitted externally to the 'last' expansion module by the customer.
Maximum expansion modules	Total 20 devices made up of DSE2130 (up to 4), DSE2157 (up to 10), DSE2548 (up to 10) This gives the possibility of : Maximum 80 additional relay outputs Maximum 80 additional LED indicators Maximum 32 additional inputs (16 of which can be analogue inputs if required)

NOTE: As a termination resistor is internally fitted to the host controller, the host controller must be the 'first' unit on the DSENet®. A termination resistor MUST be fitted to the 'last' unit on the DSENet®. For connection details, you are referred to the section entitled 'typical wiring diagram' elsewhere in this document.

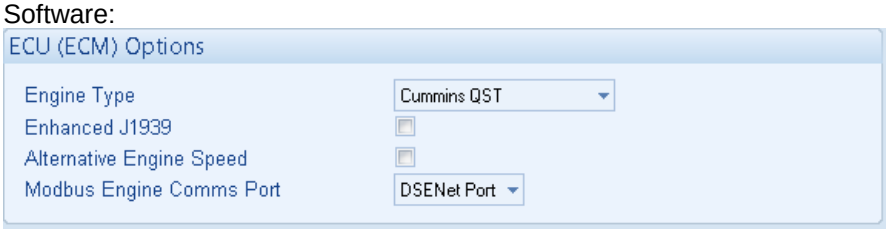
NOTE : DSE8600 series does not support the 2510/2520 display modules.

3.10.1 DSENET® USED FOR MODBUS ENGINE CONNECTION

As DSENet® utilises an RS485 hardware interface, this port can be configured for connection to Cummins Modbus engines (Engines fitted with Cummins GCS).
This leaves the RS485 interface free for connection to remote monitoring equipment (i.e. Building Management System, PLC or PC RS485 port).

While this is a very useful feature in some applications, the obvious drawback is that the DSENet® interface is no longer available for connection to expansion devices.

Example of configuring the DSENet® for connection to Cummins QST GCS using the DSE Configuration Suite Software:



3.11 SOUNDER

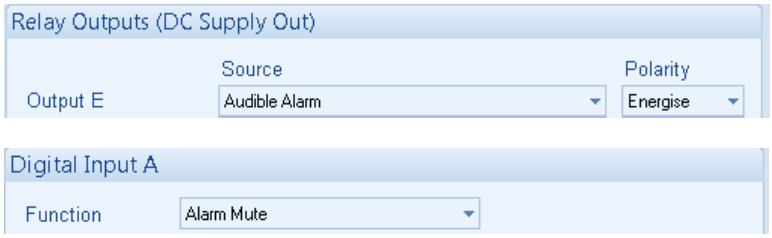
DSE8600 Series features an internal sounder to draw attention to warning, shutdown and electrical trip alarms.

Sounder level	64db @ 1m

3.11.1 ADDING AN EXTERNAL SOUNDER TO THE APPLICATION

Should an external alarm or indicator be required, this can be achieved by using the DSE Configuration Suite PC software to configure an auxiliary output for “Audible Alarm”, and by configuring an auxiliary input for “Alarm Mute” (if required).
The audible alarm output activates and de-activates at the same time as the module’s internal sounder. The Alarm mute input and internal alarm mute button activate ‘in parallel’ with each other. Either signal will mute both the internal sounder and audible alarm output.

Example of configuration to achieve external sounder with external alarm mute button:



3.12 ACCUMULATED INSTRUMENTATION

NOTE: When an accumulated instrumentation value exceeds the maximum number as listed below, it will reset and begin counting from zero again.

Engine hours run	Maximum 99999 hrs 59 minutes (approximately 11yrs 4months)
Number of starts	1,000,000 (1 million)

The number of logged Engine Hours and Number of Starts can be set/reset using the DSE Configuration Suite PC software. Depending upon module configuration, this may have been PIN number locked by your generator supplier

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3.13 DIMENSIONS AND MOUNTING

3.13.1.1 DIMENSIONS

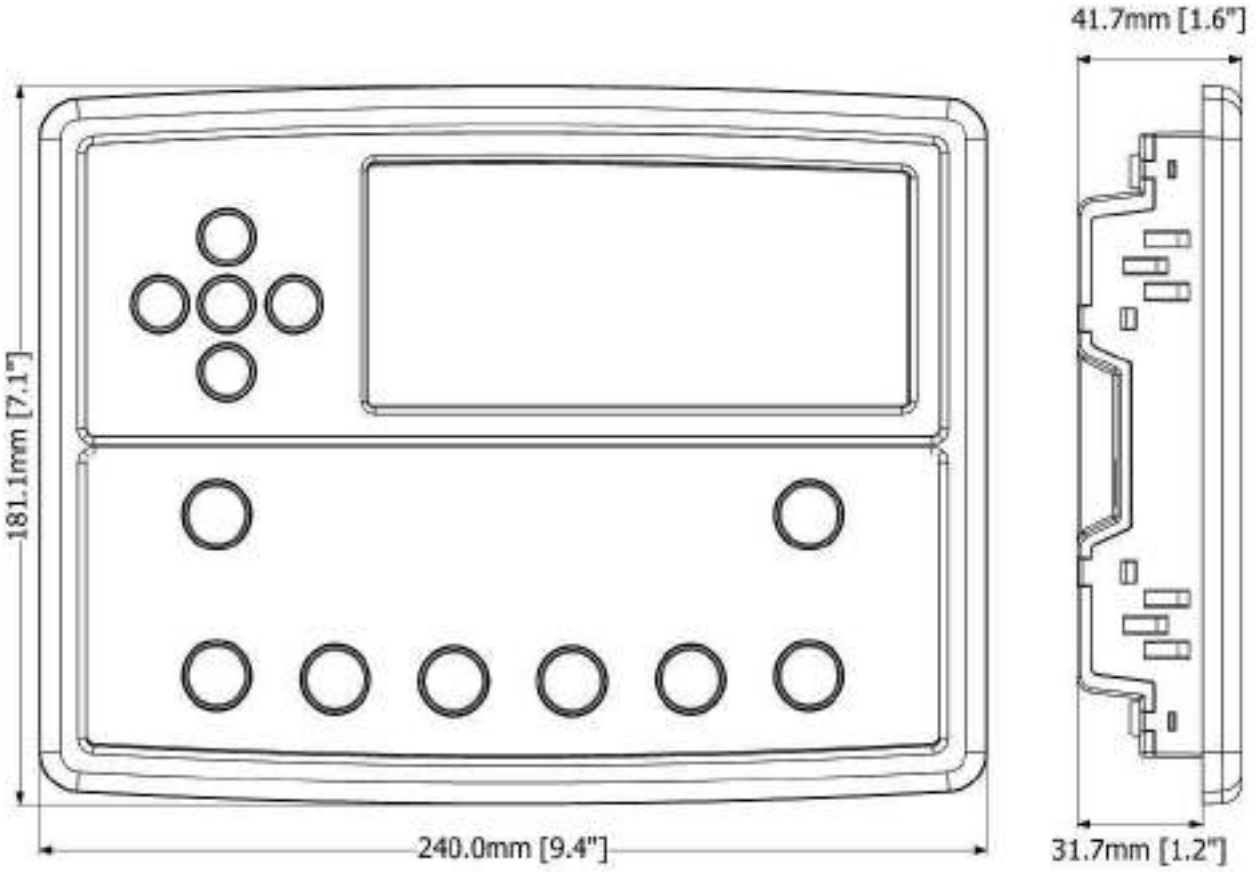
240.0mm x 181.1mm x 41.7mm (9.4” x 7.1” x 1.6”)

PANEL CUTOUT

220mm x 160mm (8.7” x 6.3”)

WEIGHT

0.7kg (1.4lb)

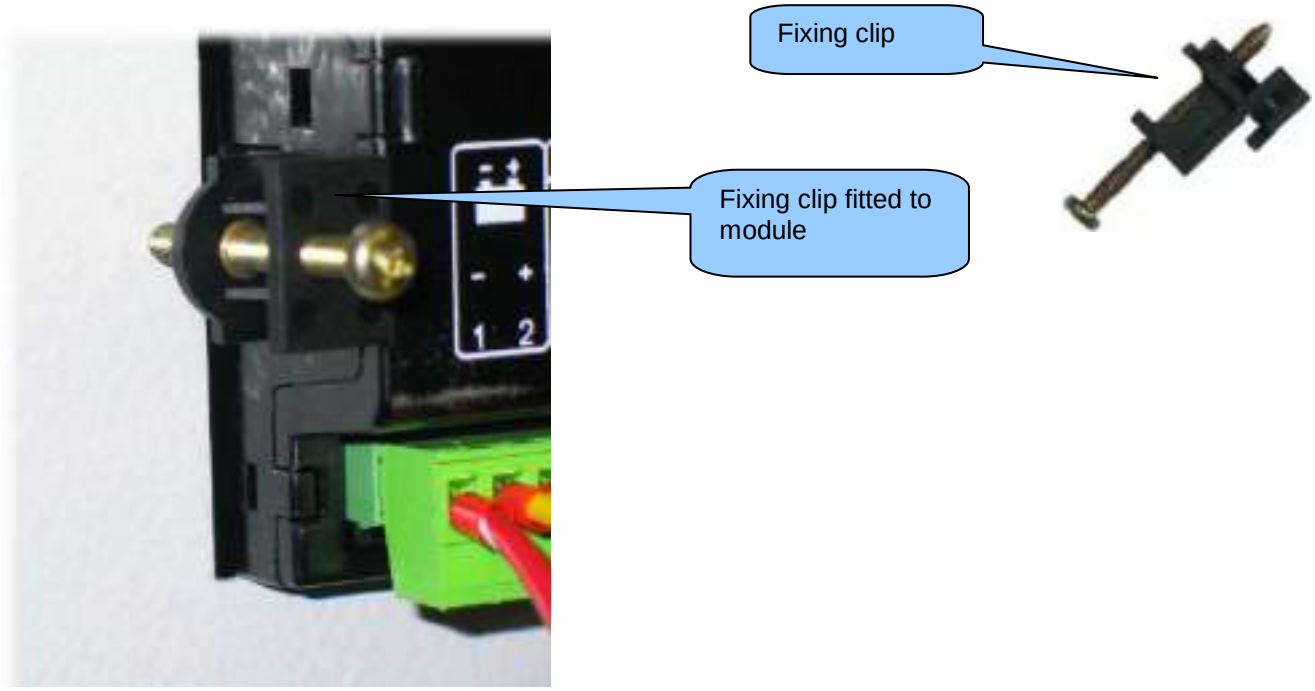


3.13.2 FIXING CLIPS

Supplied fixing clips hold the module into the panel fascia.

Withdraw the fixing clip screw (turn anticlockwise) until only the pointed end is protruding from the clip.

- Insert the three ‘prongs’ of the fixing clip into the slots in the side of the 8600 series module case.
- Pull the fixing clip backwards (towards the back of the module) ensuring all three prongs of the clip are inside their allotted slots.
- Turn the fixing clip screws clockwise until they make contact with the panel fascia.
- Turn the screws a little more to secure the module into the panel fascia. Take care not to over tighten the fixing clip screws.

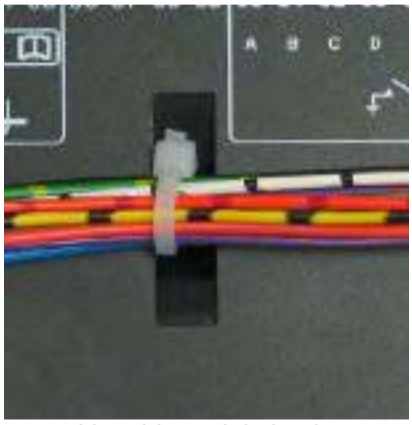


NOTE - In conditions of excessive vibration, mount the module on suitable anti-vibration mountings.

3.13.3 CABLE TIE FIXING POINTS

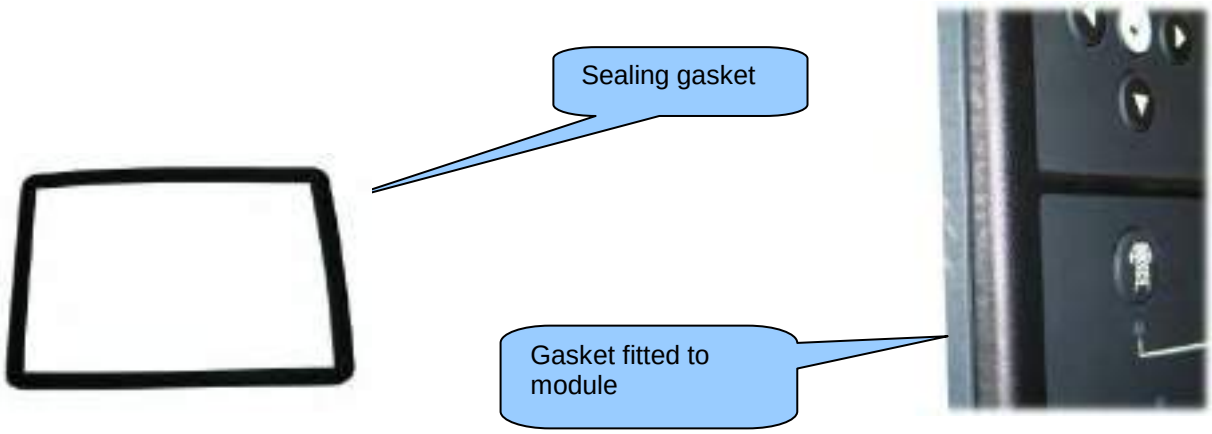
Integral cable tie fixing points are included on the rear of the module's case to aid wiring. This additionally provides strain relief to the cable loom by removing the weight of the loom from the screw connectors, thus reducing the chance of future connection failures.
Care should be taken not to over tighten the cable tie (for instance with cable tie tools) to prevent the risk of damage to the module case.

Cable tie fixing point


With cable and tie in place

3.13.4 SILICON SEALING GASKET

The supplied silicon gasket provides improved sealing between the 8600 series module and the panel fascia.
The gasket is fitted to the module before installation into the panel fascia.
Take care to ensure the gasket is correctly fitted to the module to maintain the integrity of the seal.



3.14 APPLICABLE STANDARDS

BS 4884-1	This document conforms to BS4884-1 1992 Specification for presentation of essential information.
BS 4884-2	This document conforms to BS4884-2 1993 Guide to content
BS 4884-3	This document conforms to BS4884-3 1993 Guide to presentation
BS EN 60068-2-1 (Minimum temperature)	-30°C (-22°F)
BS EN 60068-2-2 (Maximum temperature)	+70°C (158°F)
BS EN 60950	Safety of information technology equipment, including electrical business equipment
BS EN 61000-6-2	EMC Generic Immunity Standard (Industrial)
BS EN 61000-6-4	EMC Generic Emission Standard (Industrial)
BS EN 60529 (Degrees of protection provided by enclosures) (see overleaf)	IP65 (front of module when installed into the control panel with the supplied sealing gasket) IP42 (front of module when installed into the control panel WITHOUT being sealed to the panel)
UL508 **NEMA rating** (Approximate) (see overleaf)	12 (Front of module when installed into the control panel with the supplied sealing gasket). 2 (Front of module when installed into the control panel WITHOUT being sealed to the panel)
IEEE C37.2 (Standard Electrical Power System Device Function Numbers and Contact Designations)	Under the scope of IEEE 37.2, *function numbers can also be used to represent functions in microprocessor devices and software programs*. The 8610 series controller is device number 11L-8610 (Multifunction device protecting Line (generator) – 8610 series module). As the module is configurable by the generator OEM, the functions covered by the module will vary. Under the module's factory configuration, the device numbers included within the module are : 2 – Time delay starting or closing relay 6 – Starting circuit breaker 27AC – AC undervoltage relay 27DC – DC undervoltage relay 30 – annunciator relay 42 – Running circuit breaker 50 – instantaneous overcurrent relay 51 – ac time overcurrent relay 52 – ac circuit breaker 53DC – exciter or dc generator relay 54 – turning gear engaging device 59AC – AC overvoltage relay 59DC – DC overvoltage relay 62 – time delay stopping or opening relay 63 – pressure switch 74– alarm relay 81 – frequency relay 86 – lockout relay

3.14.1 ENCLOSURE CLASSIFICATIONS

IP CLASSIFICATIONS

8600 series specification under BS EN 60529 Degrees of protection provided by enclosures

IP65 (Front of module when module is installed into the control panel with the optional sealing gasket).
IP42 (front of module when module is installed into the control panel WITHOUT being sealed to the panel)

First Digit Protection against contact and ingress of solid objects	Second Digit Protection against ingress of water
0 No protection	0 No protection
1 Protected against ingress solid objects with a diameter of more than 50 mm. No protection against deliberate access, e.g. with a hand, but large surfaces of the body are prevented from approach.	1 Protection against dripping water falling vertically. No harmful effect must be produced (vertically falling drops).
2 Protected against penetration by solid objects with a diameter of more than 12 mm. Fingers or similar objects prevented from approach.	2 Protection against dripping water falling vertically. There must be no harmful effect when the equipment (enclosure) is tilted at an angle up to 15° from it s normal position (drops falling at an angle).
3 Protected against ingress of solid objects with a diameter of more than 2.5 mm. Tools, wires etc. with a thickness of more than 2.5 mm are prevented from approach.	3 Protection against water falling at any angle up to 60° from the vertical. There must be no harmful effect (spray water).
4 Protected against ingress of solid objects with a diameter of more than 1 mm. Tools, wires etc. with a thickness of more than 1 mm are prevented from approach.	4 Protection against water splashed against the equipment (enclosure) from any direction. There must be no harmful effect (splashing water).
5 Protected against harmful dust deposits. Ingress of dust is not totally prevented but the dust must not enter in sufficient quantity to interface with satisfactory operation of the equipment. Complete protection against contact.	5 Protection against water projected from a nozzle against the equipment (enclosure) from any direction. There must be no harmful effect (water jet).
6 Protection against ingress of dust (dust tight). Complete protection against contact.	6 Protection against heavy seas or powerful water jets. Water must not enter the equipment (enclosure) in harmful quantities (splashing over).

NEMA CLASSIFICATIONS

8600 series NEMA Rating (Approximate)

12 (Front of module when module is installed into the control panel with the optional sealing gasket).
2 (front of module when module is installed into the control panel WITHOUT being sealed to the panel)

NOTE: - There is no direct equivalence between IP / NEMA ratings. IP figures shown are approximate only.

1 **IP30**	Provides a degree of protection against contact with the enclosure equipment and against a limited amount of falling dirt.
2 **IP31**	Provides a degree of protection against limited amounts of falling water and dirt.
3 **IP64**	Provides a degree of protection against windblown dust, rain and sleet; undamaged by the formation of ice on the enclosure.
3R **IP32**	Provides a degree of protection against rain and sleet:; undamaged by the formation of ice on the enclosure.
4 (X) **IP66**	Provides a degree of protection against splashing water, windblown dust and rain, hose directed water; undamaged by the formation of ice on the enclosure. (Resist corrosion).
12/12K **IP65**	Provides a degree of protection against dust, falling dirt and dripping non corrosive liquids.
13 **IP65**	Provides a degree of protection against dust and spraying of water, oil and non corrosive coolants.

4 INSTALLATION

The DSE8600 Series module is designed to be mounted on the panel fascia. For dimension and mounting details, see the section entitled *Specification, Dimension and mounting* elsewhere in this document.

4.1 TERMINAL DESCRIPTION

4.1.1 DC SUPPLY, FUEL AND START OUTPUTS

Icon	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	1	DC Plant Supply Input (Negative)	2.5mm² AWG 13	
	2	DC Plant Supply Input (Positive)	2.5 mm² AWG 13	(Recommended Maximum Fuse 15A anti-surge) Supplies the module (2A anti-surge requirement) and Output relays E - K
	3	Emergency Stop Input	2.5mm² AWG 13	Plant Supply Positive. In addition, supplies outputs 1 & 2. (Recommended Maximum Fuse 20A)
	4	Output relay A (FUEL)	2.5mm² AWG 13	Plant Supply Positive from terminal 3. 15 Amp rated. Fixed as FUEL relay if electronic engine is not configured.
	5	Output relay B (START)	2.5mm² AWG 13	Plant Supply Positive from terminal 3. 15 Amp rated. Fixed as START relay if electronic engine is not configured.
	6	Charge fail / excite	2.5mm² AWG 13	Do not connect to ground (battery negative). If charge alternator is not fitted, leave this terminal disconnected.
	7	Functional Earth	2.5mm² AWG 13	Connect to a good clean earth point.
	8	Output relay E	1.0mm² AWG 18	Plant Supply Positive from terminal 2. 3 Amp rated.
	9	Output relay F	1.0mm² AWG 18	Plant Supply Positive from terminal 2. 3 Amp rated.
	10	Output relay G	1.0mm² AWG 18	Plant Supply Positive. from terminal 2. 3 Amp rated.
	11	Output relay H	1.0mm² AWG 18	Plant Supply Positive from terminal 2. 3 Amp rated.
	12	Output relay I	1.0mm² AWG 18	Plant Supply Positive from terminal 2. 3 Amp rated.
	13	Output relay J	1.0mm² AWG 18	Plant Supply Positive from terminal 2. 3 Amp rated.

NOTE:- Terminal 14 is not fitted to the DSE8600 series controller.

NOTE:- When the module is configured for operation with an electronic engine, FUEL and START output requirements may be different. Refer to *Electronic Engines and DSE Wiring* for further information. DSE Part No. 057-004.

4.1.2 ANALOGUE SENSORS

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	15	Sensor Common Return	0.5mm² AWG 20	Return feed for sensors
	16	Oil Pressure Input	0.5mm² AWG 20	Connect to Oil pressure sensor
	17	Coolant Temperature Input	0.5mm² AWG 20	Connect to Coolant Temperature sensor
	18	Fuel Level input	0.5mm² AWG 20	Connect to Fuel Level sensor
	19	Flexible sensor	0.5mm² AWG 20	Connect to additional sensor (user configurable)

NOTE:- Terminals 20 and 21 are not fitted to the 8600 series controller.

NOTE: - It is VERY important that terminal 15 (sensor common) is soundly connected to an earth point on the ENGINE BLOCK, not within the control panel, and must be a sound electrical connection to the sensor bodies. This connection MUST NOT be used to provide an earth connection for other terminals or devices. The simplest way to achieve this is to run a SEPARATE earth connection from the system earth star point, to terminal 15 directly, and not use this earth for other connections.

NOTE: - If you use PTFE insulating tape on the sensor thread when using earth return sensors, ensure you do not insulate the entire thread, as this will prevent the sensor body from being earthed via the engine block.

4.1.3 MAGNETIC PICKUP, CAN AND EXPANSION

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	22	Magnetic pickup Positive	0.5mm² AWG 20	Connect to Magnetic Pickup device
	23	Magnetic pickup Negative	0.5mm² AWG 20	Connect to Magnetic Pickup device
	24	Magnetic pickup screen	Shield	Connect to ground at one end only
CAN	25	CAN port H	0.5mm² AWG 20	Use only 120Ω CAN approved cable
	26	CAN port L	0.5mm² AWG 20	Use only 120Ω CAN approved cable
	27	CAN port Common	0.5mm² AWG 20	Use only 120Ω CAN approved cable
	28	DSENet expansion +	0.5mm² AWG 20	Use only 120Ω RS485 approved cable
	29	DSENet expansion -	0.5mm² AWG 20	Use only 120Ω RS485 approved cable
	30	DSENet expansion SCR	0.5mm² AWG 20	Use only 120Ω RS485 approved cable
MSC	31	Multiset Comms (MSC) Link H	0.5mm² AWG 20	Use only 120Ω RS485 approved cable
	32	Multiset Comms (MSC) Link L	0.5mm² AWG 20	Use only 120Ω RS485 approved cable
	33	Multiset Comms (MSC) Link SCR	0.5mm² AWG 20	Use only 120Ω RS485 approved cable
GOV	34	Analogue Governor Output B	0.5mm² AWG 20	
	35	Analogue Governor Output A	0.5mm² AWG 20	
AVR	37	Analogue AVR Output B	0.5mm² AWG 20	
	38	Analogue AVR Output A	0.5mm² AWG 20	

NOTE:- Terminal 36 is not fitted to the 8610 controller

NOTE:- Screened cable must be used for connecting the Magnetic Pickup, ensuring that the screen is earthed at one end ONLY.

NOTE:- Screened 120Ω impedance cable specified for use with CAN must be used for the CAN link and the Multiset comms (MSC) link.
DSE stock and supply Belden cable 9841 which is a high quality 120Ω impedance cable suitable for CAN use (DSE part number 016-030)

NOTE:- When the module is configured for CAN operation, terminals 22, 23 & 24 should be left unconnected. Engine speed is transmitted to the 8600 series controller on the CAN link.
Refer to *Electronic Engines and DSE Wiring* for further information. Part No. 057-004.

4.1.4 LOAD SWITCHING AND GENERATOR VOLTAGE SENSING

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	39	Output relay C	1.0mm AWG 18	Normally configured to control load switching device (Recommend 10A fuse)
	40	Output relay C	1.0mm AWG 18	Normally configured to control load switching device
	41	Output relay D	1.0mm AWG 18	Normally configured to control load switching device (Recommend 10A fuse)
	42	Output relay D	1.0mm AWG 18	Normally configured to control load switching device
V1	43	Generator L1 (U) voltage monitoring	1.0mm² AWG 18	Connect to generator L1 (U) output (AC) (Recommend 2A fuse)
	44	Generator L2 (V) voltage monitoring input	1.0mm² AWG 18	Connect to generator L2 (V) output (AC) (Recommend 2A fuse)
	45	Generator L3 (W) voltage monitoring input	1.0mm² AWG 18	Connect to generator L3 (W) output (AC) (Recommend 2A fuse)
	46	Generator Neutral (N) input	1.0mm² AWG 18	Connect to generator Neutral terminal (AC)

NOTE: - The above table describes connections to a three phase, four wire alternator. For alternative wiring topologies, please see the ALTERNATIVE AC TOPOLOGIES section of this manual.

4.1.5 BUS SENSING

These connections are to the common bus supply of the generator system.

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
V2	47	Bus L1 (R) voltage monitoring	1.0mm AWG 18	Connect to Bus L1 (R) incoming supply (AC) (Recommend 2A fuse)
	48	Bus L2 (S) voltage monitoring	1.0mm AWG 18	Connect to Bus L1 (S) incoming supply (AC) (Recommend 2A fuse)
	49	Bus L3 (T) voltage monitoring	1.0mm AWG 18	Connect to Bus L1 (T) incoming supply (AC) (Recommend 2A fuse)
	50	Bus Neutral (N) input	1.0mm AWG 18	Connect to Bus N incoming supply (AC)

4.1.6 GENERATOR CURRENT TRANSFORMERS

WARNING! - Do not disconnect this plug when the CTs are carrying current. Disconnection will open circuit the secondary of the C.T.'s and dangerous voltages may then develop. Always ensure the CTs are not carrying current and the CTs are short circuit connected before making or breaking connections to the module.

NOTE: - The 8600 series module has a burden of 0.5VA on the CT. Ensure the CT is rated for the burden of the 8600 series controller, the cable length being used and any other equipment sharing the CT. If in doubt, consult your CT supplier.

NOTE: - Take care to ensure correct polarity of the CT primary as shown below. If in doubt, check with the CT supplier.

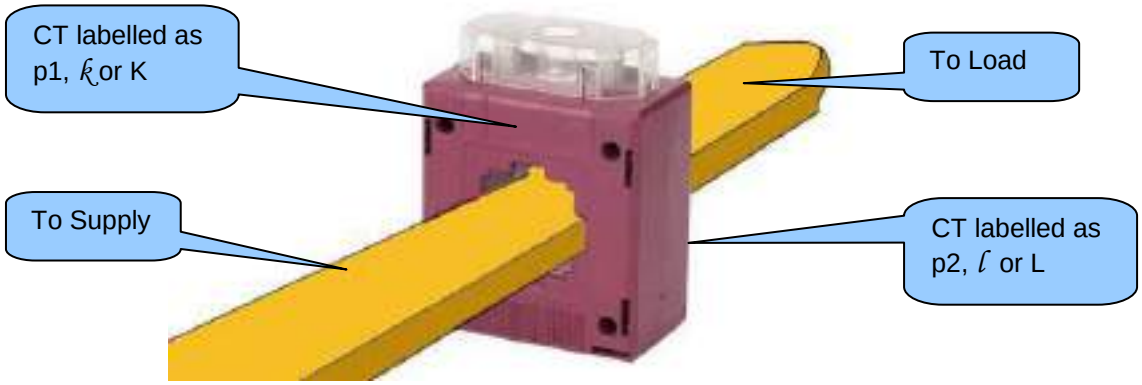
CT LABELLING

p1, k or K is the primary of the CT that 'points' towards the GENERATOR

p2, l or L is the primary of the CT that 'points' towards the LOAD

s1 is the secondary of the CT that connects to the DSE Module's input for the CT measuring (I1,I2,I3)

s2 is the secondary of the CT that should be commoned with the s2 connections of all the other CTs and connected to the CT common terminal of the DSE8600 series modules.



Connection of CT s1 terminal

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	51	CT Secondary for Gen L1	2.5mm² AWG 13	Connect to s1 secondary of L1 monitoring CT
	52	CT Secondary for Gen L2	2.5mm² AWG 13	Connect to s1 secondary of L2 monitoring CT
	53	CT Secondary for Gen L3	2.5mm² AWG 13	Connect to s1 secondary of L3 monitoring CT

Connection to terminals 54 & 55

	Pin No	Description	CABLE SIZE
	54	DO NOT CONNECT	
	55	Common for CTs connected to L1,L2,L3 (s2)	2.5mm² AWG 13

NOTE:- Terminals 56 and 57 are not fitted to the 8610 series controller.

NOTE:- Take care to ensure correct polarity of the CT primary as shown overleaf. If in doubt, check with the CT supplier.

Connection to terminals 54 & 55

The function of terminals 54 and 55 CHANGES depending upon what kind of earth fault protection (if any) is being used:

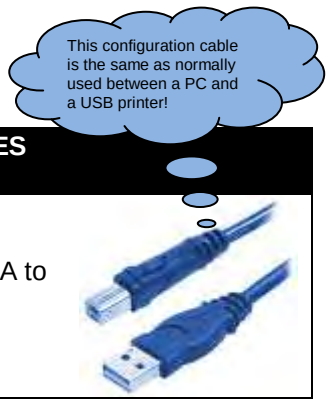
	Topology	Pin No	Description	CABLE SIZE
	No earth fault measuring	54	DO NOT CONNECT	
		55	Connect to s2 of the CTs connected to L1,L2,L3,N	2.5mm² AWG 13
	Restricted earth fault measuring	54	Connect to s2 of the CTs connected to L1,L2,L3,N	2.5mm² AWG 13
		55	Connect to s1 of the CT on the neutral conductor	2.5mm² AWG 13
	Un-restricted earth fault measuring (Earth fault CT is fitted in the neutral to earth link)	54	Connect to s1 of the CT on the neutral to earth conductor.	2.5mm² AWG 13
		55	Connect to s2 of the CT on the neutral to earth link. Also connect to the s2 of CTs connected to L1, L2, L3.	2.5mm² AWG 13

NOTE: - Terminals 56 to 59 are not fitted to the 8610 series controller.

4.1.7 CONFIGURABLE DIGITAL INPUTS

	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	60	Configurable digital input A	0.5mm² AWG 20	Switch to negative
	61	Configurable digital input B	0.5mm² AWG 20	Switch to negative
	62	Configurable digital input C	0.5mm² AWG 20	Switch to negative
	63	Configurable digital input D	0.5mm² AWG 20	Switch to negative
	64	Configurable digital input E	0.5mm² AWG 20	Switch to negative
	65	Configurable digital input F	0.5mm² AWG 20	Switch to negative
	66	Configurable digital input G	0.5mm² AWG 20	Switch to negative
	67	Configurable digital input H	0.5mm² AWG 20	Switch to negative
	68	Configurable digital input I	0.5mm² AWG 20	Switch to negative
	69	Configurable digital input J	0.5mm² AWG 20	Switch to negative
	70	Configurable digital input K	0.5mm² AWG 20	Switch to negative

4.1.8 PC CONFIGURATION INTERFACE CONNECTOR



	DESCRIPTION	CABLE SIZE	NOTES
	Socket for connection to PC with 86xx series PC software.	0.5mm² AWG 20	This is a standard USB type A to type B connector.

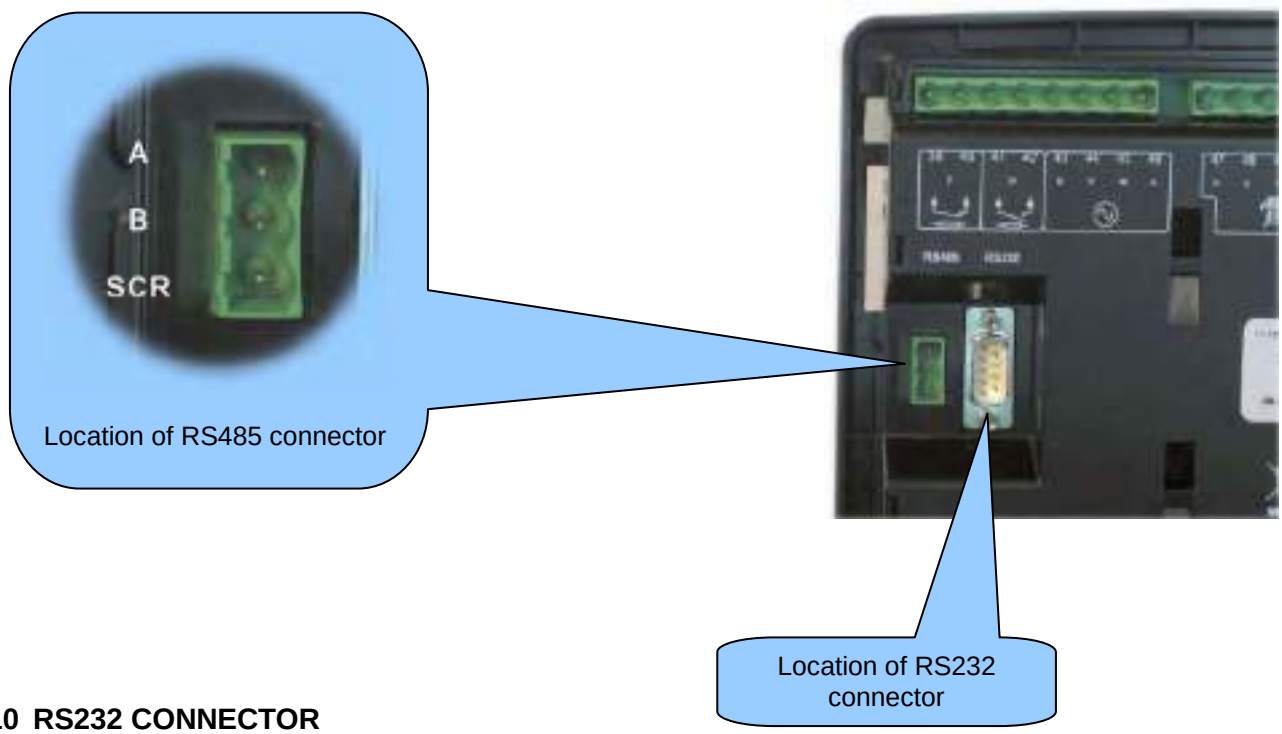
NOTE:- The USB connection cable between the PC and the 8600 series module must not be extended beyond 5m (yards). For distances over 5m, it is possible to use a third party USB extender. Typically, they extend USB up to 50m (yards). The supply and support of this type of equipment is outside the scope of Deep Sea Electronics PLC.

CAUTION!: Care must be taken not to overload the PCs USB system by connecting more than the recommended number of USB devices to the PC. For further information, consult your PC supplier.

CAUTION!: This socket must not be used for any other purpose.

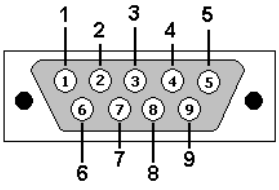
4.1.9 RS485 CONNECTOR

PIN No	NOTES
A	Two core screened twisted pair cable. 120Ω impedance suitable for RS485 use. Recommended cable type - Belden 9841 Max distance 1200m (1.2km) when using Belden 9841 or direct equivalent.
B	
SCR	



4.1.10 RS232 CONNECTOR

PIN No	NOTES
1	Received Line Signal Detector (Data Carrier Detect)
2	Received Data
3	Transmit Data
4	Data Terminal Ready
5	Signal Ground
6	Data Set Ready
7	Request To Send
8	Clear To Send
9	Ring Indicator



View looking into the male connector on the 8600 series module

4.2 TYPICAL WIRING DIAGRAMS

As every system has different requirements, these diagrams show only a TYPICAL system and do not intend to show a complete system.

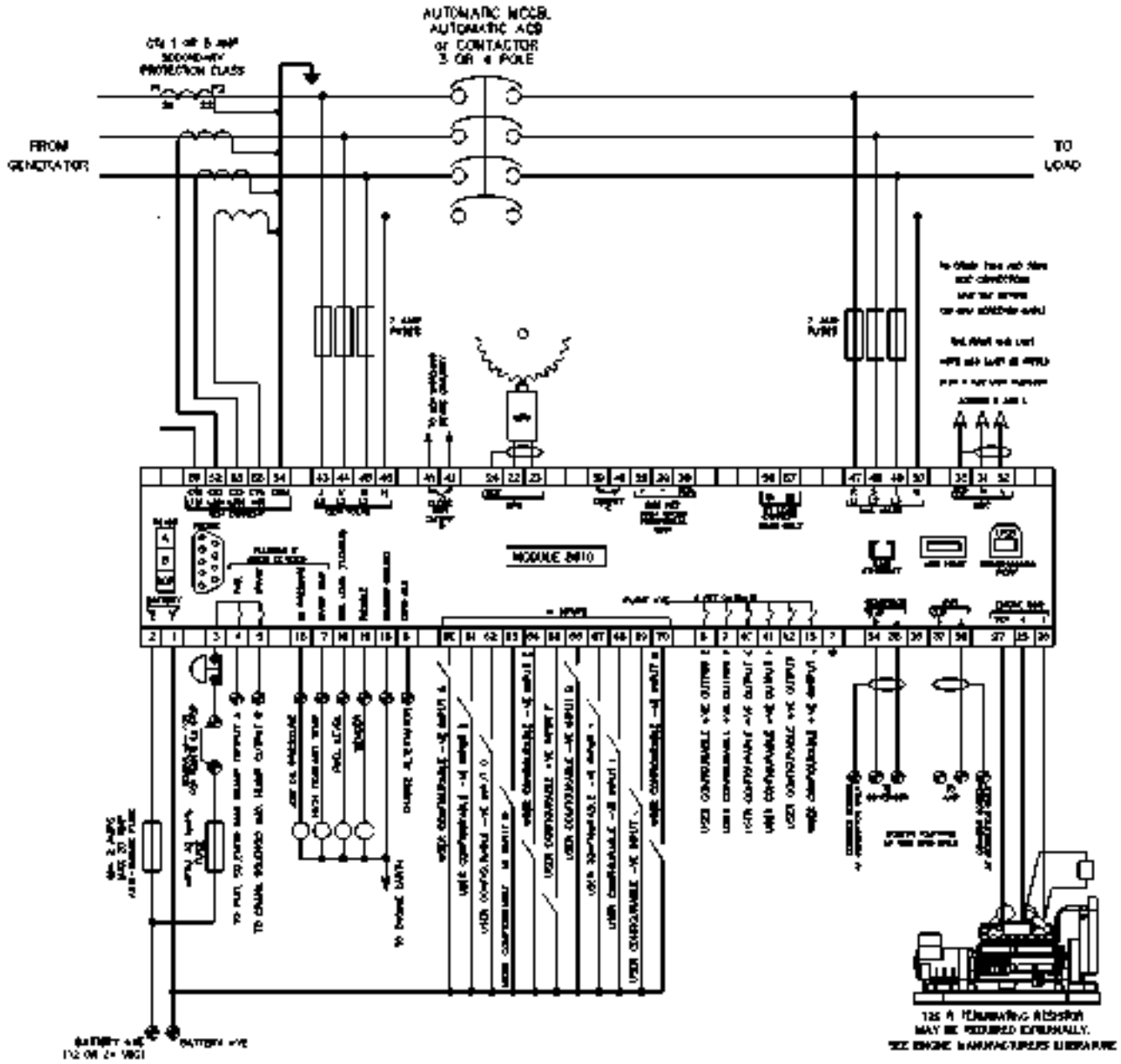
Genset manufacturers and panel builders may use these diagrams as a starting point; however, you are referred to the completed system diagram provided by your system manufacturer for complete wiring detail.

Further wiring suggestions are available in the following DSE publications, available at www.deepseaplc.com to website members.

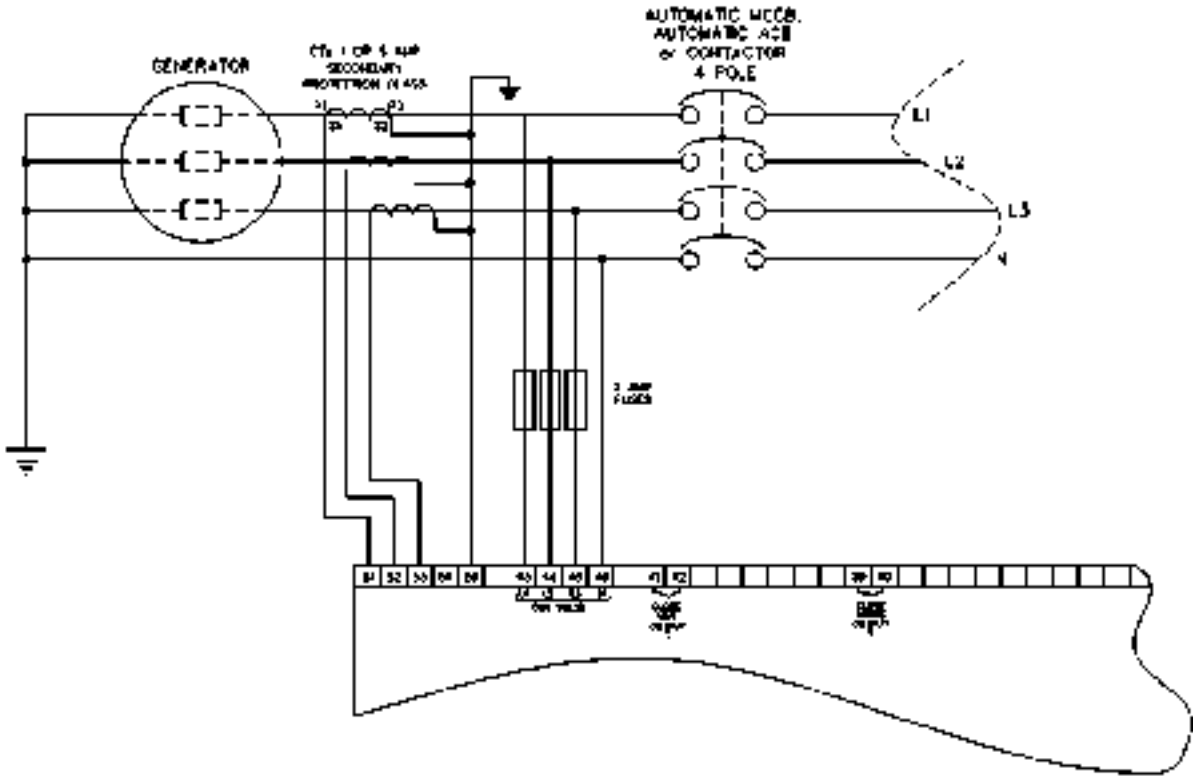
DSE PART	DESCRIPTION
056-022	Breaker Control (Training guide)
057-004	Electronic Engines and DSE Wiring

4.2.1 3 PHASE, 4 WIRE WITH RESTRICTED EARTH FAULT PROTECTION

NOTE: - Earthing the neutral conductor 'before' the neutral CT allows the module to read earth faults 'after' the CT only (Restricted to load / downstream of the CT)
Earthing the neutral conductor 'after' the neutral CT allows the module to read earth faults 'before' the CT only (Restricted to generator / upstream of the CT)

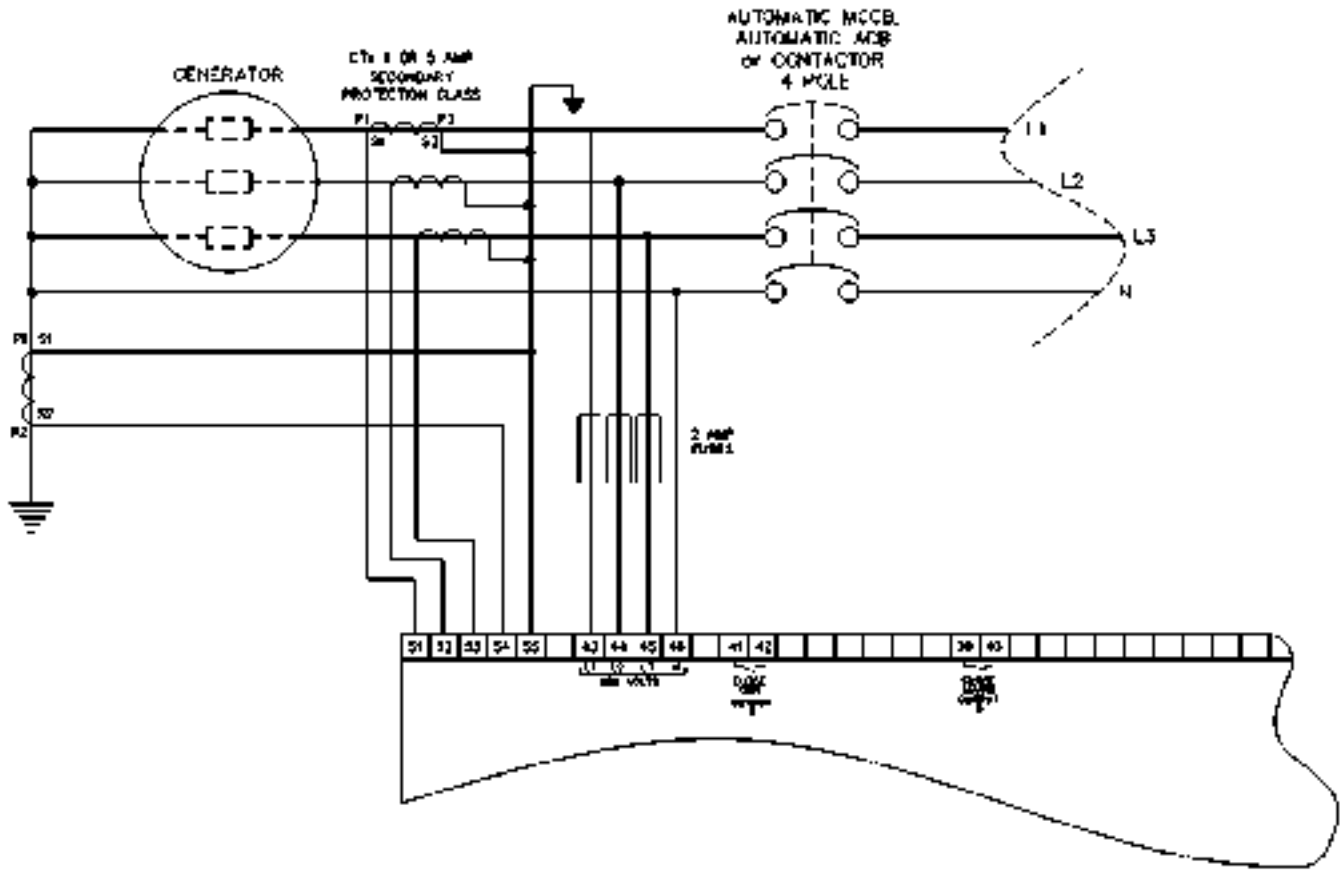


4.2.2 3 PHASE, 4 WIRE WITHOUT EARTH FAULT PROTECTION



4.2.3 3 PHASE 4 WIRE WITH UNRESTRICTED EARTH FAULT PROTECTION

NOTE:- Unrestricted Earth Fault Protection detects earth faults in the load and in the generator. Be sure to measure the natural earth fault of the site before deciding upon an earth fault alarm trip level.



4.2.4 EARTH SYSTEMS

4.2.4.1 NEGATIVE EARTH

The typical wiring diagrams located within this document show connections for a negative earth system (the battery negative connects to Earth)

4.2.4.2 POSITIVE EARTH

When using a DSE module with a Positive Earth System (the battery positive connects to Earth), the following points must be followed:

- Follow the typical wiring diagram as normal for all sections EXCEPT the earth points
- All points shown as Earth on the typical wiring diagram should connect to BATTERY NEGATIVE (not earth).

4.2.4.3 FLOATING EARTH

Where neither the battery positive nor battery negative terminals are connected to earth the following points must to be followed

- Follow the typical wiring diagram as normal for all sections EXCEPT the earth points
- All points shown as Earth on the typical wiring diagram should connect to BATTERY NEGATIVE (not earth).

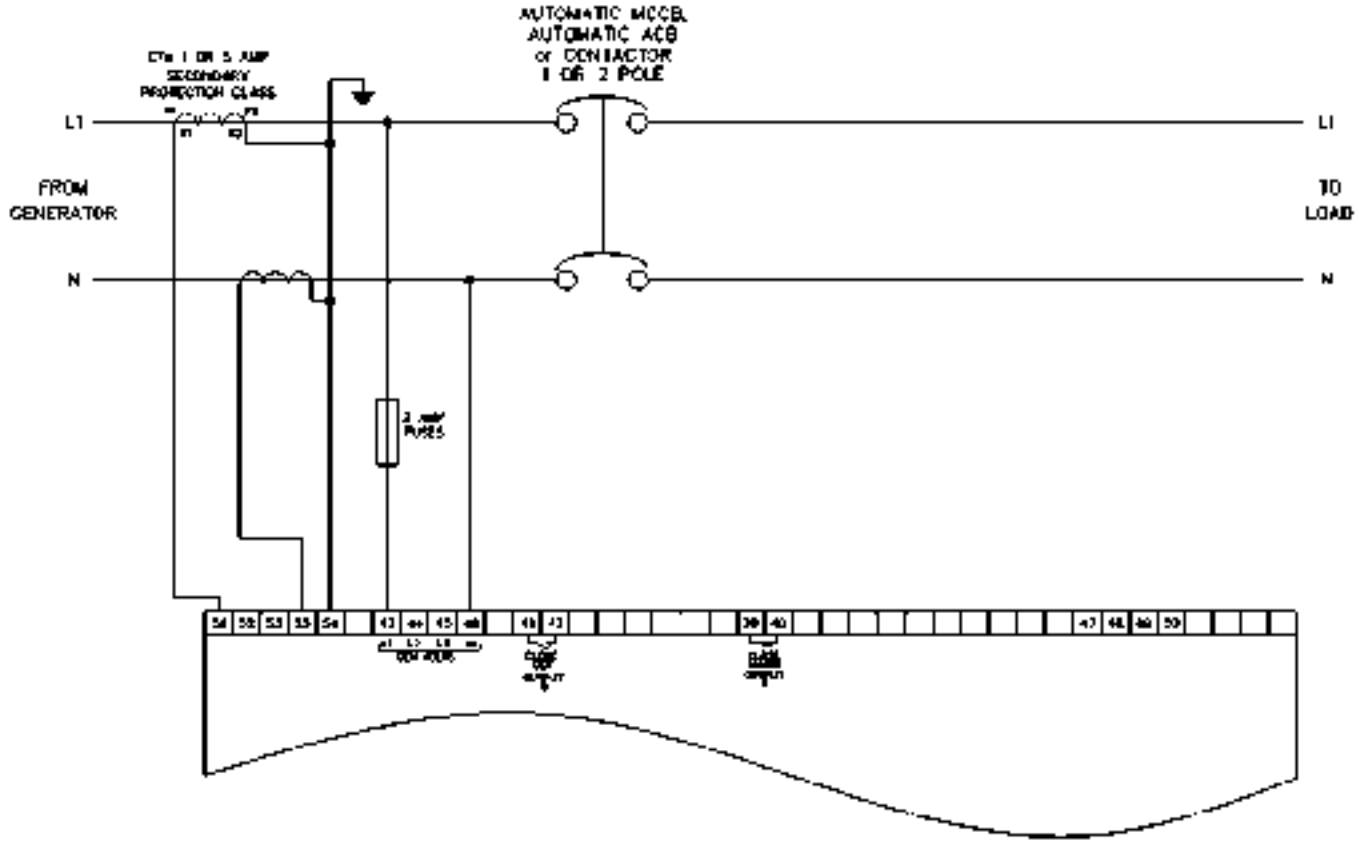
4.3 ALTERNATIVE TOPOLOGIES

The DSE8610 controller is factory configured to connect to a 3 phase, 4 wire Star connected alternator. This section details connections for alternative AC topologies. Ensure to configure the DSE8610 controller to suit the required topology.

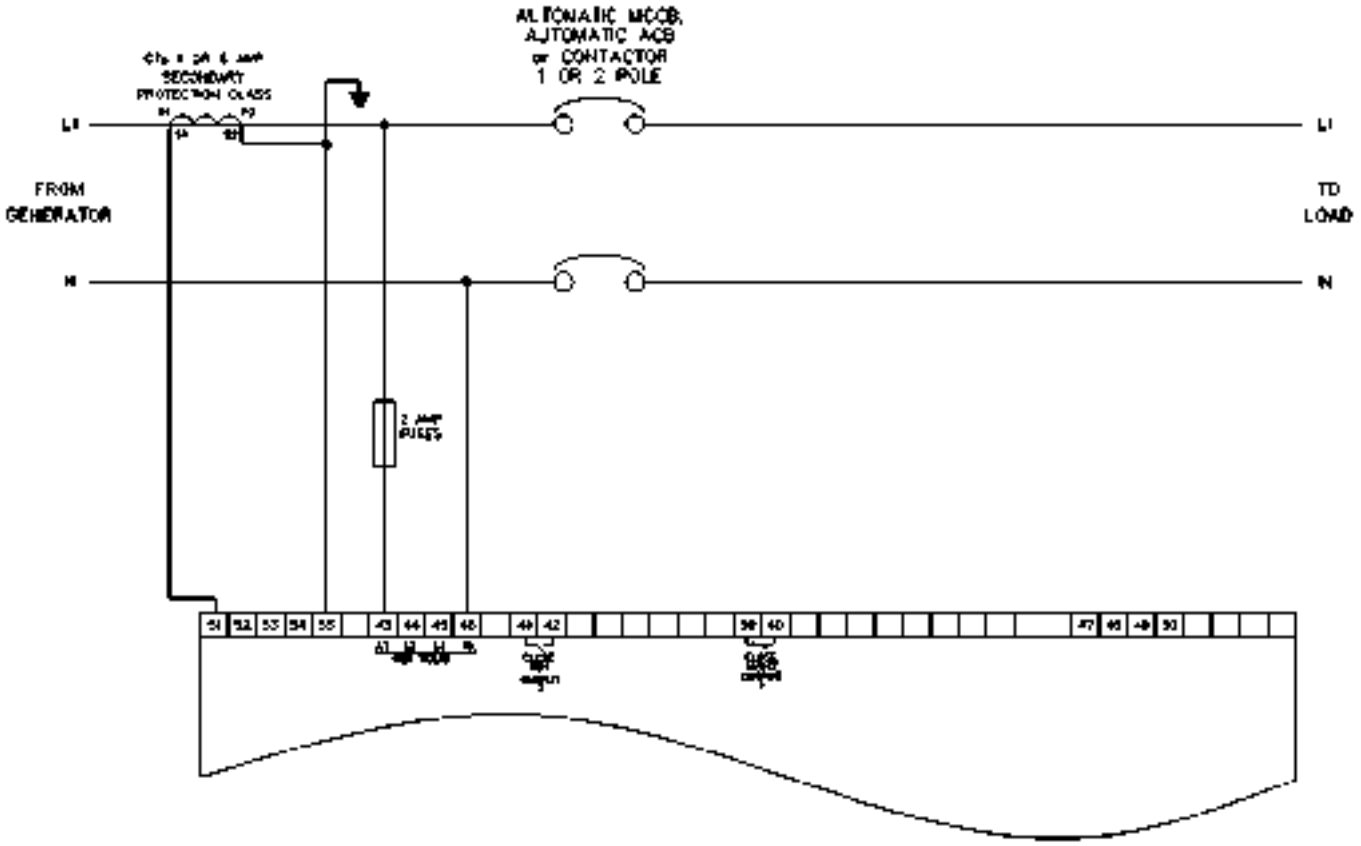
NOTE:- Further details of module configuration are contained within the DSE8610 Series configuration software manual (DSE part number 057-119)

4.3.1 SINGLE PHASE WITH RESTRICTED EARTH FAULT

NOTE:- Earthing the neutral conductor 'before' the neutral CT allows the module to read earth faults 'after' the CT only (Restricted to load / downstream of the CT)
Earthing the neutral conductor 'after' the neutral CT allows the module to read earth faults 'before' the CT only (Restricted to generator / upstream of the CT)

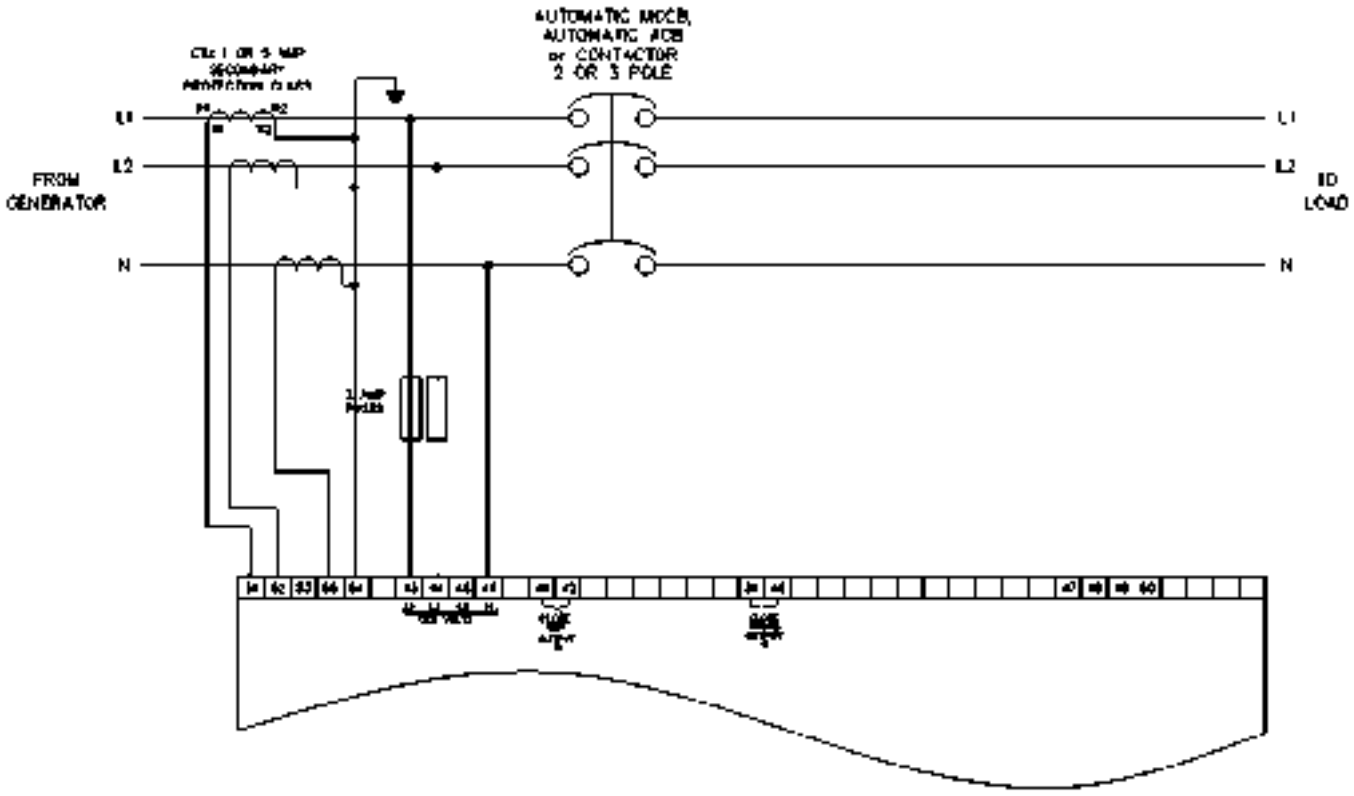


4.3.2 SINGLE PHASE WITHOUT EARTH FAULT

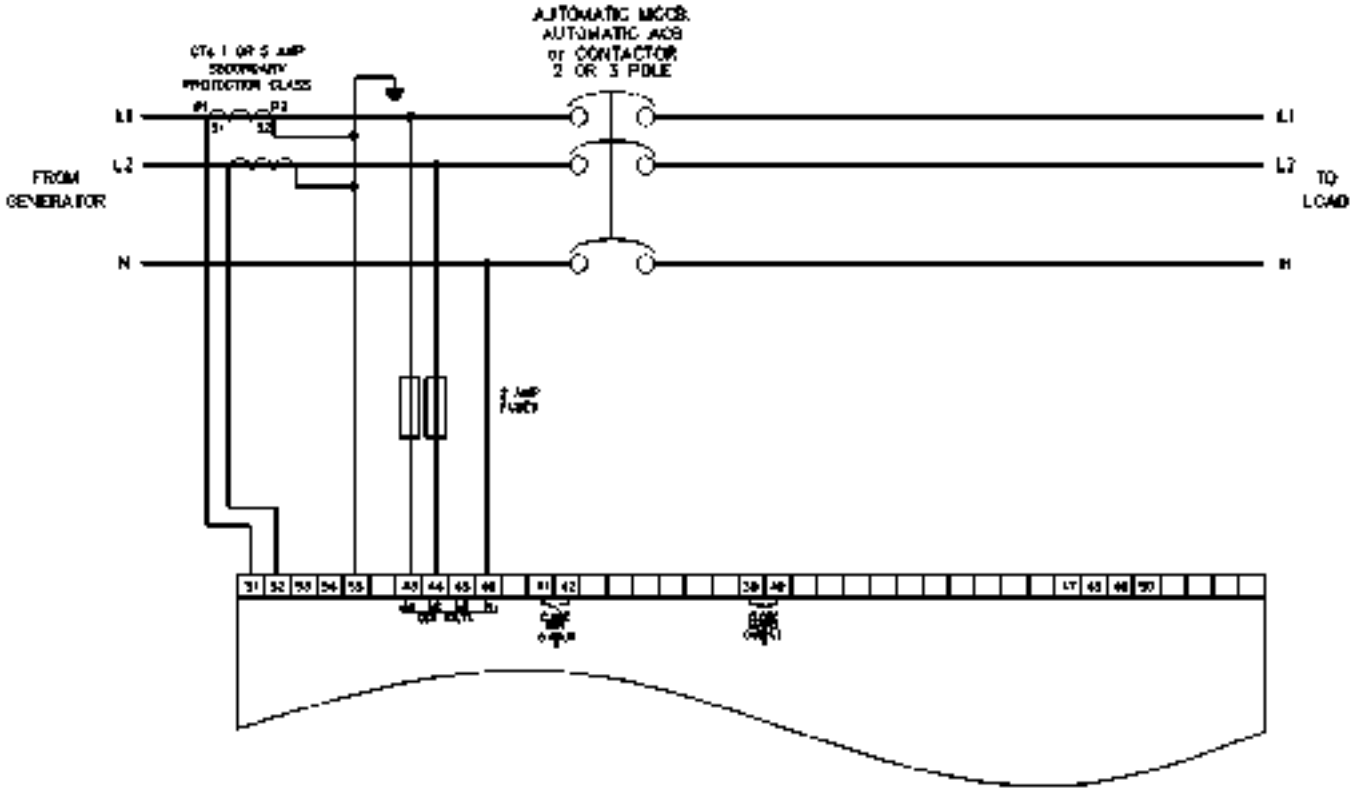


4.3.3 2 PHASE (L1 & L2) 3 WIRE WITH RESTRICTED EARTH FAULT

NOTE:- Earthing the neutral conductor 'before' the neutral CT allows the module to read earth faults 'after' the CT only (Restricted to load / downstream of the CT)
Earthing the neutral conductor 'after' the neutral CT allows the module to read earth faults 'before' the CT only (Restricted to generator / upstream of the CT)

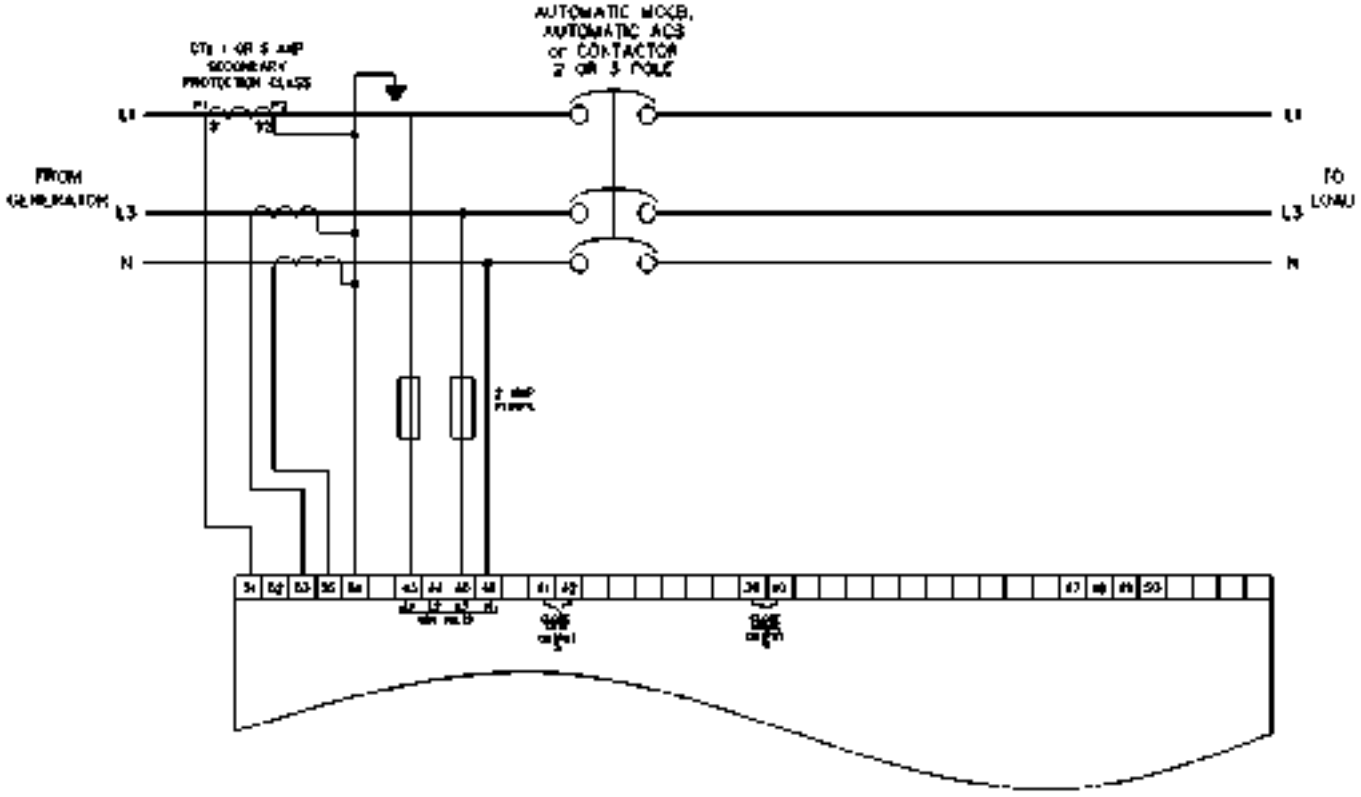


4.3.4 2 PHASE (L1 & L2) 3 WIRE WITHOUT EARTH FAULT

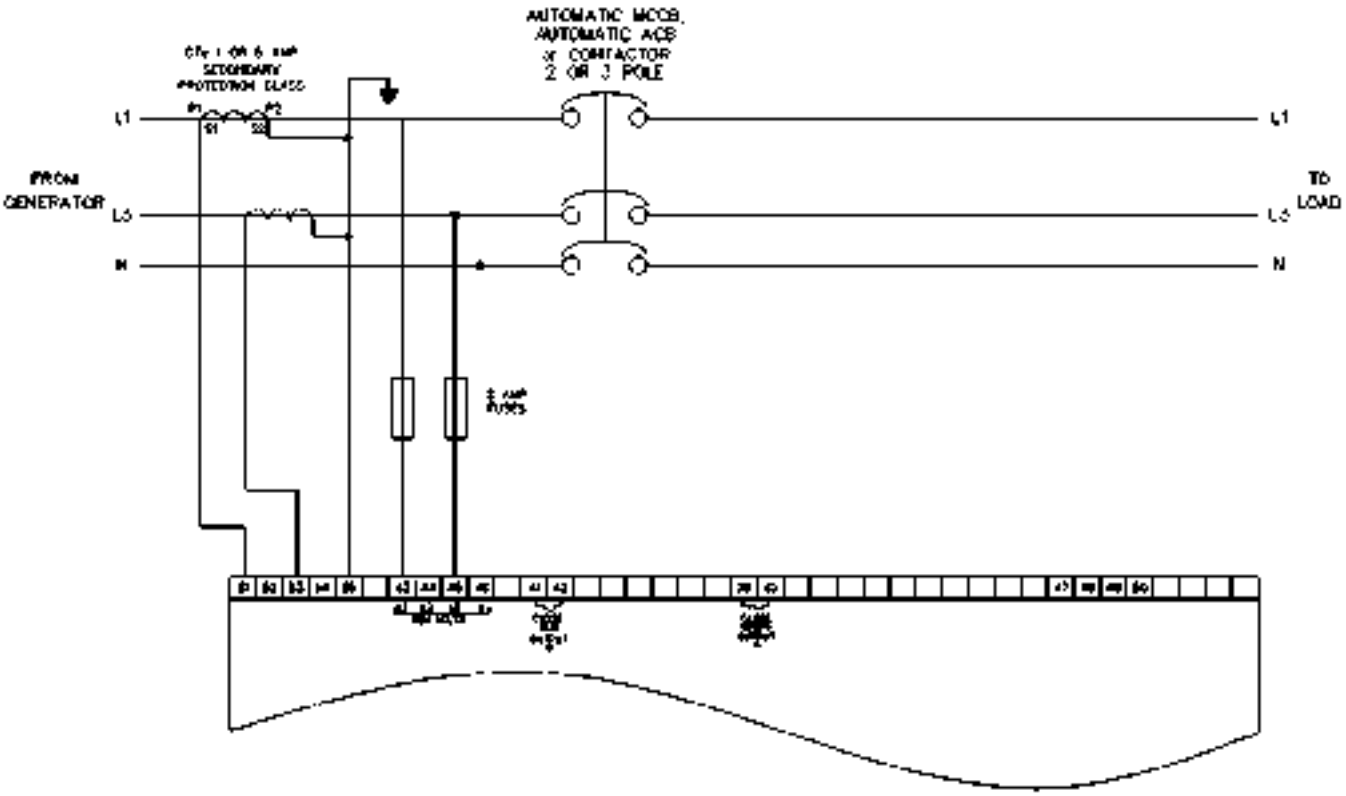


4.3.5 2 PHASE (L1 & L3) 3 WIRE WITH RESTRICTED EARTH FAULT

NOTE:- Earthing the neutral conductor 'before' the neutral CT allows the module to read earth faults 'after' the CT only (Restricted to load / downstream of the CT)
Earthing the neutral conductor 'after' the neutral CT allows the module to read earth faults 'before' the CT only (Restricted to generator / upstream of the CT)



4.3.6 2 PHASE (L1 & L3) 3 WIRE WITHOUT EARTH FAULT MEASURING



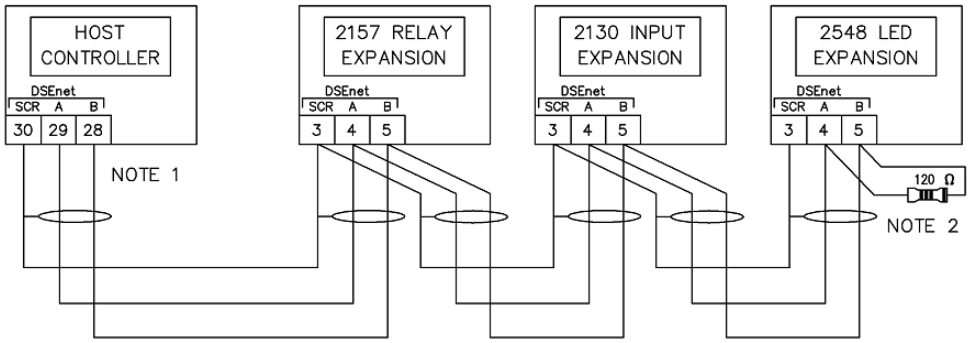
4.4 TYPICAL ARRANGEMENT OF DSENET®

Twenty (20) devices can be connected to the DSENet®, made up of the following devices :

Device	Max number supported
DSE2130 Input Expansion	4
DSE2157 Output Expansion	10
DSE2548 LED Expansion	10

For part numbers of the expansion modules and their documentation, see section entitled *DSENet Expansion Modules* elsewhere in this manual.

NOTE : DSE8600 series does not support the 2510/2520 display modules.



NOTE 1

AS A TERMINATING RESISTOR IS INTERNALLY FITTED TO THE HOST CONTROLLER, THE HOST CONTROLLER MUST BE THE FIRST UNIT ON THE DSEnet

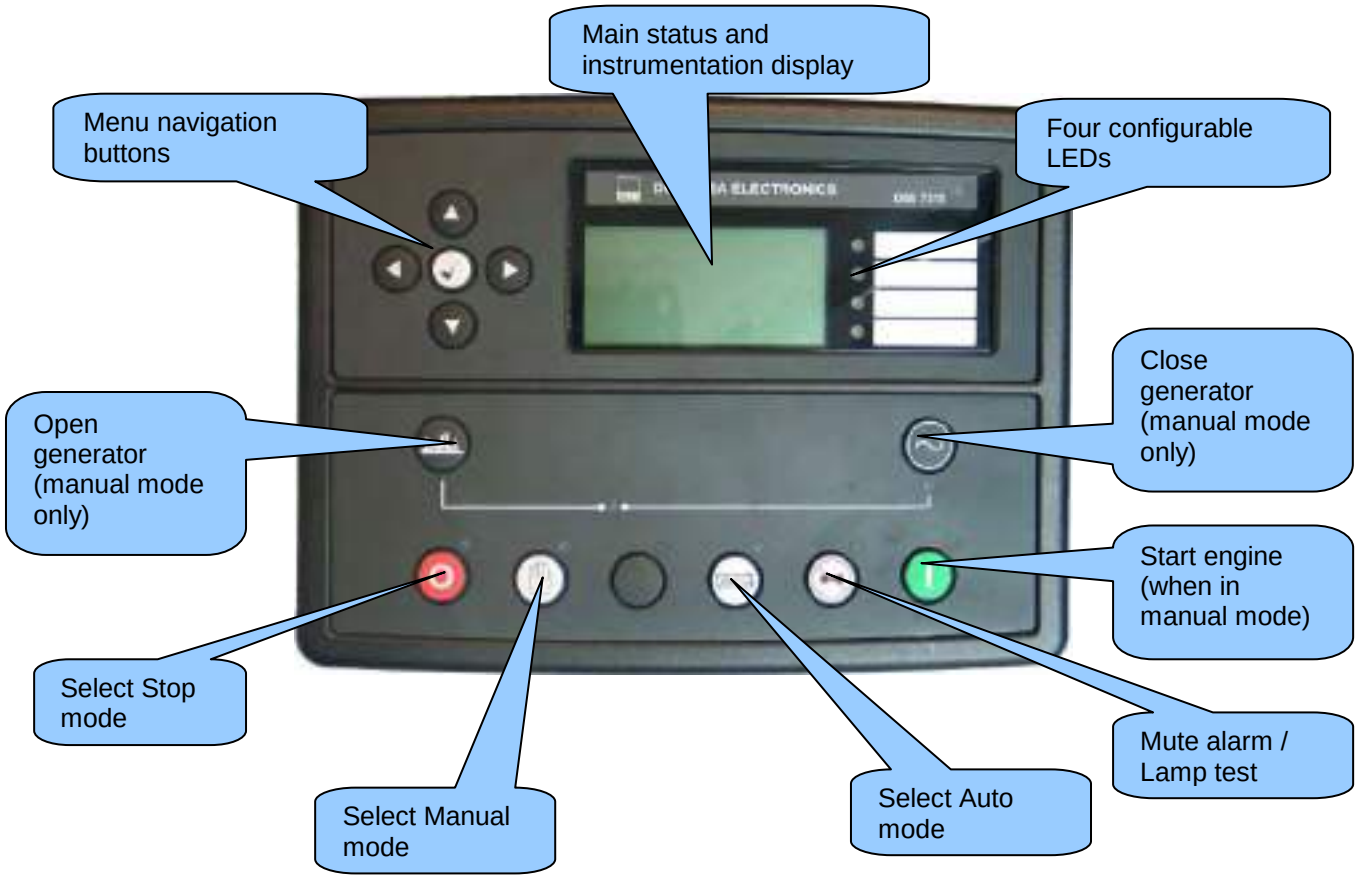
NOTE 2

A 120 OHM TERMINATION RESISTOR MUST BE FITTED TO THE LAST UNIT ON THE DSEnet

4.5 DESCRIPTION OF CONTROLS

The following section details the function and meaning of the various controls on the module.

4.6 DSE8610 AUTOSTART CONTROL MODULE



NOTE:- "Generator on load" LED has two modes of operation depending upon the configuration of the controllers digital inputs.

1) **Digital input configured for "Generator closed auxiliary" – The LED illuminates when the generator closed auxiliary input is active – The LED shows the state of the auxiliary contact.**
2) **There is NO input configured for "Generator closed auxiliary" (factory default setting) – The LED illuminates when the DSE8610 gives the loading signal to the generator – The LED shows the state of the DSE8610s loading request.**

4.7 QUICKSTART GUIDE

This section provides a quick start guide to the module's operation.

4.7.1 STARTING THE ENGINE

NOTE:- For further details, see the section entitled 'OPERATION' elsewhere in this manual.

4.7.2 STOPPING THE ENGINE

NOTE:- For further details, see the section entitled 'OPERATION' elsewhere in this manual.

4.8 VIEWING THE INSTRUMENT PAGES

It is possible to scroll to display the different pages of information by repeatedly operating the next / previous page buttons  .

If you want to view one of the instrument pages towards the end of the list, it may be quicker to scroll left through the pages rather than right!

Example

Status  Engine  Generator 

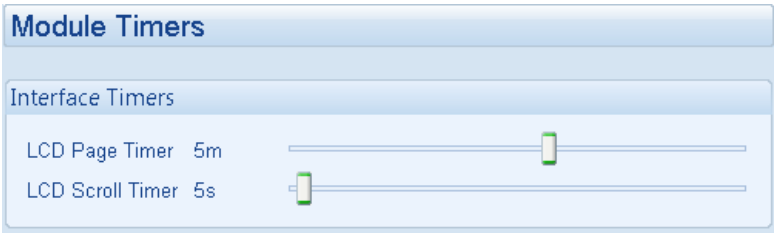
And so on until the last page is reached.
A Further press of the scroll right button returns the display to the Status page.

The complete order and contents of each information page are given in the following sections

Once selected the page will remain on the LCD display until the user selects a different page, or after an extended period of inactivity (*LCD Page Timer*), the module will revert to the status display.

If no buttons are pressed upon entering an instrumentation page, the instruments will be displayed automatically subject to the setting of the *LCD Scroll Timer*.

The *LCD Page* and *LCD Scroll* timers are configurable using the DSE Configuration Suite Software or by using the Front Panel Editor.



The screenshot shows the factory settings for the timers, taken from the DSE Configuration Suite Software.

Alternatively, to scroll manually through all instruments on the currently selected page, press the scroll  buttons. The 'autoscroll' is disabled.

If you want to view one of the instruments towards the end of the list, it may be quicker to scroll up through the instruments rather than down!

To re-enable 'autoscroll' press the scroll  buttons to scroll to the 'title' of the instrumentation page (ie Engine). A short time later (the duration of the *LCD Scroll Timer*), the instrumentation display will begin to autoscroll.

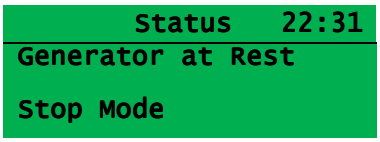
When scrolling manually, the display will automatically return to the Status page if no buttons are pressed for the duration of the configurable *LCD Page Timer*.

If an alarm becomes active while viewing the status page, the display shows the Alarms page to draw the operator's attention to the alarm condition.

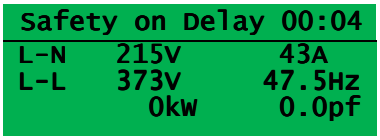
4.8.1 STATUS

This is the 'home' page, the page that is displayed when no other page has been selected, and the page that is automatically displayed after a period of inactivity (*LCD Page Timer)* of the module control buttons.

This page is configurable using the DSE Configuration Suite Software.



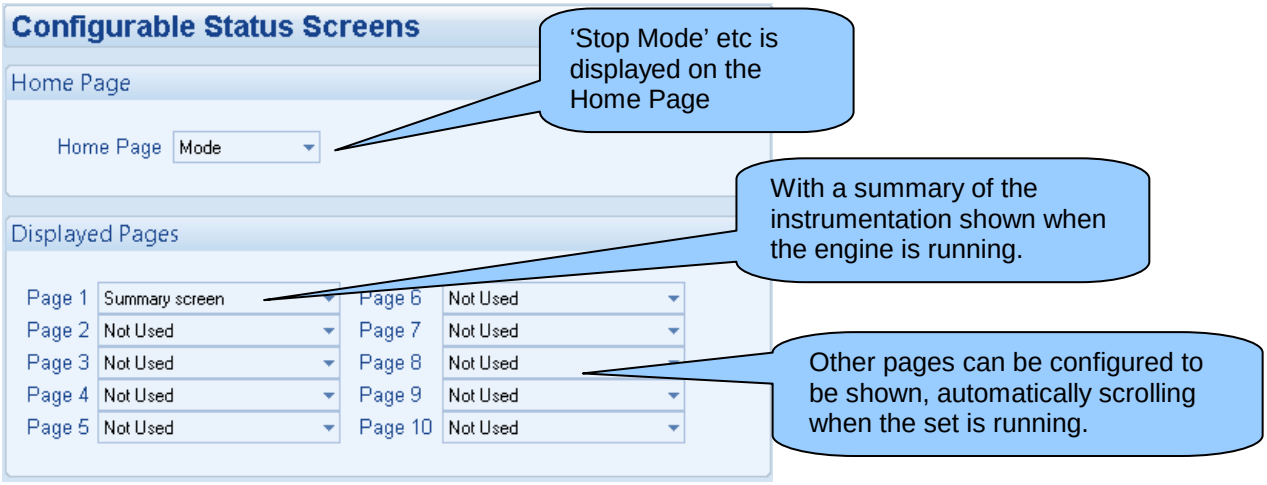
Factory setting of Status screen showing engine stopped...



...and engine running

The contents of this display may vary depending upon configuration by the generator manufacturer / supplier.

The display above is achieved with the factory settings, shown below in the DSE Configuration suite software:



NOTE:- The following sections detail instrumentation pages, accessible using the scroll left and right buttons, regardless of what pages are configured to be displayed on the 'status' screen.

4.8.2 ENGINE

Contains instrumentation gathered about the engine itself, some of which may be obtained using the CAN or other electronic engine link.

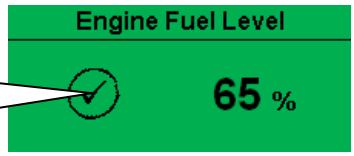
- Engine Speed
- Oil Pressure
- Coolant Temperature
- Engine Battery Volts
- Run Time
- Oil Temperature*
- Coolant Pressure*
- Inlet Temperature*
- Exhaust Temperature*
- Fuel Temperature*
- Turbo Pressure*
- Fuel Pressure*
- Fuel Consumption*
- Fuel Used*
- Fuel Level*
- Auxiliary Sensors (If fitted and configured)
- Engine Maintenance Due (If configured)
- Engine ECU Link*

*When connected to suitably configured and compatible engine ECU. For details of supported engines see 'Electronic Engines and DSE wiring' (DSE Part number 057-004).

Depending upon configuration and instrument function, some of the instrumentation items may include a tick icon beside them. This denotes a further function is available, detailed in the 'operation' section of this document.

Example:

The tick icon denotes that manual fuel pump control is enabled in this system.
Press and hold to start the fuel transfer pump, release to stop the pump. This is detailed further in the section entitled 'operation' elsewhere in this document.



4.8.3 GENERATOR

Contains electrical values of the generator (alternator), measured or derived from the module's voltage and current inputs.

- Generator Voltage (ph-N)
- Generator Voltage (ph-ph)
- Generator Frequency
- Generator Current
- Generator Earth Current
- Generator Load (kW)
- Generator Load (kVA)
- Generator Power Factor
- Generator Load (kVAr)
- Generator Load (kWh, kVAh, kVArh)
- Generator Phase Sequence
- Synchroscope display

4.8.4 BUS

Contains electrical values of the common generator bus measured or derived from the module's bus inputs.

- Bus Voltage (ph-N)
- Bus Voltage (ph-ph)
- Bus Frequency
- Bus Phase Sequence

4.8.5 RS232 SERIAL PORT

This section is included to give information about the RS232 serial port and external modem (if connected).
The items displayed on this page will change depending upon configuration of the module. You are referred to your system supplier for further details.

NOTE:- Factory Default settings are for the RS232 port to be enabled with no modem connected, operating at 19200 baud, modbus slave address 10.

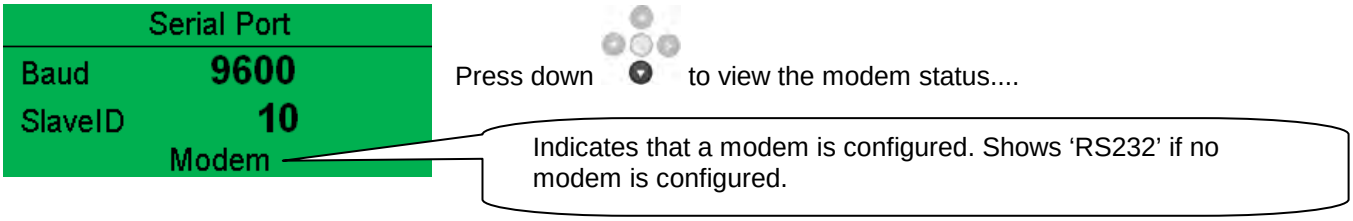
Example 1 – Module connected to an RS232 telephone modem.

When the DSE8610 series module is power up, it will send ‘initialisation strings’ to the connected modem. It is important therefore that the modem is already powered, or is powered up at the same time as the DSE86xx series module. At regular intervals after power up, the modem is reset, and reinitialised, to ensure the modem does not ‘hang up’.

If the DSE8610 series module does not correctly communicate with the modem, “Modem initialising’ appears on the Serial Port instrument screen as shown overleaf.

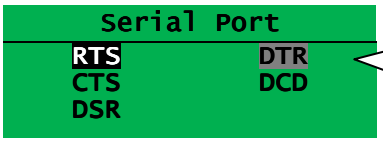
If the module is set for “incoming calls” or for “incoming and outgoing calls”, then if the modem is dialled, it will answer after two rings (using the factory setting ‘initialisation strings)’. Once the call is established, all data is passed from the dialling PC and the DSE8610 series module.

If the module is set for “outgoing calls” or for “incoming and outgoing calls”, then the module will dial out whenever an alarm is generated. Note that not all alarms will generate a dial out; this is dependant upon module configuration of the event log. Any item configured to appear in the event log will cause a dial out.



Example 1 continued – Modem diagnostics

Modem diagnostic screens are included; press  when viewing the *RS232 Serial Port* instrument to cycle the available screens. If you are experiencing modem communication problems, this information will aid troubleshooting.

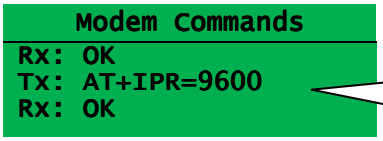


Shows the state of the modem communication lines. These can help diagnose connection problems.

Example:

RTS A dark background shows the line is active.
RTS a grey background shows that the line is toggling high and low.
RTS No background indicates that the line is inactive

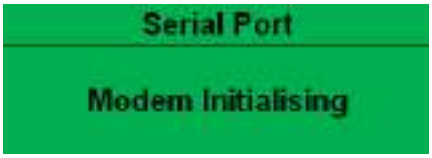
Line	Description	
RTS	Request To Send	Flow control
CTS	Clear To Send	Flow control
DSR	Data Set Ready	Ready to communicate
DTR	Data Terminal Ready	Ready to communicate
DCD	Data Carrier Detect	Modem is connected



Shows the last command sent to the modem and the result of the command.

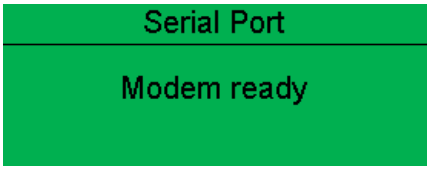
Modem Setup Sequence

1)



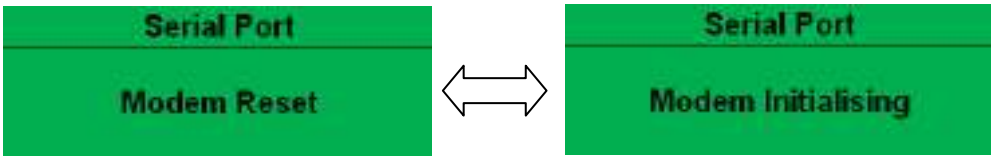
If the Modem and DSE8600 series communicate successfully:

2)



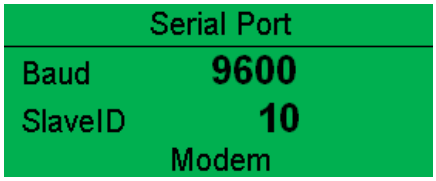
In case of communication failure between the modem and DSE8600 series module, the modem is automatically reset and initialisation is attempted once more:

3)

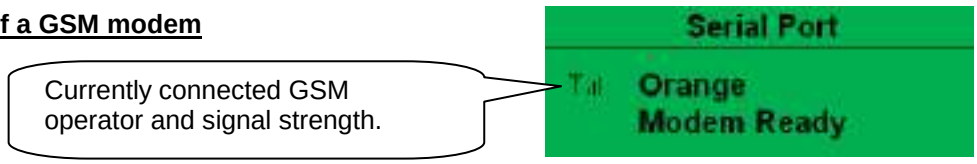


In the case of a module that is unable to communicate with the modem, the display will continuously cycle between 'Modem Reset' and 'Modem Initialising' as the module resets the modem and attempts to communicate with it again, this will continue until correct communication is established with the modem. In this instance, you should check connections and verify the modem operation.

Example 2 – Module connected to a modem.



Example 3 – Modem status of a GSM modem



Many GSM modems are fitted with a status LED to show operator cell status and ringing indicator. These can be a useful troubleshooting tool.

In the case of GSM connection problems, try calling the DATA number of the SIMCARD with an ordinary telephone. There should be two rings, followed by the modem answering the call and then 'squealing'. If this does not happen, you should check all modem connections and double check with the SIM provider that it is a DATA SIM and can operate as a data modem. DATA is NOT the same as FAX or GPRS and is often called Circuit Switched Data (CSD) by the SIM provider.

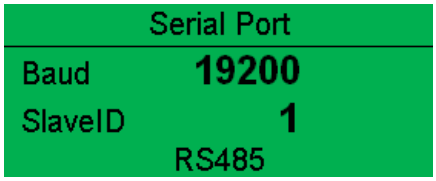
NOTE: In the case of GSM modems, it is important that a DATA ENABLED SIM is used. This is often a different number than the 'voice number' and is often called Circuit Switched Data (CSD) by the SIM provider.

If the GSM modem is not purchased from DSE, ensure that it has been correctly set to operate at 9600 baud. You may need to install a terminal program on your PC and consult your modem supplier to do this. GSM modems purchased from DSE are already configured to work with the DSE86xx series module.

4.8.6 RS485 SERIAL PORT

This section is included to give information about the currently selected serial port and external modem (if connected).
The items displayed on this page will change depending upon configuration of the module. You are referred to your system supplier for further details.

NOTE:- Factory Default settings are for the RS485 port to operating at 19200 baud, modbus slave address 10.



Module RS485 port configured for connection to a modbus master.

DSE86xx series modules operate as a modbus RTU slave device.
In a modbus system, there can be only one Master, typically a PLC, HMI system or PC SCADA system.
This master requests for information from the modbus slave (DSE86xx series module) and may (in control systems) also send request to change operating modes etc. Unless the Master makes a request, the slave is 'quiet' on the data link.
The factory settings are for the module to communicate at 19200 baud, modbus slave address 10.
To use the RS485 port, ensure that 'port usage' is correctly set using the DSE Configuration Suite Software.
Required settings are shown below.

'Master inactivity timeout' should be set to at least twice the value of the system scan time. For example if a modbus master PLC requests data from the DSE86xx modbus slave once per second, the timeout should be set to at least 2 seconds.

The DSE Modbus Gencomm document containing register mappings inside the DSE module is available upon request from support@deepseaplc.com. Email your request along with the serial number of your DSE module to ensure the correct information is sent to you.

Typical requests (using Pseudo code)

`BatteryVoltage=ReadRegister(10,0405,1)` : reads register (hex) 0405 as a single register (battery volts) from slave address 10.

`WriteRegister(10,1008,2,35701, 65535-35701)` : Puts the module into AUTO mode by writing to (hex) register 1008, the values 35701 (auto mode) and register 1009 the value 65535-35701 (the bitwise opposite of auto mode)

`Shutdown=(ReadRegister(10,0306,1) >> 12) & 1)` : reads (hex) 0306 and looks at bit 13 (shutdown alarm present)
`Warning=(ReadRegister(10,0306,1) >> 11) & 1)` : reads (hex) 0306 and looks at bit 12 (Warning alarm present)
`ElectricalTrip=(ReadRegister(10,0306,1) >> 10) & 1)` : reads (hex) 0306 and looks at bit 11 (Electrical Trip alarm present)

`ControlMode=ReadRegister(10,0304,2);` reads (hex) register 0304 (control mode).

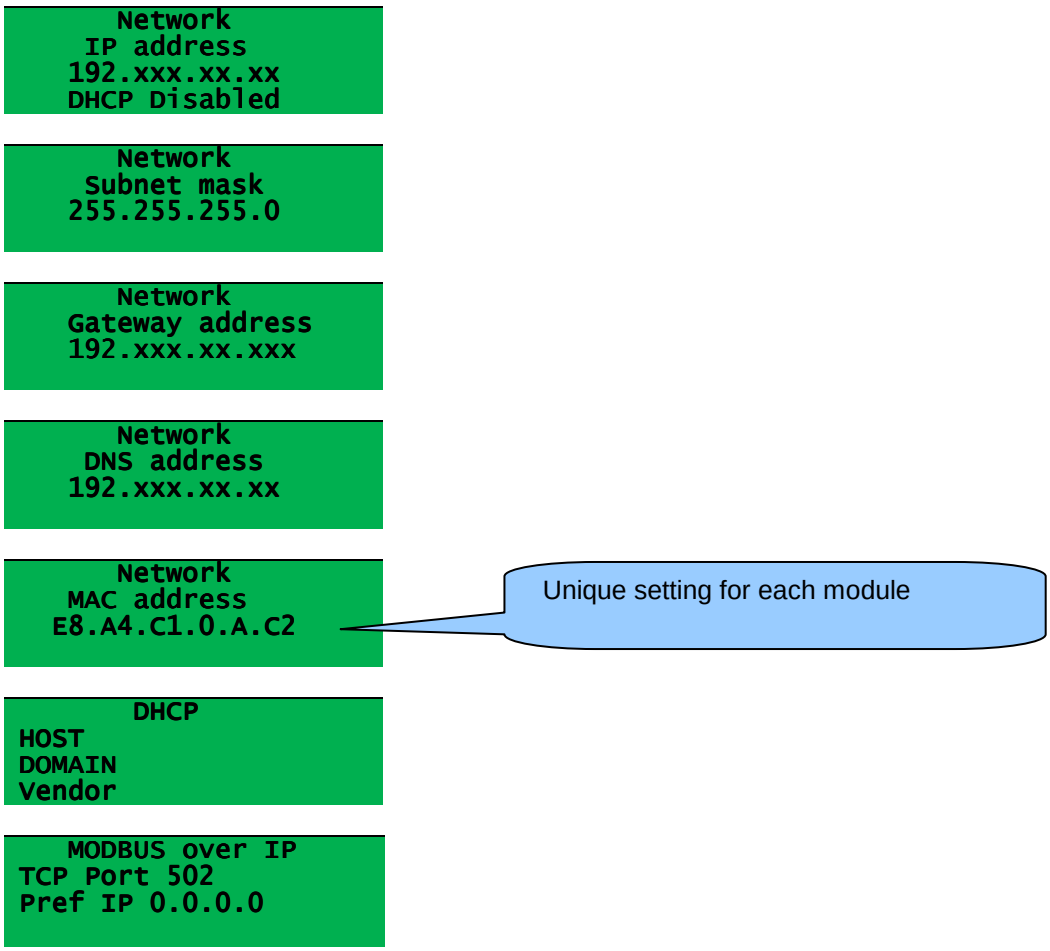
4.8.7 ABOUT

Contains important information about the module and the firmware versions. This information may be asked for when contacting DSE Technical Support Department for advice.

- Module Type (i.e. 8610)
- Application Version – The version of the module's main firmware file – Updatable using the Firmware Update Wizard in the DSE Configuration Suite Software.
- USB ID – unique identifier for PC USB connection
- Analogue Measurements software version
- Firmware Update Boot loader software version.

4.8.7.1 ETHERNET PAGES

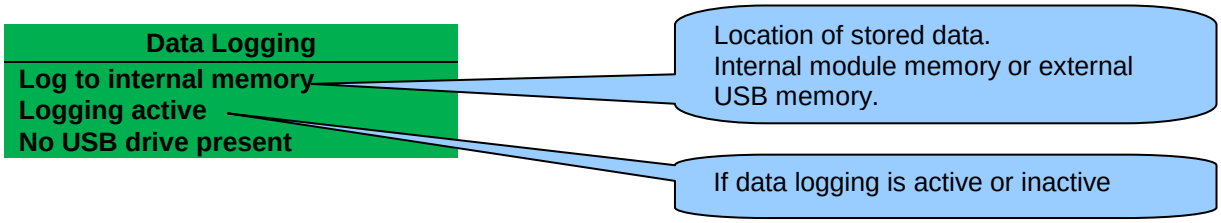
- Update Network settings using DSE Configuration Suite Software+ 1 Power cycle off/on before the editor pages are updated..



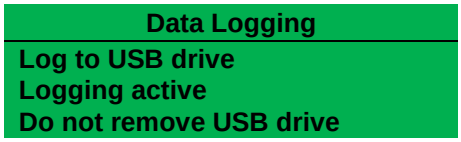
Pages available in the "ABOUT" screen to confirm Network settings.

4.8.7.2 DATA LOGGING PAGES

The DSE data logging pages show information depending on the configuration in the module.

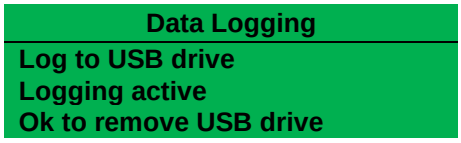


Inserting a USB drive to the host USB will display the following change to the page.



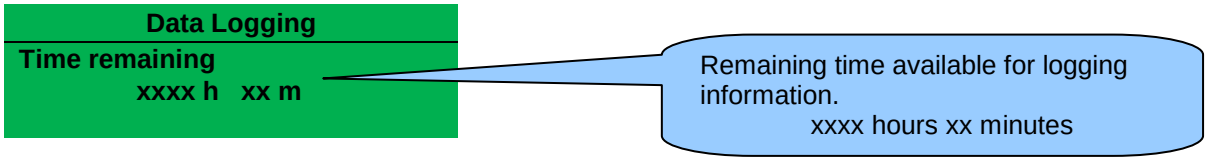
NOTE:- Removal of the USB drive should only be carried out using the following method.

Press and hold the tick button until “Ok to remove USB drive” is displayed.

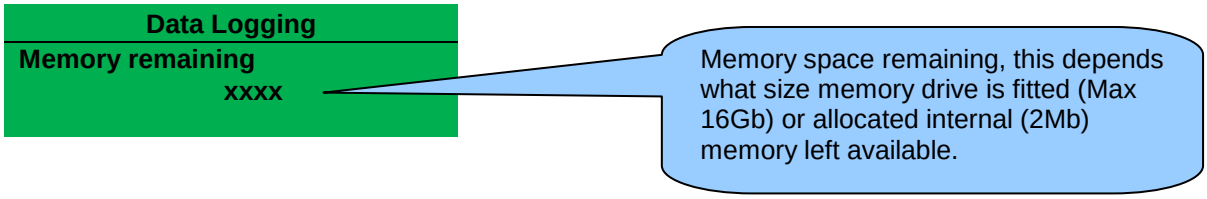


It is now safe to remove the USB drive.
This ensures the logging data file will save to memory complete and will not become corrupt.

Press down to view the next page.



Press down to view the next page.



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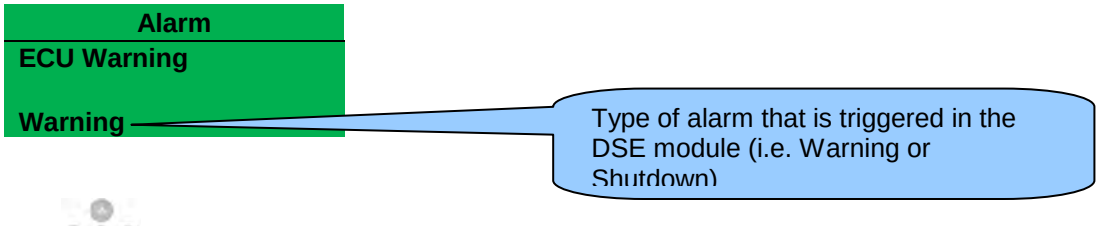
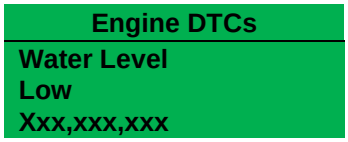
4.8.8 CAN ERROR MESSAGES

When connected to a suitable CAN engine the 8600 series controller displays alarm status messages from the ECU.



Press  to access the list of current active Engine DTCs (Diagnostic Trouble Codes).



The code interpreted by the module shows on the display as a text message. Additionally, the manufacturer's code is shown.

NOTE: - For details on these code meanings, refer to the ECU instructions provided by the engine manufacturer, or contact the engine manufacturer for further assistance.

NOTE: - For further details on connection to electronic engines please refer to *Electronic engines and DSE wiring.* Part No. 057-004

4.9 VIEWING THE EVENT LOG

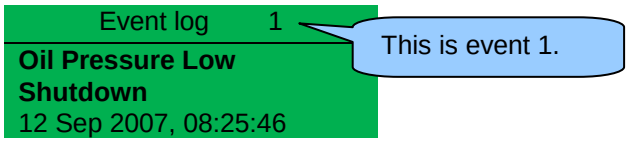
The DSE8600 series modules maintain a log of past alarms and/or selected status changes.
The log size has been increased in the module over past module updates and is always subject to change. At the time of writing, the 86xx series log is capable of storing the last 250 log entries.

Under default factory settings, the event log only includes shutdown and electrical trip alarms logged (The event log does not contain Warning alarms**);** however, this is configurable by the system designer using the DSE Configuration Suite software.

Example showing the possible configuration of the DSE8600 series event log (DSE Configuration Suite Software)
This also shows the factory settings of the module (Only shutdown alarms and the mains status are logged).

Once the log is full, any subsequent shutdown alarms will overwrite the oldest entry in the log.
Hence, the log will always contain the most recent shutdown alarms.
The module logs the alarm, along with the date and time of the event (or engine running hours if configured to do so).
If the module is configured and connected to send SMS text

To view the event log, repeatedly press the next page button  until the LCD screen displays the Event log :

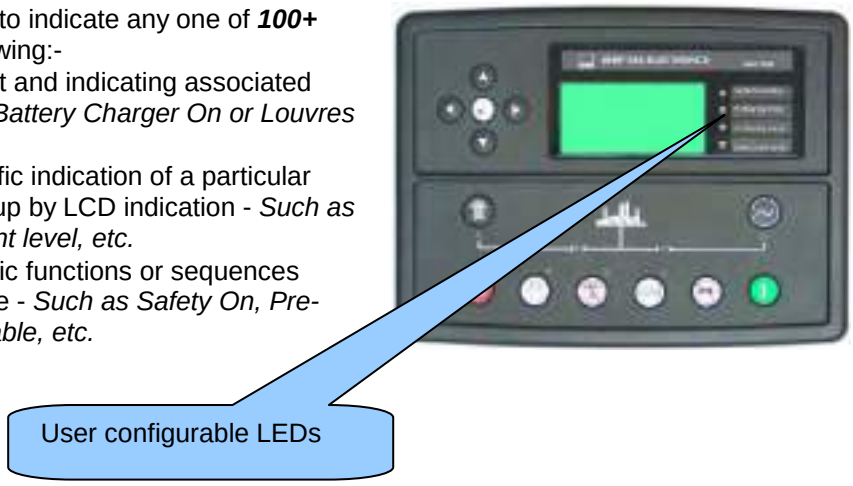


Press down  to view the next most recent shutdown alarm:

Continuing to press down  cycles through the past alarms after which the display shows the most recent alarm and the cycle begins again.

To exit the event log and return to viewing the instruments, press the next page  button to select the next instrumentation page.

4.10 USER CONFIGURABLE INDICATORS



These LEDs can be configured by the user to indicate any one of ***100+ different functions*** based around the following:-

- **Indications** - Monitoring of a digital input and indicating associated functioning user's equipment - *Such as Battery Charger On or Louvres Open, etc*.
- **WARNINGS a**nd **SHUTDOWNS** - Specific indication of a particular warning or shutdown condition, backed up by LCD indication - *Such as Low Oil Pressure Shutdown, Low Coolant level, etc.*
- **Status Indications** - Indication of specific functions or sequences derived from the modules operating state - *Such as Safety On, Pre-heating, Panel Locked, Generator Available, etc.*

4.11 CONTROLS

Stop / Reset This button places the module into its **Stop/Reset** mode. This will clear any alarm conditions for which the triggering criteria have been removed. If the engine is running and the module is in Stop mode, the module will automatically instruct the changeover device to unload the generator *('**Close Generator**' becomes inactive (if used))*. The fuel supply de-energises and the engine comes to a standstill. Should a **remote start signal** be present while operating in this mode, a remote start will not occur.	
Manual This mode allows manual control of the generator functions. Once in **Manual mode** the module will respond to the start button, start the engine, and run off load. If the engine is running off-load in the **Manual mode** and a **remote start signal** becomes present, the module will automatically instruct the changeover device to place the generator on load *('**Close Generator**' becomes active (if used))*. Upon removal of the **remote start signal**, the generator remains on load until either selection of the **'STOP/RESET'** or **'AUTO'** modes. *For further details, please see the more detailed description of 'Manual operation' elsewhere in this manual.*	
Auto This button places the module into its **'Automatic'** mode. This mode allows the module to control the function of the generator automatically. The module will monitor the *remote start* input and mains supply status and once a start request is made, the set will be automatically started and placed on load. Upon removal of the starting signal, the module will automatically transfer the load from the generator and shut the set down observing the *stop delay* timer and *cooling* timer as necessary. The module will then await the next start event. *For further details, please see the more detailed description of 'Auto operation' elsewhere in this manual.*	
4.11.1.1 START This button is only active in STOP/RESET or MANUAL mode. Pressing this button in manual or test mode will start the engine and run off load (manual) or on load (test). Pressing this button in STOP/RESET mode will turn on the CAN engine ECU (when correctly configured and fitted to a compatible engine ECU)	
Mute / Lamp Test This button silences the audible alarm if it is sounding and illuminates all of the LEDs as a lamp test feature/ When correctly configured and fitted to a compatible engine ECU, pressing this button in STOP/RESET mode after pressing the START button (to power the ECU) will cancel any "passive" alarms on the engine ECU.	

Transfer to generator Allows the operator to transfer the load to the generator, synchronising first if required. (when in Manual mode only)	
Open generator (DSE8610 only) Allows the operator to open the generator breaker (when in Manual mode only)	
Menu navigation Used for navigating the instrumentation, event log and configuration screens. For further details, please see the more detailed description of these items elsewhere in this manual.	

5 OPERATION

The following description details the sequences followed by a module containing the standard '*factory configuration*'.

Remember that if you have purchased a completed generator set or control panel from your supplier, the module's configuration will probably have been changed by them to suit their particular requirements.

Always refer to your configuration source for the exact sequences and timers observed by any particular module in the field.

5.1 ALTERNATIVE CONFIGURATIONS

Depending upon the configuration of your system by the generator supplier, the system may have selectable configurations (for example to select between 50Hz and 60Hz running). If this has been enabled your generator supplier will advise how this selection can be made (usually by externally operated selector switch or by selecting the required configuration file in the DSE8600 series front panel configuration editor).

5.2 DUMMY LOAD / LOAD SHEDDING CONTROL

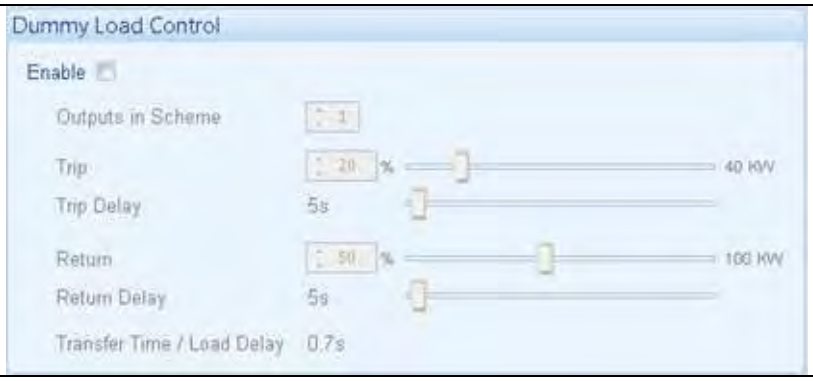
This feature may be enabled by the system designer to ensure the loading on the generator is kept to a nominal amount. If the load is low, 'dummy loads' (typically static load banks) can be introduced to ensure the engine is not too lightly loaded. Conversely, as the load increases towards the maximum rating of the set, non-essential loads can be shed to prevent overload of the generator.

5.2.1 DUMMY LOAD CONTROL

The *dummy load control* feature (if enabled) allows for a maximum of five dummy load steps.
When the set is first started, all configured *Dummy Load Control* outputs are de-energised.
Once the generator is placed onto load, the generator loading is monitored by the *Dummy Load Control* scheme.

If the generator loading falls below the *Dummy Load Control Trip* setting (kW), the *Dummy Load Control Trip Delay* is displayed on the module display. If the generator loading remains at this low level for the duration of the timer, the first *Dummy Load Control* output is energised. This is used to energise external circuits to switch in (for instance) a static load bank.
The generator loading has now been increased by the first dummy load. Again, the generator loading is monitored. This continues until all configured *Dummy Load Control* outputs are energised.

Should the generator loading rise above the *Dummy Load Return* level, the *Dummy Load Return Delay* begins.
If the loading remains at these levels after the completion of the timer, the 'highest' active *Dummy Load Control* output is de-energised. This continues until all *Dummy Load Control* outputs have been de-energised.



Example screen shot of *Dummy Load Control* setup in the DSE Configuration Suite

5.2.2 LOAD SHEDDING CONTROL

The *Load Shedding Control* feature (if enabled) allows for a maximum of five load-shedding steps.
When the generator is about to take load, the configured number of *Load Shedding Control Outputs at Startup* will energise. This configurable setting allows (for instance) certain loads to be removed from the generator prior to the set's load switch being closed. This can be used to ensure the initial loading of the set is kept to a minimum, below the *Load Acceptance* specification of the generating set.
The generator is then placed on load. The *Load Shedding Control* scheme begins.
When the load reaches the *Load Shedding Trip* level, the *Trip Delay* timer will start. If the generator loading is still high when the timer expires, the first *Load shedding Control* output will energise. When the load has been above the trip level for the duration of the timer the 'next' *Load shedding Control* output will energise and so on until all *Load Shedding Control outputs are energised.*
If at any time the load falls back below the *Load Shedding Return* level, the *Return Time* will start. If the load remains below the return level when the timer has expired the 'highest' *Load Shedding Control* output that has been energised will be de-energised. This process will continue until all outputs have been de-energised.
When the set enters a stopping sequence for any reason the *Load Shedding control*' outputs will de-energise at the same time as the generator load switch is signalled to open.

Example screen shot of *Load Shedding Control* setup in the DSE Configuration Suite

5.3 STOP MODE

STOP mode is activated by pressing the button.

In STOP mode, the module will immediately remove the generator from load (if necessary) before stopping the engine if it is already running. No cooling run is provided for this operation. Where a cooling run is required, switch to MANUAL mode and open the breaker manually. Allow the set to cool off load, before pressing the STOP button to stop the engine.

If the engine does not stop when requested, the FAIL TO STOP alarm is activated (subject to the setting of the *Fail to Stop* timer). To detect the engine at rest the following must occur:

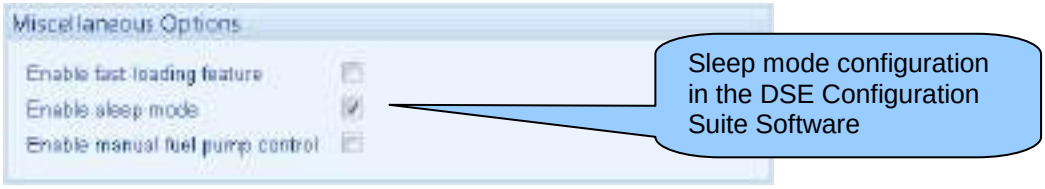
- Engine speed is zero as detected by the Magnetic Pickup or CANbus ECU (depending upon module variant).
- Generator frequency must be zero.
- Oil pressure switch must be closed to indicate low oil pressure (MPU version only)

When the engine has stopped, it is possible to send configuration files to the module from DSE Configuration Suite PC software and to enter the Front Panel Editor to change parameters.

Any latched alarms that have been cleared will be reset when STOP mode is entered.

The engine will not be started when in STOP mode. If remote start signals are given, the input is ignored until AUTO mode is entered.

When configured to do so, when left in STOP mode for five minutes with no presses of the fascia buttons, the module enters low power mode. To 'wake' the module, press the button or any other fascia control button.



5.3.1 ECU OVERRIDE

NOTE:- Depending upon system design, the ECU may be powered or unpowered when the module is in STOP mode. ECU override is only applicable if the ECU is unpowered when in STOP mode.

When the ECU is powered down (as is normal when in STOP mode), it is not possible to read the diagnostic trouble codes or instrumentation. Additionally, it is not possible to use the engine manufacturers' configuration tools.

As the ECU is usually unpowered when the engine is not running, it must be turned on manually as follows:

- Select STOP mode on the DSE controller.
- Press and hold the START button to power the ECU. As the controller is in STOP mode, the engine will not be started.
- Continue to hold the start button for as long as you need the ECU to be powered.
- The ECU will remain powered until a few seconds after the START button is released.

This is also useful if the engine manufacturer's tools need to be connected to the engine, for instance to configure the engine as the ECU needs to be powered up to perform this operation.

5.4 AUTOMATIC MODE

NOTE:- If a digital input configured to *panel lock* is active, changing module modes will not be possible. Viewing the instruments and event logs is NOT affected by panel lock.

Activate auto mode be pressing the AUTO pushbutton. An LED indicator beside the button confirms this action.

Auto mode will allow the generator to operate fully automatically, starting and stopping as required with no user intervention.

5.4.1 WAITING IN AUTO MODE

If a starting request is made, the starting sequence will begin.
Starting requests can be from the following sources:

- Activation of an auxiliary input that has been configured to *remote start on load* or *remote start off load.*
- Request from DSE8660 mains controller or from another DSE8610 controller over the MSC link.
- Activation of the inbuilt exercise scheduler.
- Instruction from external remote telemetry devices using the RS232 or RS485 interface.

5.4.2 STARTING SEQUENCE

To allow for 'false' start requests such as mains brownouts, the *start delay* timer begins. There are individual start delay timers for each of the different start request types.

Should all start requests be removed during the *start delay* timer, the unit will return to a stand-by state.

If a start request is still present at the end of the *start delay* timer, the fuel relay is energised and the engine will be cranked.

NOTE:- If the unit has been configured for CAN, compatible ECU's will receive the start command via CAN.

If the engine fails to fire during this cranking attempt then the starter motor is disengaged for the *crank rest* duration after which the next start attempt begins. Should this sequence continue beyond the set number of attempts, the start sequence will be terminated and the display shows ***Fail to Start.***

The starter motor is disengaged when the engine fires. Speed detection is factory configured to be derived from the main alternator output frequency, but can additionally be measured from a Magnetic Pickup mounted on the flywheel (Selected by PC using the 8600 series configuration software).

Additionally, rising oil pressure or charge alternator voltage can be used to disconnect the starter motor (but cannot detect underspeed or overspeed).

NOTE:- If the unit has been configured for CAN, speed sensing is via CAN.

After the starter motor has disengaged, the *Safety On* timer activates, allowing Oil Pressure, High Engine Temperature, Under-speed, Charge Fail and any delayed Auxiliary fault inputs to stabilise without triggering the fault.

5.4.3 ENGINE RUNNING

Once the engine is running, the *Warm Up* timer, if selected, begins, allowing the engine to stabilise before accepting the load.

If the common bus is measured to be ‘dead bus’, the load breaker is closed.
If the bus is measured to be ‘live bus’, synchronising takes place before the breaker is closed.

NOTE:-The load transfer signal remains inactive until the Oil Pressure has risen. This prevents excessive wear on the engine.

As the load increases and decreases, the DSE86xx series module (may (depending upon configuration) add dummy loads or remove non-essential loads. This is configured as part of the *Load Shedding* and *Dummy Load* control settings in the DSE Configuration Suite Software.
See section entitled *Dummy Load / Load Shedding* elsewhere in this document for further details.

Additionally, when configured as part of a multiset package, the generator may be automatically started and stopped depending upon load requirements.

If in doubt, consult your system supplier for details of how your particular system has been configured.

If all start requests are removed, the *stopping sequence* will begin.

5.4.4 STOPPING SEQUENCE

The *return delay* timer operates to ensure that the starting request has been permanently removed and is not just a short-term removal. Should another start request be made during the cooling down period, the set will return on load.

If there are no starting requests at the end of the *return delay* timer, the load is ramped off the generator being the breaker is opened and the *cooling* timer is initiated.

The *cooling* timer allows the set to run off load and cool sufficiently before being stopped. This is particularly important where turbo chargers are fitted to the engine.

If the set is called to return to load before the *cooling timer* has expired, the *Engine Running* operation is again followed.

After the *cooling* timer has expired, the set is stopped.

5.5 MANUAL MODE

NOTE:- If a digital input configured to *panel lock* is active, changing module modes will not be possible. Viewing the instruments and event logs is NOT affected by panel lock.

Activate Manual mode be pressing the pushbutton. An LED indicator beside the button confirms this action.

Manual mode allows the operator to start and stop the set manually, and if required change the state of the load switching devices.

5.5.1 WAITING IN MANUAL MODE

When in manual mode, the set will not start automatically.

To begin the starting sequence, press the button.

5.5.2 STARTING SEQUENCE

NOTE:- There is no *start delay* in this mode of operation.

The fuel relay is energised and the engine is cranked.

NOTE:- If the unit has been configured for CAN, compatible ECU's will receive the start command via CAN.

If the engine fails to fire during this cranking attempt then the starter motor is disengaged for the *crank rest* duration after which the next start attempt is made. Should this sequence continue beyond the set number of attempts, the start sequence will be terminated and the display shows ***Fail to Start.***

When the engine fires, the starter motor is disengaged. Speed detection is factory configured to be derived from the main alternator output frequency but can additionally be measured from a Magnetic Pickup mounted on the flywheel (Selected by PC using the 8600 series configuration software).

Additionally, rising oil pressure or charge alternator voltage can be used to disconnect the starter motor (but cannot detect underspeed or overspeed).

NOTE:- If the unit has been configured for CAN, speed sensing is via CAN.

After the starter motor has disengaged, the *Safety On* timer activates, allowing Oil Pressure, High Engine Temperature, Under-speed, Charge Fail and any delayed Auxiliary fault inputs to stabilise without triggering the fault.

5.5.3 ENGINE RUNNING

In manual mode, the load is not transferred to the generator unless a 'loading request' is made.
A loading request can come from a number of sources.

- Pressing the *transfer to generator* button.
- Request from DSE8660 mains controller or from another DSE8610 controller over the MSC link.
- Activation of an auxiliary input that has been configured to *remote start on load*
- Activation of the inbuilt exercise scheduler if configured for 'on load' runs.

NOTE:-The load transfer signal remains inactive until the Oil Pressure has risen. This prevents excessive wear on the engine.

If the common bus is measured to be 'dead bus', the load breaker is closed.
If the bus is measured to be 'live bus', synchronising takes place before the breaker is closed.

Once the load has been transferred to the generator, the load switch will not be automatically opened unless:

- Press the *Open Generator* button (DSE8610/DSE8610 only)
- Press the *auto mode* button to return to automatic mode.

5.5.4 MANUAL FUEL PUMP CONTROL

- Navigate to the instruments page using the buttons and locate FUEL LEVEL. is shown on the module display to indicate that this feature is available.
- Press and hold the button to energise the transfer pump. The pump starts two seconds after the button is pressed.
- Release the button to de-energise the transfer pump.

5.5.5 MANUAL SPEED CONTROL

- Navigate to the instruments page using the buttons and locate ENGINE SPEED. is shown on the module display to indicate that this feature is available.
- Press the button to enter edit mode
- Press (up or down) to change the engine speed.
- Press the button again to exit the editor and leave the engine running at the newly selected speed.

5.5.6 STOPPING SEQUENCE

In manual mode the set will continue to run until either :

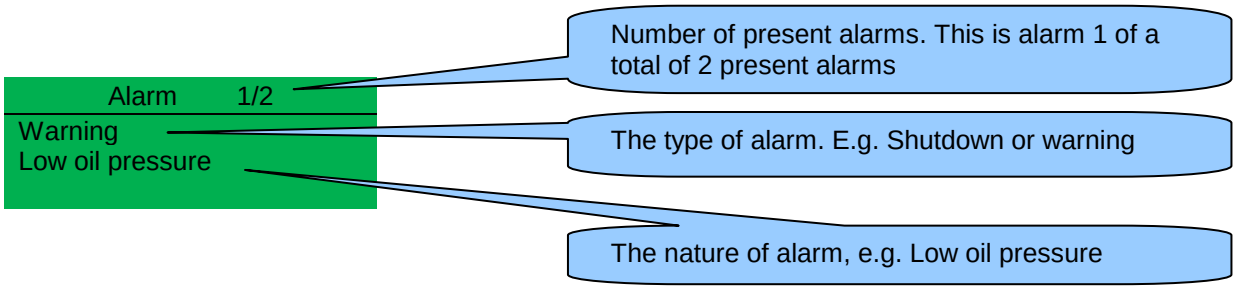
- The *stop button*  is pressed – The set will immediately stop
- The *auto button*  is pressed. The set will observe all auto mode start requests and stopping timers before beginning the *Auto mode stopping sequence*.

6 PROTECTIONS

When an alarm is present, the Audible Alarm will sound and the Common alarm LED if configured will illuminate.

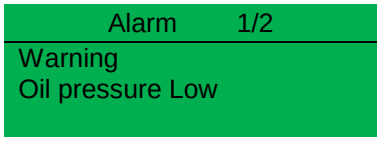
The audible alarm can be silenced by pressing the *Mute button* 

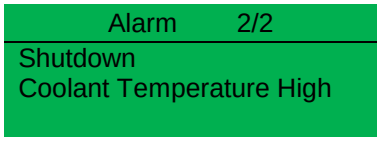
The LCD display will jump from the 'Information page' to display the Alarm Page



The LCD will display multiple alarms E.g. "High Engine Temperature shutdown", "Emergency Stop" and "Low Coolant Warning". These will automatically scroll in the order that they occurred.

In the event of a warning alarm, the LCD will display the appropriate text. If a shutdown then occurs, the module will again display the appropriate text.
Example:-





6.1 PROTECTIONS DISABLED

User configuration is possible to prevent Shutdown / Electrical Trip alarms from stopping the engine.
Under such conditions, *Protections Disabled* will appear on the module display to inform the operator of this status.

This feature is provided to assist the system designer in meeting specifications for “Warning only”, “Protections Disabled”, “Run to Destruction”, “War mode” or other similar wording.

When configuring this feature in the PC software, the system designer chooses to make the feature either permanently active, or only active upon operation of an external switch. The system designer provides this switch (not DSE) so its location will vary depending upon manufacturer, however it normally takes the form of a key operated switch to prevent inadvertent activation. Depending upon configuration, a warning alarm may be generated when the switch is operated.

The feature is configurable in the PC configuration software for the module. Writing a configuration to the controller that has “Protections Disabled” configured, results in a warning message appearing on the PC screen for the user to acknowledge before the controller’s configuration is changed. This prevents inadvertent activation of the feature.

6.1.1 INDICATION / WARNING ALARMS

Under Indication or Warning alarms:

- The module operation is unaffected by the *Protections Disabled* feature. See sections entitled *Indications* and *Warnings* elsewhere in this document.

6.1.2 SHUTDOWN / ELECTRICAL TRIP ALARMS

NOTE:- The EMERGENCY STOP input and shutdown alarm continues to operate even when *Protections Disabled* has been activated.

Under Shutdown or Electrical Trip alarm conditions (excluding Emergency Stop):

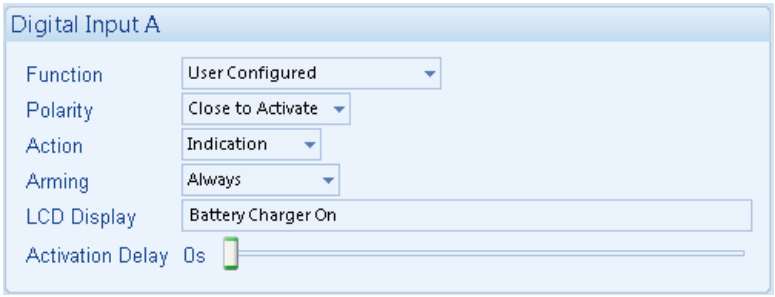
- The alarm is displayed on the screen as detailed in the section entitled *Shutdown alarm*s elsewhere in this document.
- The set continues to run.
- The load switch maintains its current position (it is not opened if already closed)
- ***Shutdown Blocked*** also appears on the LCD screen to inform the operator that the Protections Disabled feature has blocked the shutdown of the engine under the normally critical fault.
- The ‘shutdown’ alarm is logged by the controllers *Event Log (*if configured to log shutdown alarms) and logs that the Shutdown was prevented.

6.2 INDICATIONS

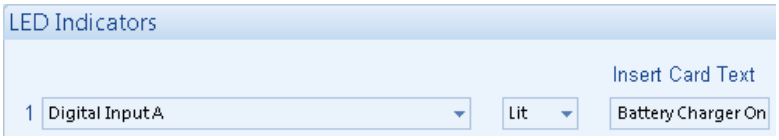
Indications are non-critical and often status conditions. They do not appear on the LCD of the module as a text message. However, an output or LED indicator can be configured to draw the operator's attention to the event.

Example

- Input configured for indication.
- The LCD text will not appear on the module display but can be added in the configuration to remind the system designer what the input is used for.
- As the input is configured to *Indication* there is no alarm generated.



- LED Indicator to make LED1 illuminate when Digital Input A is active.
- The Insert Card Text allows the system designer to print an insert card detailing the LED function.

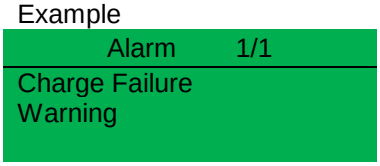


- Sample showing operation of the LED.

6.3 WARNINGS

Warnings are non-critical alarm conditions and do not affect the operation of the generator system, they serve to draw the operators attention to an undesirable condition.

Example



In the event of an alarm the LCD will jump to the alarms page, and scroll through all active warnings and shutdowns.

By default, warning alarms are self-resetting when the fault condition is removed. However enabling 'all warnings are latched' will cause warning alarms to latch until reset manually. This is enabled using the 8600 series configuration suite in conjunction with a compatible PC.

Display	Reason
CHARGE FAILURE	The auxiliary charge alternator voltage is low as measured from the W/L terminal.
BATTERY UNDER VOLTAGE	The DC supply has fallen below the low volts setting level for the duration of the low battery volts timer
BATTERY OVER VOLTAGE	The DC supply has risen above the high volts setting level for the duration of the high battery volts timer
FAIL TO STOP	The module has detected a condition that indicates that the engine is running when it has been instructed to stop. **NOTE:- 'Fail to Stop' could indicate a faulty oil pressure sensor or switch - If the engine is at rest check oil sensor wiring and configuration.**
FUEL USAGE	Indicates the amount of fuel measured by the fuel level sensor is in excess of the *Fuel Usage* alarm settings. This often indicates a fuel leak or potential fuel theft.
AUXILIARY INPUTS	Auxiliary inputs can be user configured and will display the message as written by the user.
LOW FUEL LEVEL	The level detected by the fuel level sensor is below the low fuel level setting.
CAN ECU ERROR	The engine ECU has detected a warning alarm and has informed the DSE module of this situation. The exact error is also indicated on the module's display.
kW OVERLOAD	The measured Total kW is above the setting of the kW overload warning alarm
EARTH FAULT	The measured Earth Fault Current has been in excess of the earth fault trip and has surpassed the IDMT curve of the Earth Fault alarm.
NEGATIVE PHASE SEQUENCE	Indicates 'out of balance' current loading of the generator. Sometimes also called Negative Sequence Current or Symmetry Fault
MAINTENANCE DUE	Indicates that the maintenance alarm has triggered. A visit is required by the Generator service company.
LOADING VOLTAGE NOT REACHED	Indicates that the generator voltage is not above the configured *loading voltage.* The generator will not take load when the alarm is present after the safety timer.
LOADING FREQUENCY NOT REACHED	Indicates that the generator frequency is not above the configured *loading frequency.* The generator will not take load when the alarm is present after the safety timer.

PROTECTIONS DISABLED	Shutdown and electrical trip alarms can be disabled by user configuration. In this case, Protections Disabled will appear on the module display; The alarm text is displayed but the engine will continue to run. This is 'logged' by the module to allow DSE Technical Staff to check if the protections have been disabled on the module at any time. This feature is available from V4 onwards.
LOW OIL PRESSURE	The module detects that the engine oil pressure has fallen below the low oil pressure pre-alarm setting level after the *Safety On* timer has expired.
ENGINE HIGH TEMPERATURE	The module detects that the engine coolant temperature has exceeded the high engine temperature pre-alarm setting level after the *Safety On* timer has expired.
ENGINE LOW TEMPERATURE	The module detects that the engine coolant temperature has fallen below the high engine temperature pre-alarm setting level.
OVERSPEED	The engine speed has risen above the overspeed pre alarm setting
UNDERSPEED	The engine speed has fallen below the underspeed pre alarm setting
GENERATOR OVER FREQUENCY	The generator output frequency has risen above the pre-set pre-alarm setting.
GENERATOR UNDER FREQUENCY	The generator output frequency has fallen below the pre-set pre-alarm setting after the *Safety On* timer has expired.
GENERATOR OVER VOLTAGE	The generator output voltage has risen above the pre-set pre-alarm setting.
GENERATOR UNDER VOLTAGE	The generator output voltage has fallen below the pre-set pre-alarm setting after the *Safety On* timer has expired.
ECU WARNING	The engine ECU has detected a warning alarm and has informed the DSE module of this situation. The exact error is also indicated on the module's display.

If the module is configured for, **CAN** and receives an "error" message from the engine control unit, 'Can ECU Warning" is shown on the module's display and a warning alarm is generated.

6.4 HIGH CURRENT WARNING ALARM

GENERATOR HIGH CURRENT, if the module detects a generator output current in excess of the pre-set trip a warning alarm initiates. The module shows Alarm Warning High Current. If this high current condition continues for an excess period, then the alarm escalates to a shutdown condition. For further details of the high current alarm, please see High Current Shutdown Alarm.

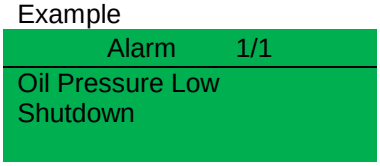
By default, High Current Warning Alarm is self-resetting when the overcurrent condition is removed. However enabling 'all warnings are latched' will cause the alarm to latch until reset manually. This is enabled using the 8600 series configuration suite in conjunction with a compatible PC.

6.5 SHUTDOWNS

NOTE:- Shutdown and Electrical Trip alarms can be disabled by user configuration. See the section entitled *Protections Disabled* elsewhere in this document.

Shutdowns are latching alarms and stop the Generator. Clear the alarm and remove the fault then press Stop/Reset to reset the module.

Example



NOTE:- The alarm condition must be rectified before a reset will take place. If the alarm condition remains, it will not be possible to reset the unit (The exception to this is the Low Oil Pressure alarm and similar 'active from safety on' alarms, as the oil pressure will be low with the engine at rest).

Display	Reason
EARTH FAULT	The measured Earth Fault Current has been in excess of the earth fault trip and has surpassed the IDMT curve of the Earth Fault alarm.
FAIL TO START	The engine has not fired after the preset number of start attempts
EMERGENCY STOP	The emergency stop button has been depressed. This is a failsafe (normally closed to battery positive) input and will immediately stop the set should the signal be removed. Removal of the battery positive supply from the emergency stop input will also remove DC supply from the Fuel and Start outputs of the controller. **NOTE:- The Emergency Stop Positive signal must be present otherwise the unit will shutdown.**
LOW OIL PRESSURE	The engine oil pressure has fallen below the low oil pressure trip setting level after the *Safety On* timer has expired.
ENGINE HIGH TEMPERATURE	The engine coolant temperature has exceeded the high engine temperature trip setting level after the *Safety On* timer has expired.
FUEL USAGE	Indicates the amount of fuel measured by the fuel level sensor is in excess of the *Fuel Usage* alarm settings. This often indicates a fuel leak or potential fuel theft.
PHASE ROTATION	The phase rotation is measured as being different to the configured direction.
OVERSPEED	The engine speed has exceeded the pre-set trip **NOTE:-During the start-up sequence, the overspeed trip logic can be configured to allow an extra trip level margin. This is used to prevent nuisance tripping on start-up - Refer to the 8600 series configuration software manual under heading 'Overspeed Overshoot' for details.**
UNDERSPEED	The engine speed has fallen below the pre-set trip after the ***Safety On*** timer has expired.

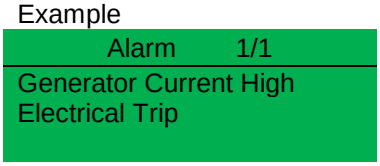
Display	Reason
GENERATOR OVER FREQUENCY	The generator output frequency has risen above the preset level
GENERATOR UNDER FREQUENCY	The generator output frequency has fallen below the preset level
GENERATOR OVER VOLTAGE	The generator output voltage has risen above the preset level
GENERATOR UNDER VOLTAGE	The generator output voltage has fallen below the preset level
OIL PRESSURE SENSOR OPEN CIRCUIT	The oil pressure sensor is detected as not being present (open circuit)
AUXILIARY INPUTS	An active auxiliary input configured as a shutdown will cause the engine to shut down. The display shows the text as configured by the user.
LOSS OF SPEED SIGNAL	The DSE controller is not receiving the speed signal from the magnetic pickup.
ECU DATA FAIL	The module is configured for CAN operation and does not detect data on the engine Can data link, the engine shuts down.
ECU SHUTDOWN	The engine ECU has detected a shutdown alarm and has informed the DSE module of this situation. The exact error is also indicated on the module's display.
kW OVERLOAD	The measured Total kW is above the setting of the kW overload shutdown alarm
NEGATIVE PHASE SEQUENCE	Indicates 'out of balance' current loading of the generator. Sometimes also called Negative Sequence Current or Symmetry Fault
MAINTENANCE DUE	Indicates that the maintenance alarm has triggered. A visit is required by the Generator service company.
GENERATOR HIGH CURRENT	A High Current condition has continued for an excess period, then the alarm escalates to either a shutdown or electrical trip condition (depending upon module configuration). For further details of the high current alarm, please see High Current Shutdown / Electrical Trip Alarm.
LOADING VOLTAGE NOT REACHED	Indicates that the generator voltage is not above the configured *loading voltage* after the safety timer. The generator will shutdown.
LOADING FREQUENCY NOT REACHED	Indicates that the generator frequency is not above the configured *loading frequency* after the safety timer. The generator will shutdown.
PROTECTIONS DISABLED	Shutdown and electrical trip alarms can be disabled by user configuration. In this case, Protections Disabled will appear on the module display; The alarm text will be displayed but the engine will continue to run. This is 'logged' by the module to allow DSE Technical Staff to check if the protections have been disabled on the module at any time. This feature is available from V4 onwards.

6.6 ELECTRICAL TRIPS

NOTE:- Shutdown and Electrical Trip alarms can be disabled by user configuration. See the section entitled *Protections Disabled* elsewhere in this document.

Electrical trips are latching and stop the Generator but in a controlled manner. On initiation of the electrical trip condition the module will de-energise the **'Close Generator'** Output to remove the load from the generator. Once this has occurred the module will start the Cooling timer and allow the engine to cool off-load before shutting down the engine. The alarm must be accepted and cleared, and the fault removed to reset the module.

Example



Electrical trips are latching alarms and stop the Generator. Remove the fault then press Stop/Reset to reset the module.

Display	Reason
GENERATOR HIGH CURRENT	If a generator output in excess of the high current alarm point, a warning alarm occurs. If this high current condition continues for an excess period, then the alarm escalates to either a shutdown or electrical trip condition (depending upon module configuration). For further details of the high current alarm, please see High Current Shutdown / Electrical Trip Alarm.
AUXILIARY INPUTS	If an auxiliary input configured as an electrical trip is active, the user configured message shows on the display.
kW OVERLOAD	The measured Total kW is above the setting of the kW overload Electrical Trip alarm
EARTH FAULT	The measured Earth Current is above the setting of the Earth fault alarm.
NEGATIVE PHASE SEQUENCE	Indicates 'out of balance' current loading of the generator. Sometimes also called Negative Sequence Current or Symmetry Fault
FUEL USAGE	Indicates the amount of fuel used is in excess of the *Fuel Usage* alarm settings. This often indicates a fuel leak or potential fuel theft.
LOADING VOLTAGE NOT REACHED	Indicates that the generator voltage is not above the configured loading voltage after the safety timer. The generator will shutdown.
LOADING FREQUENCY NOT REACHED	Indicates that the generator frequency is not above the configured loading frequency after the safety timer. The generator will shutdown.
PROTECTIONS DISABLED	Shutdown and electrical trip alarms is disabled by user configuration. In this case, Protections Disabled will appear on the module display; The alarm text is displayed but the engine will continue to run. This is 'logged' by the module to allow DSE Technical Staff to check if the protections have been disabled on the module at any time. This feature is available from V4 onwards.
GENERATOR UNDER FREQUENCY	The generator output frequency has fallen below the preset level
GENERATOR UNDER VOLTAGE	The generator output voltage has fallen below the preset level
MSC OLD UNITS ON BUS	If the module detects a module on the MSC link which is incompatible with the current module, then the MSC Compatibility alarm will be triggered. Check all the modules' version numbers (under *About* | *Application Number* on the modules' displays), modules pre V3 cannot communicate with modules V4 and onwards. Use the DSE Configuration Suite Software to upgrade the firmware (*Tools* | *Update Firmware*) of the older modules to V4 and onwards.
UNDERSPEED	The engine speed has fallen below the underspeed setting

6.7 HIGH CURRENT SHUTDOWN / ELECTRICAL TRIP ALARM

The overcurrent alarm combines a simple warning trip level with a fully functioning IDMT curve for thermal protection.

6.7.1 IMMEDIATE WARNING

If the *Immediate Warning* is enabled, the DSE8600 Series controller generates a *warning alarm* as soon as the *Trip* level is reached. The alarm automatically resets once the generator loading current falls below the *Trip* level (unless *All Warnings are latched* is enabled). For further advice, consult your generator supplier.

6.7.2 IDMT ALARM

If the *IDMT Alarm* is enabled, the DSE8600 Series controller begins following the IDMT 'curve' when the *trip* level is passed.

If the *Trip* is surpassed for an excess amount of time the *IDMT Alarm* triggers (*Shutdown* or *Electric trip* as selected in *Action*).

High current shutdown is a latching alarm and stops the Generator.

Remove the fault then press Stop/Reset to reset the module.

High current electrical trip is a latching alarm and removes the generator from the load, before stopping the Generator after the off load *cooling* timer.

Remove the fault then press Stop/Reset to reset the module.

The higher the overload, the faster the trip. The speed of the trip is dependent upon the fixed formula:

$$T = t / ((I_A / I_T) - 1)^2$$

Where: T is the tripping time in seconds
I_A is the actual current of the most highly loaded line (L1 or L2 or L3)
I_T is the delayed over-current trip point
t is the time multiplier setting and also represents the tripping time in seconds at twice full load (when $I_A / I_T = 2$).

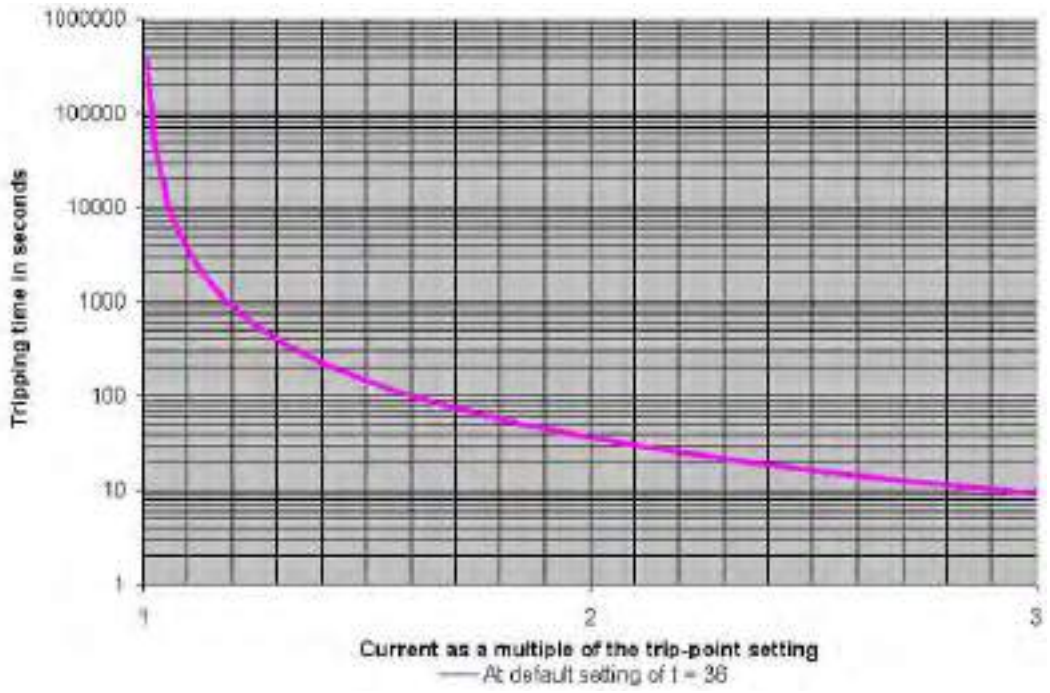
Factory settings for the *IDMT Alarm* when used on a brushless alternator are as follows (screen capture from the DSE Configuration Suite PC software :

These settings provide for normal running of the generator up to 100% full load. If full load is surpassed, the *Immediate Warning* alarm is triggered, the set continues to run.
The effect of an overload on the generator is that the alternator windings begin to overheat; the aim of the *IDMT alarm* is to prevent the windings being overload (heated) too much. The amount of time that the set can be safely overloaded is governed by how high the overload condition is.

With typical settings as above, the tripping curve is followed as shown below.

This allows for overload of the set to the limits of the *Typical Brushless Alternator* whereby 110% overload is permitted for 1 hour.

If the set load reduces, the controller then *follows* a cooling curve. This means that a second overload condition may trip much sooner than the first as the controller *knows* if the windings have not cooled sufficiently.



For further details on the *Thermal damage curve* of your alternator, you are referred to your alternator manufacturer and generator supplier.

6.8 SHORT CIRCUIT AND EARTH FAULT SHUTDOWN / ELECTRICAL TRIP ALARM

When the module is suitably connected using the 'Earth Fault CT'. The module measures Earth Fault and can optionally be configured to generate an alarm condition (shutdown or electrical trip) when a specified level is surpassed.

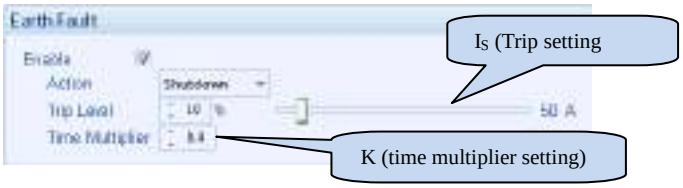
Short Circuit alarm operates in the same way as the Earth Fault, using the same curve formula, but typically uses a lower value for K (time multiplier) to give a faster acting trip.

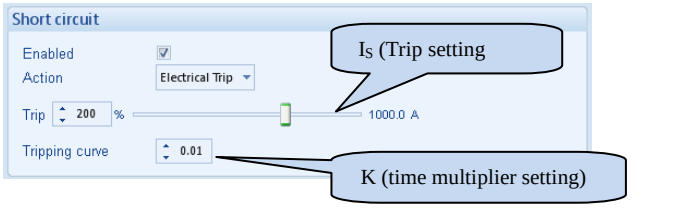
If the A*larm* is enabled, the DSE8610 Series controller begins following the IDMT 'curve'. If the current surpasses the *Trip* for an excess of time, the Alarm triggers (*Shutdown* or *Electric trip* as selected in *Action*).

The higher the fault, the faster the trip. The speed of the trip is dependent upon the fixed formula:

$$T = K \times 0.14 / ((I / I_s)^{0.02} - 1)$$

Where: T is the tripping time in seconds (accurate to +/- 5% or +/- 50ms (whichever is the greater)
K is the time multiplier setting
I is the actual earth current measured
Is is the trip setting value

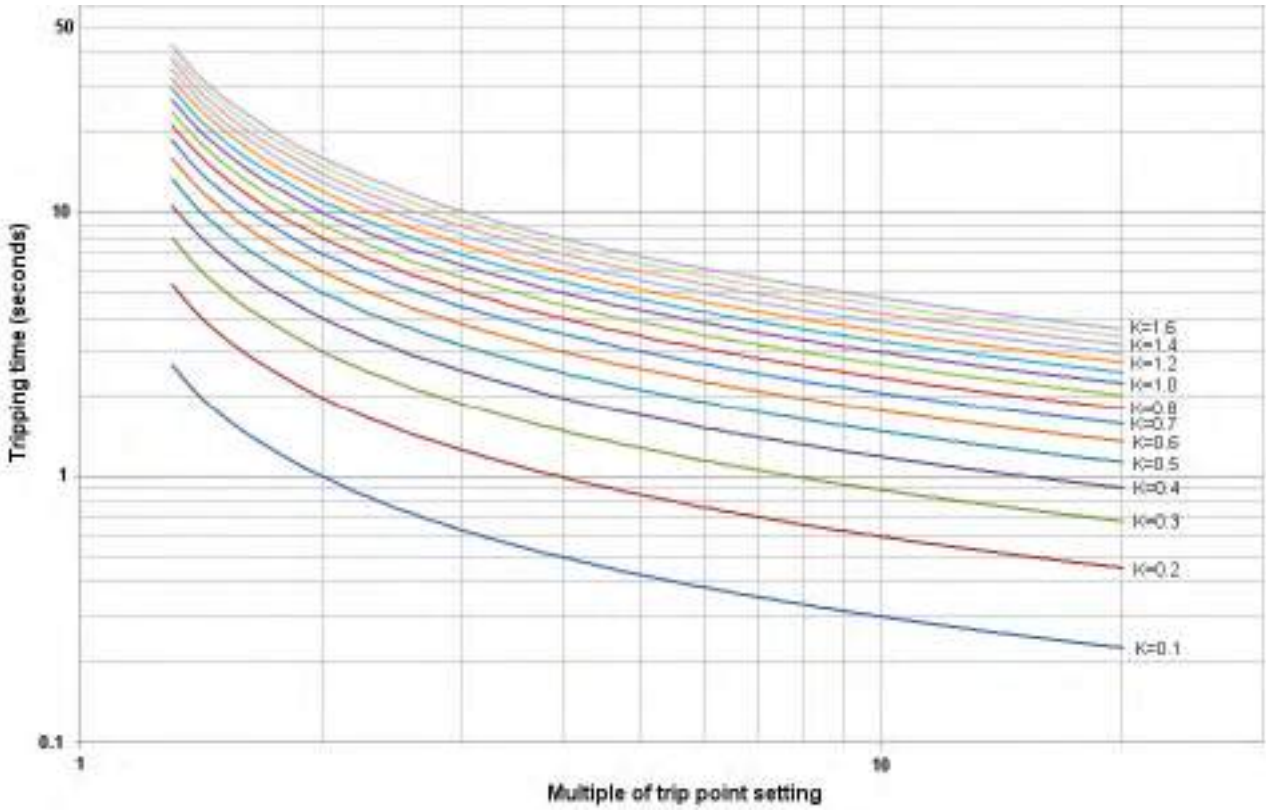




The settings shown in the example above are a screen capture of the DSE factory settings, taken from the DSE Configuration Suite software.

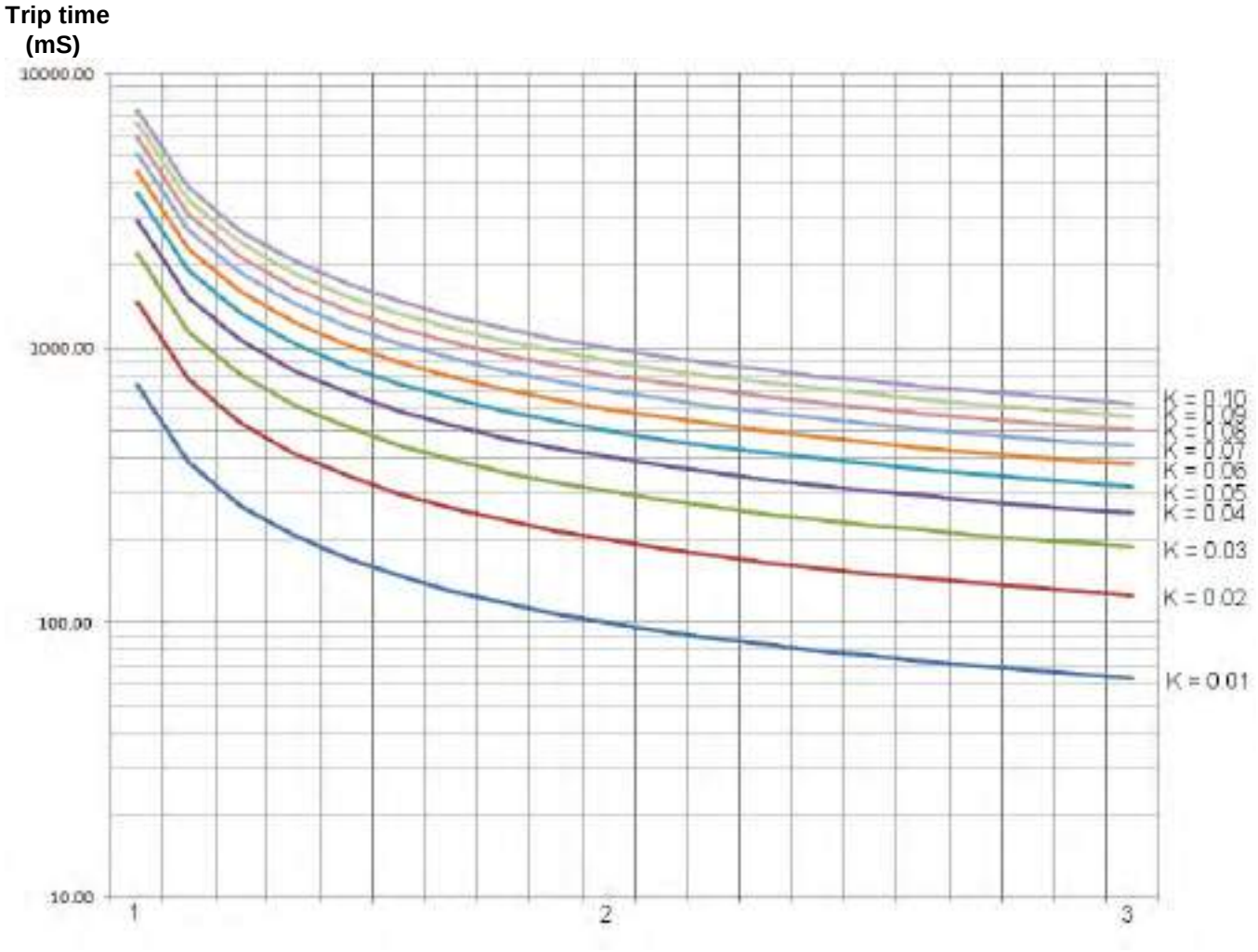
6.8.1 EARTH FAULT TRIPPING CURVES

NOTE: DSE Factory setting is time multiplier (K) = 0.4



6.8.1 SHORT CIRCUIT TRIPPING CURVES

NOTE: DSE Factory setting is time multiplier (K) = 0.01



6.9 ROCOF / VECTOR SHIFT

When configured to run in parallel with the mains (utility) supply, the module monitors for ROCOF / Vector shift trips according to the module's configuration settings. This is included within the module and will detect failure of the mains supply during parallel operation with the generator.

NOTE:- This protection operates only when in parallel with the mains supply and is disabled at all other times.

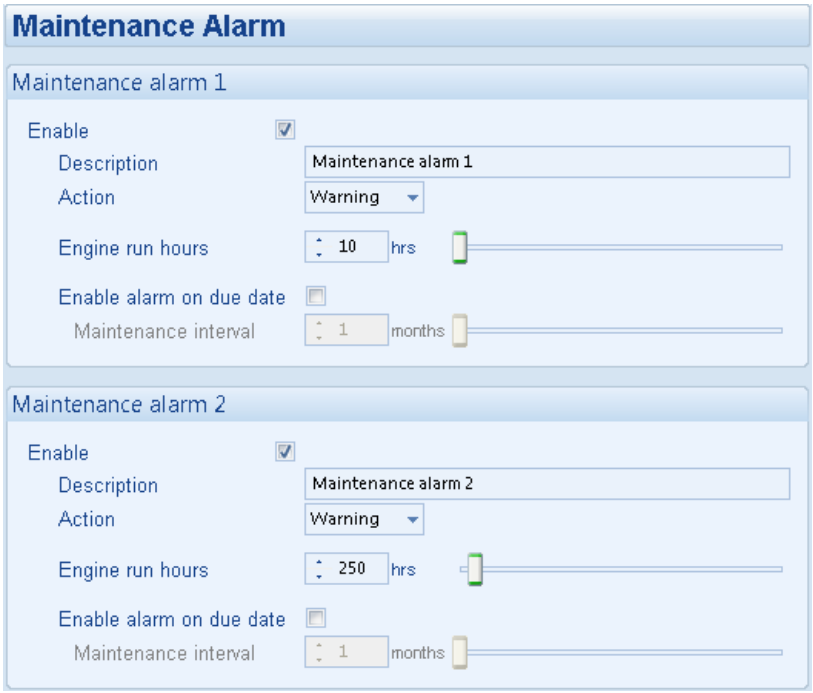
Should either of these alarms operate, the module will perform a controlled shutdown (electrical trip) of the generator. This operation must be manually reset :

1) Press O button. The engine will stop if it is still running and the alarm is cleared.
2) Activate digital input configured to "Clear ROCOF/Vector shift" if this has been provided.
3) Press and button together and hold for 5 seconds. The ROCOF/Vector shift instrument is displayed and all 'peak hold' values are reset, clearing the ROCOF/Vector shift alarm.

For details on activating and configuring the ROCOF/Vector shift protection, you are referred to the 8600 configuration software manual.

7 MAINTENANCE ALARM

Depending upon module configuration one or more levels of maintenance alarm may occur based upon a configurable schedule.
There are three maintenance alarms in the DSE86xx/DSE86xx series V3 and above, and one level of maintenance alarm in prior versions.



Example 1

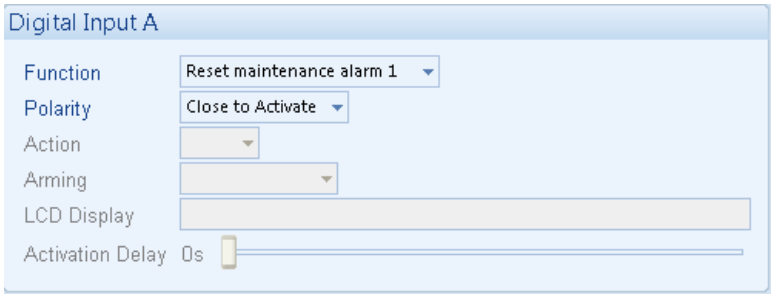
Screen capture from DSE Configuration Suite Software showing the configuration of Maintenance Alarm 1 and Maintenance Alarm 2.

When activated, the maintenance alarm can be either a **warning** (set continues to run) or **shutdown** (running the set is not possible).
The site service engineer normally performs resetting the maintenance alarm after performing the required maintenance.
The method of reset is either by:

- Activating an input that has been configured to maintenance x reset, where x is the number of the maintenance alarm (1 to 3).
- Pressing the maintenance reset button in the DSE Configuration Suite, Maintenance section.

Example 2

Screen capture from DSE Configuration Suite Software showing the configuration of a digital input for Reset Maintenance Alarm 1.



Example 3

Screen capture from DSE Configuration Suite Software showing the Maintenance Alarm Reset 'button' in the DSE Configuration Suite SCADA | MAINTENANCE section.

8 SCHEDULER

DSE8600 Series contains an inbuilt exercise run scheduler, capable of automatically starting and stopping the set. Up to 16 scheduled start/stop sequences can be configured to repeat on a 7-day or 28-day cycle.
Scheduled runs may be on load or off load depending upon module configuration.

Example

Screen capture from DSE Configuration Suite Software showing the configuration of the Exercise Scheduler.

In this example the set will start at 09:00 on Monday and run for 5 hours, then start at 13:30 on Tuesday and run for 30 minutes.

8.1.1 STOP MODE

- Scheduled runs will not occur when the module is in STOP/RESET mode.

8.1.2 MANUAL MODE

- Scheduled runs will not occur when the module is in MANUAL mode.
- Activation of a Scheduled Run ‘On Load’ when the module is operating OFF LOAD in Manual mode will have no effect, the set continues to run OFF LOAD

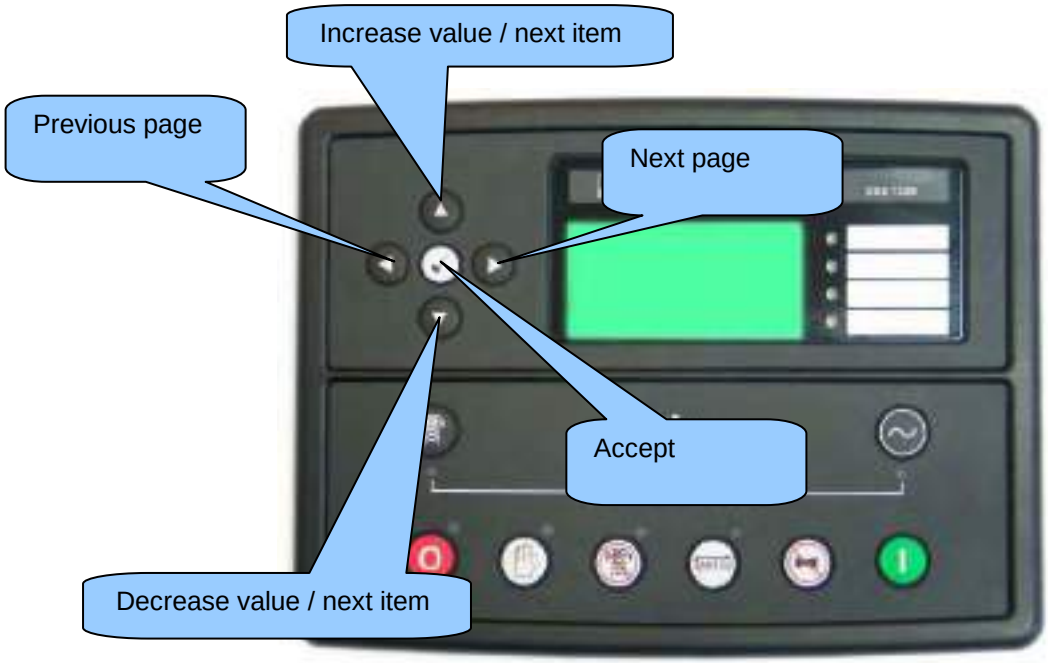
8.1.3 AUTO MODE

- Scheduled runs will operate ONLY if the module is in AUTO mode with no Shutdown or Electrical Trip alarm present.
- If the module is in STOP or MANUAL mode when a scheduled run begins, the engine is not started. However, if the module moves into AUTO mode during a scheduled run, the engine is called to start.
- Depending upon configuration by the system designer, an external input can be used to inhibit a scheduled run.
- If the engine is running OFF LOAD in AUTO mode and a scheduled run configured to ‘On Load’ begins, the set is placed ON LOAD for the duration of the Schedule.

9 FRONT PANEL CONFIGURATION

This configuration mode allows the operator limited customising of the way the module operates.

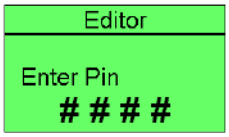
Use the module's navigation buttons to traverse the menu and make value changes to the parameters:



9.1 ACCESSING THE MAIN FRONT PANEL CONFIGURATION EDITOR

Ensure the engine is at rest and the module is in STOP mode by pressing the Stop/Reset button.

Press the Stop/Reset and Info buttons simultaneously.
If a module security PIN has been set, the PIN number request is then shown :



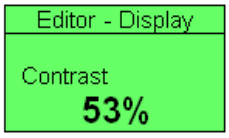
Press , the first '#' changes to '0'. Press (up or down) to adjust it to the correct value.

Press (right) when the first digit is correctly entered. The digit you have just entered will now show '#' for security.

Repeat this process for the other digits of the PIN number. You can press (left) if you need to move back to adjust one of the previous digits.

When is pressed after editing the final PIN digit, the PIN is checked for validity. If the number is not correct, you must re-enter the PIN.

If the PIN has been successfully entered (or the module PIN has not been enabled), the editor is displayed :



NOTE: The PIN number is not set by DSE when the module leaves the factory. If the module has a PIN code set, this has been affected by your generator supplier who should be contacted if you require the code. If the code has been 'lost' or 'forgotten', the module must be returned to the DSE factory to have the module's code removed. A charge will be made for this procedure.
NB - This procedure cannot be performed away from the DSE factory.

9.1.1 EDITING A PARAMETER

Enter the editor as described above.

Press the  (left) or  (right) buttons to cycle to the section you wish to view/change.

Press the  (up or down) buttons to select the parameter you wish to view/change within the currently selected section.

To edit the parameter, press ✓ to enter edit mode. The parameter begins to flash to indicate that you are editing the value.

Press the  (up or down) buttons to change the parameter to the required value.

Press ✓ to save the value. The parameter ceases flashing to indicate that it has been saved.

To exit the editor at any time, press and hold the ✓ button.

⚠NOTE: - The editor automatically exits after 5 minutes of inactivity to ensure security.

⚠NOTE: - The PIN number is automatically reset when the editor is exited (manually or automatically) to ensure security.

⚠ NOTE: - More comprehensive module configuration is possible using the 86xx series PC configuration software. Please contact us for further details.

9.1.2 ADJUSTABLE PARAMETERS

Front Panel Configuration Editor. For descriptions of the parameters, you are referred to The DSE8600 series Configuration Suite Manual, DSE Part 057-119.

Section	Parameter as shown on display	Values
Display	Contrast	53%
	Language	English, others.
	Current Date and Time	*hh:mm*
Timers	LCD Page Timer	5m
	Scroll Delay	*2s*
	Engine Pre Heat Timer	0s
	Engine Crank Duration	10s
	Engine Crank Rest Time	10s
	Engine Safety On Delay	10s
	Engine Smoke Limiting	0s
	Engine Smoke Limiting Off	0s
	Engine Warm Up Time	1s
	Engine Cool Down Time	1m
	Engine Speed Overshoot Delay	0s
	Engine Failed To Stop	30s
	Battery Under Voltage Warning Delay	1m
	Battery Over Voltage Warning Delay	1m
	Return Delay	30s
	Generator Transient Delay	0s
Generator	Under Voltage Shutdown	184v
	Under Voltage Pre-Alarm	196v
	Nominal Voltage	230v
	Over Voltage Pre-Alarm	265v
	Over Voltage Shutdown	277v
	Under Frequency Shutdown	40Hz
	Under Frequency Pre-Alarm	42Hz
	Short Circuit Trip	200%
	Nominal frequency	50Hz
	Over Frequency Pre-Alarm	54Hz
	Over Frequency Shutdown	57Hz
	Full Load Rating	500A
	Delayed Over current	Active
	Delayed Over Current	100%
	AC System	3 Phase 4 Wire
	CT Primary	600A
	CT Secondary	5A
	Earth CT Primary	500A
	Earth Fault Trip	Inactive
	Earth Fault Trip	10%
	Transient Delay	0s
	Gen Reverse Power Delay	2s
	Full kW rating	245kW
	Full kVAr rating	258kVAr
	Load Ramp Rate	3%
	Load Level For More Sets	80%
	Load Level For Less Sets	70%
	Load Demand Priority	1
	Gen Reverse Power	35kW
	Gen Over Current	0%
	Insufficient Capacity Delay	1s
	Insufficient Capacity Action	None
	Reactive Load CTL Mode VAr Share	None
	Load Parallel Power	172kW When In Mains Parallel Mode
	Load Power factor	0% When In Mains Parallel Mode
Engine	Oil Pressure Low shutdown	1.03bar
	Oil Pressure Low Pre-Alarm	1.17bar
	Coolant Temp High Pre-Alarm	90°C
	Coolant Temp High Electrical Trip	92°C
	Coolant Temp High Shutdown	95°C
	Start Delay Off load	5s
	Start Delay on load	5s
	Start Delay mains fail	0s
	Start Delay Telemetry	5s
	Pre Heat Timer	0s
	Crank Duration	10s
	Crank rest Time	10s
	Safety On Delay	10s
	Smoke Limited	0s
	Smoke limiting off	0s
	Warm Up Time	1s
	Cool Down Time	1m
	Speed Overshoot Delay	0s
	Speed Overshoot	0%
	Fail To Stop Delay	30s
	Battery Under Volts Warning	Active
	Battery Under Volts Warning Delay	1m
	Battery Under Volts Warning	19v
	Battery Over Volts Warning	Active
	Battery Over Volts Warning Delay	1m
	Battery Over Volts Warning	30v
	Charge Alternator Failure Warning	Active
	Charge Alternator Failure Warning	6.0v
	Charge Alternator Warning Delay	5s
	Charge Alternator Failure Shutdown	Active
	Charge Alternator Failure Shutdown	4.0
	Charge Alternator Shutdown Delay	5s
	Droop %	Active, Inactive. Electronic engines only when droop is enabled.
Scheduler	Scheduler	Active, Inactive
	Schedule On Load	Active , Inactive (Only Available When Scheduler Is Active)
	Schedule Period	Weekly, Monthly (Only Available When Scheduler Is Active)
	Schedule Time & Date Selection (1-16)	Press ✓ to begin editing then press ▲ or ▼ when selecting the different parameters in the scheduler.

9.2 ACCESSING THE 'RUNNING' CONFIGURATION EDITOR

The 'running' editor can be entered while the engine is running. All protections remain active if the engine is running while the running editor is entered.

Press and hold the button to enter the running editor.

9.2.1 EDITING A PARAMETER

Enter the editor as described above.

Press the  (left) or  (right) buttons to cycle to the section you wish to view/change.

Press the  (up or down) buttons to select the parameter you wish to view/change within the currently selected section.

To edit the parameter, press to enter edit mode. The parameter begins to flash to indicate that you are editing the value.

Press the  (up or down) buttons to change the parameter to the required value.

Press to save the value. The parameter ceases flashing to indicate that it has been saved.

To exit the editor at any time, press and hold the button.

9.2.2 ADJUSTABLE PARAMETERS (RUNNING EDITOR)

Running Editor (Factory default settings are shown in bold italicised text)

Section	Parameter as shown on display	Factory Setting
DISPLAY	Contrast	53%
	Language	English
	Load Demand priority	**(1)**
	Load Power factor	0-100% **(0)**
	Load parallel power	0-100% **(50)**
	Enable commissioning screens	Inactive, Active
	Override starting alarms	Inactive, Active
	Voltage adjust (manual mode only engine running breaker open)	0-100 % **(0)**
	Frequency adjust (manual mode only engine running breaker open)	0-100 % **(0)**
	Enable mains decoupling test mode (Stop mode only)	Inactive Active

10 COMMISSIONING

10.1.1 PRE-COMMISSIONING

Before the system is started, it is recommended that the following checks are made:-

10.1. The unit is adequately cooled and all the wiring to the module is of a standard and rating compatible with the system. Check all mechanical parts are fitted correctly and that all electrical connections (including earths) are sound.

10.2. The unit **DC** supply is fused and connected to the battery and that it is of the correct polarity.

10.3. The Emergency Stop input is wired to an external **normally closed** switch connected to **DC positive.**

NOTE:- If Emergency Stop feature is not required, link this input to the DC Positive. The module will not operate unless either the Emergency Stop is fitted correctly OR terminal 3 is connected to DC positive.

10.4. Make all checks on the engine and alternator as detailed by their respective manufacturer documentation.
10.5. Check all other parts in the system according to the manufacturer documentation.
10.6. Thoroughly review the configuration of the DSE controller and check that all parameters meet the requirements of your system.
10.7. To check the start cycle operation, take appropriate measures to prevent the engine from starting (disable the operation of the fuel solenoid). After a visual inspection to ensure it is safe to proceed, connect the battery supply. Select **"MANUAL"** and then press **"START"** the unit start sequence will commence.

10.8. The starter will engage and operate for the pre-set crank period. After the starter motor has attempted to start the engine for the pre-set number of attempts, the LCD will display 'Failed *to start*. Select the **STOP/RESET** position to reset the unit.

10.9. Restore the engine to operational status (reconnect the fuel solenoid). Select **"MANUAL"** and then press **"START"**. This time the engine will start and the starter motor will disengage automatically. If not then check the engine is fully operational (fuel available, etc.) and the fuel solenoid is operating. The engine will now run up to operating speed. If not, and an alarm is present, check the alarm condition for validity, and check input wiring. The engine will continue to run for an indefinite period. At this time to view the engine and alternator parameters - refer to the 'Description of Controls' section of this manual.

10.10. Fully commission the engine/alternator and any other parts in the system as detailed in the respective manufacturer documentation. This includes load bank testing, load acceptance, breaker control and more.

10.11. When building a synchronising system, follow the DSE "4 Steps To Synchronising" as detailed elsewhere in this document before attempting to parallel the set with another supply.

10.12. Set the modules internal clock/calendar to ensure correct operation of the scheduler and event logging functions. For details of this procedure see section entitled *Front Panel Configuration – Editing the date and time.*

10.13. If despite repeated checking of the connections between the **8600** series controller and the customer's system, satisfactory operation cannot be achieved, then the customer is requested to contact the factory for further advice on:-

INTERNATIONAL TEL: +44 (0) 1723 890099
INTERNATIONAL FAX: +44 (0) 1723 893303
E-mail: Support@Deepseaplc.com
Website : www.deepseaplc.com

11 FAULT FINDING

SYMPTOM	POSSIBLE REMEDY
Unit is inoperative Read/Write configuration does not operate	Check the battery and wiring to the unit. Check the DC supply. Check the DC fuse.
Unit shuts down	Check DC supply voltage is not above 35 Volts or below 9 Volts Check the operating temperature is not above 70°C. Check the DC fuse.
Unit locks out on Emergency Stop	If no Emergency Stop Switch is fitted, ensure that a DC positive signal is connected to the Emergency Stop input. Check emergency stop switch is functioning correctly. Check Wiring is not open circuit.
Intermittent Magnetic Pick-up sensor fault	Ensure that Magnetic pick-up screen only connects to earth at one end, if connected at both ends, this enables the screen to act as an aerial and will pick up random voltages. Check pickup is correct distance from the flywheel teeth.
Low oil Pressure fault operates after engine has fired	Check engine oil pressure. Check oil pressure switch/sensor and wiring. Check configured polarity (if applicable) is correct (i.e. Normally Open or Normally Closed) or that sensor is compatible with the 73x0 Module and is correctly configured.
High engine temperature fault operates after engine has fired.	Check engine temperature. Check switch/sensor and wiring. Check configured polarity (if applicable) is correct (i.e. Normally Open or Normally Closed) or that sensor is compatible with the 8600 series module.
Shutdown fault operates	Check relevant switch and wiring of fault indicated on LCD display. Check configuration of input.
Warning fault operates	Check relevant switch and wiring of fault indicated on LCD display. Check configuration of input.
Fail to Start is activated after pre-set number of attempts to start	Check wiring of fuel solenoid. Check fuel. Check battery supply. Check battery supply is present on the Fuel output of the module. Check the speed-sensing signal is present on the 8600 series module's inputs. Refer to engine manual.
Continuous starting of generator when in **AUTO**	Check that there is no signal present on the "Remote Start" input. Check configured polarity is correct.
Generator fails to start on receipt of Remote Start signal.	Check Start Delay timer has timed out. Check signal is on "Remote Start" input. Confirm correct configuration of input Check that the oil pressure switch or sensor is indicating low oil pressure to the controller. Depending upon configuration, then set will not start if oil pressure is not low.
Pre-heat inoperative	Check wiring to engine heater plugs. Check battery supply. Check battery supply is present on the Pre-heat output of module. Check pre-heat configuration is correct.
Starter motor inoperative	Check wiring to starter solenoid. Check battery supply. Check battery supply is present on the Starter output of module. Ensure that the Emergency Stop input is at Positive. Ensure oil pressure switch or sensor is indicating the "low oil pressure" state to the 8610 series controller.
Engine runs but generator will not take load	Check Warm up timer has timed out. Ensure generator load inhibit signal is not present on the module inputs. Check connections to the switching device. Note that the set will not take load in manual mode unless there is an active remote start on load signal.
Synchronising or load sharing is not operating satisfactorily	Follow the DSE "4 Steps To Synchronising" as detailed in the following section.

SYMPTOM	POSSIBLE REMEDY
Incorrect reading on Engine gauges Fail to stop alarm when engine is at rest	Check engine is operating correctly. Check sensor and wiring paying particular attention to the wiring to terminal 47 (refer to appendix). Check that sensor is compatible with the 8600 series module and that the module configuration is suited to the sensor.
Module appears to 'revert' to an earlier configuration	When editing a configuration using the PC software it is vital that the configuration is first 'read' from the controller before editing it. This edited configuration must then be "written" back to the controller for the changes to take effect. When editing a configuration using the fascia editor, be sure to press the Accept button to save the change before moving to another item or exiting the fascia editor
Set will not take load	Ensure the generator available LED is lit Check that the output configuration is correct to drive the load switch device and that all connections are correct. Remember that the set will not take load in manual mode unless a remote start on load input is present or the close generator button is pressed.
Inaccurate generator measurements on controller display	Check that the CT primary, CT secondary and VT ratio settings are correct for the application. Check that the CTs are wired correctly with regards to the direction of current flow (p1,p2 and s1,s2) and additionally ensure that CTs are connected to the correct phase (errors will occur if CT1 is connected to phase 2). Remember to consider the power factor. Ie (kW = kVA x power factor) The 8600 series controller is true RMS measuring so gives more accurate display when compared with an 'averaging' meter such as an analogue panel meter or some lower specified digital multimeters. Accuracy of the controller is better than 1% of full scale. I.e. Gen volts full scale is 333V ph-n so accuracy is ±3.33V (1% of 333V).

NOTE:- The above fault finding is provided as a guide check-list only. As the module is configurable for a range of different features, always refer to the source of your module configuration if in doubt.

12 DSE 4 STEPS TO SUCCESSFUL SYNCHRONISING

Synchronising and load sharing is often considered to be a complex subject. In fact, it is very simple when broken down into smaller steps.

After following the *Commissioning* section of this manual, the *4 Steps* **must** be followed before any parallel operation is attempted.

The following information is a *short form* guide only, intended as a memory jogger once the steps are fully understood.
The full video presentation of the *4 Steps* is available on the DSE website. www.deepseaplc.com. Registration on the website is required. This is free of charge, along with all other downloads.

This page is also available as a training document (handout style) from DSE. Part Number 056-001 Four Steps to Synchronising – included on the DSE website.

12.1 CONTROL

Check the control of the engine is working:

- Control of AVR
- Control of Governor
- Direction of Control

Failure of the above steps will result in poor control of the governor/AVR leading to problems during synchronising and/or load sharing if not corrected.

12.2 METERING

- CTs on the Right Phase
- CTs in the Right Direction

Failure of the above steps will result in incorrect power factor and kW calculations leading to problems load sharing if not corrected.

12.3 COMMUNICATIONS

- All Modules Connected on the MSC Link
- Re-Calibrate, Sync + Load Control, Multi-Set
- Remove One MSC Plug

Failure of the above steps will result in the controllers being unable to communicate leading to problems during synchronising and/or load sharing if not corrected.

12.4 SYNC CHECKS

- Use the Built in Sync Scope to Determine Correct Phase Wiring
- Phase Checks across the Breaker.

Failure of the above steps will result in serious damage to the system (breakers, bus bars, alternators, engines etc)

13 MAINTENANCE, SPARES, REPAIR AND SERVICING

The DSE8600 Series controller is *Fit and Forget*. As such, there are no user serviceable parts within the controller. In the case of malfunction, you should contact your original equipment manufacturer (OEM).

13.1 PURCHASING ADDITIONAL CONNECTOR PLUGS FROM DSE

If you require additional plugs from DSE, please contact our Sales department using the part numbers below.

13.1.1.1 PACK OF PLUGS

Module type	Plug Pack Part Number

13.1.1.2 INDIVIDUAL PLUGS

8600 series terminal designation		Plug description	Part No.
1-13		13 way 5.08mm	007-166
15-19		5 way 5.08mm	007-445
22-38	 **MSC GOV AVR**	17 way 5.08mm	007-452
39-46	 **V1**	8 way 7.62mm	007-454
47-50	**V2**	4 way 7.62mm	007-171
51-57		7 way 5.08mm	007-447
60-70		11 way 5.08mm	007-451
		PC Configuration interface lead (USB type A – USB type B)	016-125

NOTE:- Terminals 20, 21, 58 and 59 are not fitted to DSE8600 series controllers.

13.2 PURCHASING ADDITIONAL FIXING CLIPS FROM DSE

Item	Description	Part No.
	8600 series fixing clips (packet of 4)	020-294

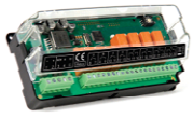
13.3 PURCHASING ADDITIONAL SEALING GASKET FROM DSE

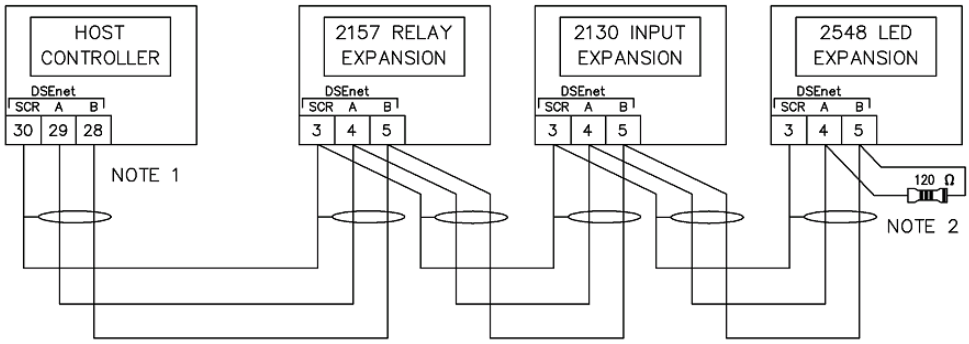
Item	Description	Part No.
	8600 series silicon sealing gasket	020-507

13.4 DSENET EXPANSION MODULES

NOTE:- A maximum of twenty (20) expansion modules can be connected to the DSENet®.

NOTE:- DSENet® utilises an RS485 connection. Using Belden 9841 (or equivalent) cable allows for the expansion cable to be extended to a maximum of 1.2km.
DSE Stock and supply Belden 9841 cable. DSE Part Number 016-030.

Item	Max No. supported	Description	DSE Part numbers			
			Model order number	Sales literature	Operator manual	Installation Instructions
	4	Model DSE2130 expansion input module provides additional analogue and digital inputs for use with the DSE8600 series controller.	2130-001-00	055-060	057-082	053-033
	10	Model DSE2157 expansion relay module provides eight additional voltage free relays for use with the DSE8600 series controller	2157-001-00	055-061	057-083	053-034
	10	Model DSE2548 expansion LED module provides additional LED indications, internal sounder and remote lamp test/alarm mute for use with the DSE8600 series controller.	2548-001-00	055-062	057-084	053-032



NOTE 1
AS A TERMINATING RESISTOR IS INTERNALLY FITTED TO THE HOST CONTROLLER, THE HOST CONTROLLER MUST BE THE FIRST UNIT ON THE DSEnet

NOTE 2
A 120 OHM TERMINATION RESISTOR MUST BE FITTED TO THE LAST UNIT ON THE DSEnet

14 WARRANTY

DSE provides limited warranty to the equipment purchaser at the point of sale. For full details of any applicable warranty, you are referred to your original equipment supplier (OEM).

15 DISPOSAL

15.1 WEEE (WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT)

Directive 2002/96/EC
If you use electrical and electronic equipment you must store, collect, treat, recycle and dispose of WEEE separately from your other waste.

15.2 ROHS (RESTRICTION OF HAZARDOUS SUBSTANCES)

Directive 2002/95/EC: 2006
To remove specified hazardous substances (Lead, Mercury, Hexavalent Chromium, Cadmium, PBB & PBDE´s)

Exemption Note: Category 9. (Monitoring & Control Instruments) as defined in Annex 1B of the WEEE directive will be exempt from the RoHS legislation. This was confirmed in the August 2005 UK´s Department of Trade and Industry RoHS REGULATIONS Guide (Para 11).

Despite this exemption, DSE has been carefully removing all non RoHS compliant components from our supply chain and products.
When this is completed, a Lead Free & RoHS compatible manufacturing process will be phased into DSE production.

This process is almost complete and is being phased through different product groups.