



MAC 800G

MANUAL



Pictures

MAC 800G Air Heater

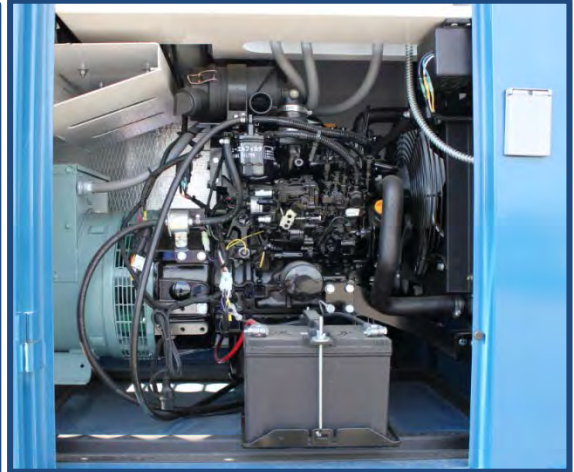


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MAC800G Air Heater

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Specifications

MAC800G Air Heater

MAC800G Specifications

Heater	800,000 BTU's/Hour
Type	Indirect fired, self-contained
Power	Isuzu diesel, liquid cooled
Engine controls	Manual key startup/shutdown
Burner	Riello 40 series F15 solid state
Fuel	Diesel fuel #1 (below 32°F) or #2 (above 32°F)
Burner range	630,000 BTU's/Hour – 1,000,000 BTU's/Hour
Generator	Marathon Magna Plus Single 12kW/3Ph
Fuel Capacity	192 US Gallons
Combustion chamber/Heat exchanger	Stainless steel
Construction	Fabricated steel, fully enclosed, single axle trailer mounted with fork lift tubes
Dimensions (LxWxH)	186" x 72" x 87.5"
Weight	4,620lbs (dry)
Finish	Interior – White powder coated finish Exterior – Blue powder coat finish
Fan	Twin City Fan SWSI No. 135 Class II 3,900 Cubic feet per minute @ 3" static pressure

Factory Settings

MAC800G Air Heater

<u>Item</u>	<u>Factory Set</u>
BTU's/hr	800,000
Burner fuel rate +/-5%	5.7 US gallons per hour
Nozzle	4.5 US gallons per hour x 60° solid
Fuel pressure	160 PSI
Turbulator set	5.5 index
Fan	Twin City Fan 135 3,520 RPM 3,900 Cubic feet per minute output @ 3" static pressure

Warranty

MAC800G Air Heater

ONE (1) YEAR LIMITED WARRANTY

MAC, Inc. warrants to the original purchaser of the equipment, that all workmanship and materials utilized in the construction of the equipment by MAC, Inc. will be free from substantial defects in material and workmanship for a period of one (1) year from the date of purchase.

In addition to the above warranty, these components have an extended warranty period beyond one (1) year.

Engine:

BASE ENGINE WARRANTY TERM AND SCHEDULE

APPLICATION	WARRANTY PERIOD		COVERAGE	
	Months*	Hours*	Parts	Labor
INDUSTRIAL "2C", "3C" Models	0-12	UNLIMITED**	100%	100%
	12-24	2000**	100%	100%

* Whichever occurs first
** Coverage for all electrical, fuel system and turbocharger components is limited to 2yrs/1000 hours, which ever occurs first.
Note: In the absence of a functional hourmeter, the engine will be deemed to be in use for 8 hours per calendar day commencing from the start of the warranty period.

This warranty extends only to the original purchaser of MAC, Inc.'s equipment and is not transferable to any other parties. MAC, Inc. does not assume responsibility for any promises, warranties or representations beyond those expressed in the written document.

MAC, Inc.'s obligations and understandings in this warranty are limited to the repair or replacement, at this option, of any defective products manufactured by MAC, Inc., and in no event shall MAC, Inc. be liable for any consequential, indirect or incidental costs or damages, including loss or use or any other damages of any type arising out of such defective parts or products.

Some states in the U.S.A. do not allow exclusion or limitation of incidental or consequential damages or implied warranties. In addition, you may have other rights which vary from state to state. Any items of this warranty which conflict with the laws of our state are deemed amended by the law of our state.

Warranty (cont.)

MAC800G Air Heater

In the event that you believe and product manufactured by MAC, Inc. has a defect or malfunction or failure to conform to this written warranty, you should contact MAC, Inc. at its Bismarck, ND address:

MAC, Inc.

2106 East Indiana Ave.

Bismarck, ND U.S.A. 58504

+1.800.272.4604

www.macheaters.com

Follow this procedure for warranty:

1. Contact MAC, Inc. at +1.800.272.4604
2. Ask to speak to a service representative
3. Have the following information ready when you call
 - a. Original purchaser's company name
 - b. Model number of your equipment
 - c. Serial number of your equipment
 - d. Purchase date of your equipment
4. Defective product may need to be returned to MAC, Inc. with the freight prepaid. Take appropriate precautions against damage during shipping.
5. Supply the following information with the returned product
 - a. Name, address, contact person and telephone number of the original purchaser of the equipment and indicate the date of purchase
 - b. Serial number and model number of defective part is attached

MAC, Inc. will replace or repair and defective products within a reasonable period of time and return them to you. If MAC, Inc. determines there is no failure to this limited warranty, you will be notified to retrieve your product from the service facility. MAC, Inc. assumes no responsibility for merchandise not retrieved within thirty (30) days of notification to the original purchaser or owner of the product.

This warranty has been drafted to comply with Federal legislation and rules promulgated by the Federal Trade Commission.

You have additional legal rights in addition to those set forth in this written limited warranty.

General Trailering Information

MAC800G Air Heater

- Driving a vehicle with a trailer in tow is vastly different from driving the same vehicle without a trailer in tow. It takes longer to get up to speed. You need more room to turn and pass, and more distance to stop when towing a trailer. You are responsible for keeping your vehicle and trailer in control, and for all damage that is caused if you lose control of your vehicle and trailer.
- It is critical that the trailer be securely coupled to the hitch and that the safety chains are correctly attached. Uncoupling while towing may result in death or serious injury.
- If the trailer comes loose from the hitch for any reason, we have provided safety chains so that control of the trailer can be maintained.
- Your trailer is equipped with a breakaway brake system that will apply the brakes on your trailer if your trailer comes loose from the hitch. The safety chains and breakaway brake system must be in good condition and properly rigged to be effective. The breakaway brake system must not be used as a substitute for a parking brake or wheel chocking.
- Be sure your hitch and tow vehicle are rated for the Gross Vehicle Weight Rating (GVWR) of your trailer.
- Be sure tires are inflated to pressure indicated on sidewall before towing. Improper inflation can result in a blowout and loss of control, which can lead to death or serious injury.
- Be sure lug nuts are tight before each tow.
- Be sure that the electric brakes and all of the lights on your trailer are functioning properly before each tow.
- Altering your trailer can damage essential safety items. **DO NOT** alter your trailer.

Safe trailer Towing Guidelines

MAC800G Air Heater

- Before towing, check coupling, safety chains, safety brake, tires, wheels and lights.
- Check the breakaway battery. Make sure it is fully charged.
- Check the wheel lug nuts or bolts for tightness. 85-95 ft. /lbs.
- Check coupler tightness after towing 50 miles (80km).
- Adjust the brake controller to engage the trailer brakes before the tow vehicle brakes.
- Use your mirrors to verify that you have enough room to change lanes or pull into traffic.
- Use your turn signals well in advance.
- Allow plenty of stopping distance for your trailer and tow vehicle.
- Do not drive faster than the conditions will allow.
- Allow plenty of room for passing. A rule of thumb is that passing distance with a trailer is 4 times the passing distance without a trailer.
- Use lower gears for climbing and descending grades.
- Do not ride the brakes while descending grades; this can cause overheating and potential brake failure.
- Slow down for bumps in the road. Take your foot off the brake pedal when crossing the bump.
- Slow down prior to entering a curve; maintain a constant safe speed that allows you to remain in control of your trailer. The towing vehicle will then remain in control of the trailer.
- Do not apply the tow vehicle brakes to correct extreme trailer swaying. Continued pulling of the trailer, and even slight acceleration, or carefully applying the trailer brakes (using the electronic brake controller) will provide a stabilizing force.

Safe Trailer Towing Guidelines (cont.)

MAC800G Air Heater

Make regular stops to confirm

- The coupler is secure to the hitch and is locked.
- Electrical connections are made.
- There is appropriate slack in the safety chains.
- There is appropriate slack in the breakaway switch pull-pin cable.
- The tires are inflated to proper air pressure and no damage or unusual wear to tread or sidewalls.
- The trailer and doors are secure, latched and in good condition.

Wheel chock user guidelines

- Improper use may result in product failure.
- Select wheel chock according to the equipment type and size.
- Always use in pairs and on firm surfaces.
- Chock in direction of grade.
- Chock both sides of wheel if direction of grade is undetermined.
- Use only after parking brake is applied and tested.
- Center chocks snugly and squarely against tread of each wheel.
- Always test chocks to insure they meet requirements.
- Do not drive over wheel chocks.

For more trailering information check out:

US Department of Transportation, National Highway Traffic Safety Administration website at:

<http://www.nhtsa.gov/Cars/Problems/Equipment/towing/index.htm>

Warnings and Cautions

MAC800G Air Heater

The MAC 800G air heater is designed and built for sustained reliable heat production under severe operating conditions, particularly oil field and other similar environments. The MAC 800G is built to withstand rough and frequent handling.

The standard skid sub-frame has forklift access at either side for loading, transport, tie down, and chain attach points for skid positioning of the unit.

The total enclosure design protects the operating components allowing all-weather storage or operations.

Burner options to suit buyer specifications are available. All options incorporate integrated control and safety systems to insure reliable operations.

WARNINGS AND CAUTIONS LISTED IN THIS MANUAL MUST BE COMPLIED

REMEMBER

SAFETY FIRST!! Operator must know and understand all operating instructions, warnings, and cautions before operating the heater.

WARNING!

Adequate airflow to the heater is MANDATORY for safe, reliable operation!

WARNING!

Heater should not be left unattended when manual operation is selected.

WARNING!

SHUT GENERATOR OFF BEFORE CHECKING OIL LEVELS.

For questions or more information, please contact:

MAC, Inc.

2106 East Indiana Avenue

Bismarck, ND U.S.A. 58504

+1.800.272.4604

www.macheaters.com

Pre-Start Checklist

MAC800G Air Heater

BURNER COMPARTMENT

- Check for cleanliness, spilled fuel, and foreign debris.
- Burner covers installed and secure.
- Check for security and damage of all fuel lines, filters, and electrical connections.

Warning!

Do not use gasoline or ANY fuel contaminated with gasoline!

EXTERIOR

- Check general condition of heater.
- Check fuel tanks for proper fuel. Service with fuel oil No. 1, 2, & A.
- *ATTN: MAKE SURE FUEL OIL HAS NO ADDITIVES***
- Check fan air inlet for screen condition, obstruction and damage.
- Check ENGINE and BURNER exhaust stacks for damage and obstruction.

Warning!

**Do not operate heater with guard doors open!
The unit must be completely shut off before opening the guard doors.
Severe injury may result if precautions are not followed!**

ENGINE COMPARTMENT

- Check for cleanliness, spilled fuel, and foreign debris.
- Battery and cables secured.
- Check engine oil and coolant levels.
- Check fuel lines and electrical cables for damage and security.
- Check engine control panel for security.

Warning!

**Make sure generator is shut off before checking oil levels.
Heater must be run on level ground to prevent rolling
or serious injury may occur**

OPERATING INSTRUCTIONS

STARTING PROCEDURE

1. Check all engine fluids.
2. Turn ignition key to **"RUN"** position, wait for the light to go out.
3. Turn ignition key to **"START"** engine.
4. Allow engine to warm up for 90 seconds.
5. Turn main disconnect switch to **"ON"** position.
6. Press **"GREEN"** blower **"START"** button.
7. Turn burner switch to **"ON"** position.
8. Monitor outlet air temperature.

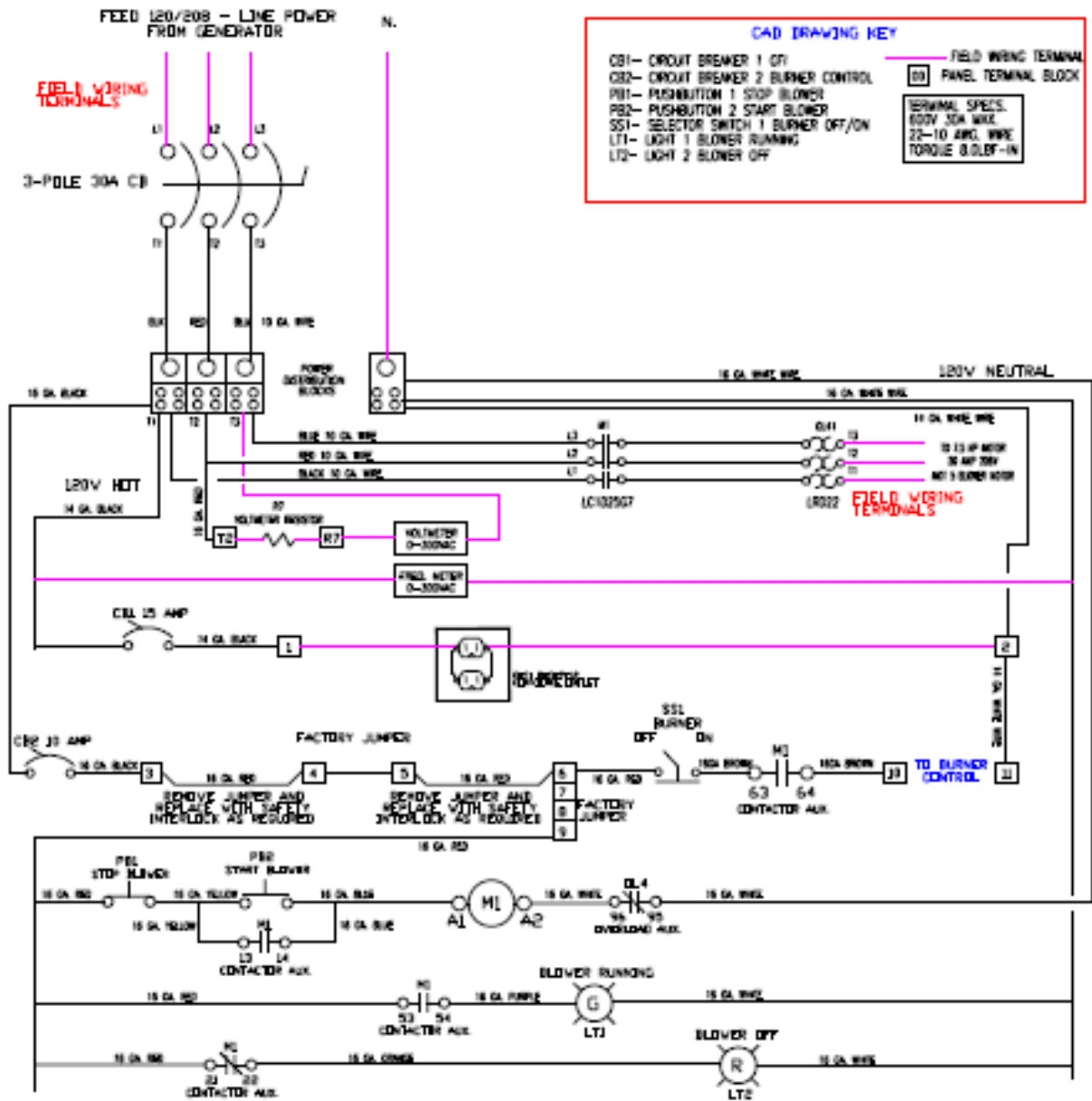
SHUT DOWN PROCEDURE

1. Turn burner switch to **"OFF"** position.
2. Allow outlet air temperature to cool for a **MINIMUM** of 90 seconds.
3. Press **"RED"** blower **"STOP"** button.
4. Turn ignition key to **"OFF"** position.

Blower Panel Schematics

MAC800G Air Heater

MAC INC. - BLOWER PANEL



MAGNAPLUS[®] GENERATOR

280–430 Frame Installation, Operation, and Maintenance Manual



Marathon MagnaPLUS Generator

MAC800G Air Heater

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SAFETY

PLEASE REMEMBER SAFETY FIRST. If you are not sure of the instructions or procedures contained herein, seek qualified help before continuing.

This service manual emphasizes the safety precautions necessary during the installation, operation, and maintenance of your MagnaPLUS® generator. Each section of this manual has caution and warning messages. These messages are for your safety, and the safety of the equipment involved. If any of these cautions or warnings are not readily understood, seek clarification from qualified personnel before proceeding.

Before any service work is done, disconnect all power sources and lock out all controls to prevent an unexpected start up of the generator set driver. Proper grounding (earthing) of the generator frame and distribution system in compliance with local and national electrical codes and specific site requirements must be provided. These safety precautions are necessary to prevent potential serious personal injury, or even death.

The hazards associated with lifting or moving your MagnaPLUS® generator are pointed out in the installation and maintenance sections. Incorrect lifting or moving can result in personal injury or damage to the unit.

Prior to start up of the unit ensure that all generator leads are properly connected to the generator link board located inside the connection box. Always assume that there will be voltage present at the generator terminals whenever the generator's shaft is rotating, and proceed accordingly. Residual voltage is present at the generator terminals and at the automatic voltage regulator panel connections even with the regulator fuse removed. Caution must be exercised, or serious injury or death can result.

This manual is not intended to be a substitute for properly trained personnel. Installation and repairs should only be attempted by qualified, trained people. The cautions and warnings point out known conditions and situations that are potentially hazardous. Each installation may well create its own set of hazards.

When in doubt, ask. Questions are much easier to handle than mistakes caused by a misunderstanding of the information presented in this manual.

RECEIVING AND STORAGE

RECEIVING AND STORAGE

Upon receipt of the generator, it is recommended that it be carefully examined for possible shipping damage. The generator was given to the freight carrier in good condition; thus, the carrier is responsible for the product from the factory dock to the destination. Any damage should be noted on the freight bill before accepting the shipment. Any claims for damage must be promptly filed with the delivering carrier.

UNPACKING AND HANDLING

Carefully read all instruction tags shipped with the unit. When lifting, attach an overhead crane to the lifting lug(s) on the generator frame. Apply lifting forces in a vertical direction. When transporting single bearing generators, the generator's rotor must be adequately supported to prevent damage.



THE LIFTING LUG(S) ON THE GENERATOR ARE DESIGNED TO SUPPORT THE GENERATOR ONLY. DO NOT LIFT A COMPLETE GENERATOR AND DRIVER ASSEMBLY BY MEANS OF LIFTING LUG(S) ON THE GENERATOR. PERSONAL INJURY OR EQUIPMENT DAMAGE MAY RESULT.

STORAGE

In the event that the generator is not immediately installed on its prime mover, it is recommended that the unit be stored indoors in a clean, dry area which is not subject to rapid changes in temperature and humidity. If the generator is stored for a long period of time, the generator should be tested, cleaned and dried as required before being put into service. See the maintenance section of this manual for further information. If the unit has been stored in an area where it has been subjected to vibration, it is recommended that the bearing(s) be inspected and replaced as necessary.

Marathon Magnaplug Generator

MAC800G Air heater

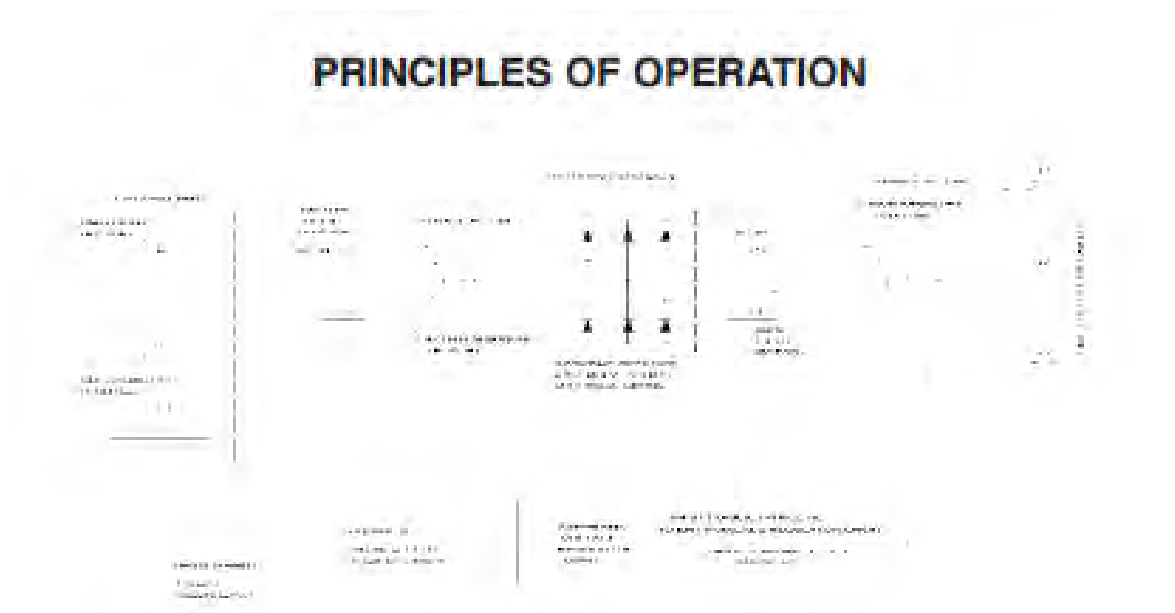


FIGURE 1 – MagnaPLUS® Circuit Diagram

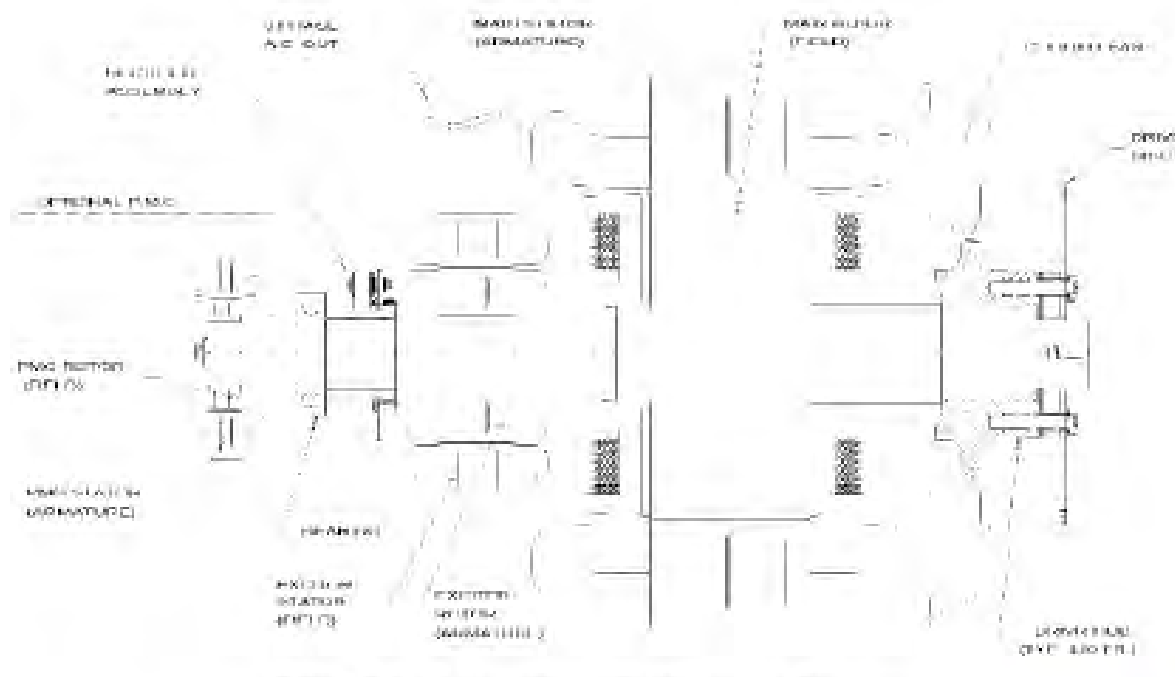


FIGURE 2 – Typical MagnaPLUS® Layout Diagram

Marathon Magnaplus Generator

MAC800G Air Heater

PRINCIPLE OF OPERATION

MagnaPLUS® generators are brushless, self excited, externally voltage regulated, synchronous AC generator. The generator is made up of six major components: main stator (armature), main rotor (field), exciter stator (field), exciter rotor (armature), rectifier assembly, and voltage regulator. In understanding the above terminology, note the following: stators are stationary, rotors rotate, a field is a DC electrical input, and an armature is an AC electrical output. These system components are electrically interconnected as shown in Figure 1 and physically located as shown in Figure 2.

The generator's exciter consists of a stationary field and a rotating armature. The stationary field (exciter stator) is designed to be the primary source of the generator's residual magnetism. This residual magnetism allows the exciter rotor (armature) to produce AC voltage even when the exciter stator (field) is not powered. This AC voltage is rectified to DC by the rotating rectifier assembly and fed directly to the main rotor (field). As the generator shaft continues to rotate, the main rotor (field) induces a voltage into the generator's main stator (armature). At rated speed, the main stator's voltage produced by the residual magnetism of the exciter allows the automatic voltage regulator to function. The regulator provides voltage to the exciter field resulting in a build-up of generator terminal voltage. This system of using residual magnetism eliminates the need for a special field flashing circuit in the regulator. After the generator has established the initial residual voltage, the regulator provides a controlled DC field voltage to the exciter stator resulting in a controlled generator terminal voltage.

Voltage Regulation

In the standard configuration (shunt excited), the automatic voltage regulator receives both its input power and voltage sensing from the generator's output terminals (See Figure 1). With the optional PMG configuration, the regulator receives input power from the PMG. The regulator automatically monitors the generator's output voltage against an internal reference set point and provides the necessary DC output voltage to the exciter field required to maintain constant generator terminal voltage. The generator's terminal voltage is changed by adjusting the regulator's reference set point. Consult the regulator manual for specific adjustment and operating instructions.

MOTOR STARTING

When a motor is started, a large surge of current is drawn by the motor. This starting current is equivalent to the motor's locked rotor or stall current and is 5 to 10 times normal full load current. When the generator supplies this in-rush of starting current, the generator voltage dips temporarily. If the motor is too large for the generator, the generator's voltage dips greater than 30 percent. This may result in the motor stator de-energizing or the motor stalling. MagnaPlus® generators generally supply .3 to .4 horsepower per

generator KW in motor starting capability. For specific data contact Marathon Electric.

PARALLEL OPERATION

All MagnaPlus® generators are built with 2/3 pitch main stator windings and full amortisseur (damper) windings. These features make the MagnaPlus® generators suitable for parallel operation when equipped with the proper voltage regulators and voltage regulator accessories. Consult with the factory for further information relative to parallel operations.

NONLINEAR LOADING

Solid state electronic control devices (variable frequency drives, precision motor controls, battery chargers, etc.) utilize electronic switching circuits (thyristors, SCRs, Diodes, etc.). These switching circuits introduce high frequency harmonics which distort the normal wave form of the generator. This creates additional heat in the generator windings and may cause the generator to over-heat. Problems which can occur are not limited to the generator. Poor wave shape may adversely affect various loads connected to the generator. Consult Marathon Electric for further information relative to nonlinear loads.

INSTALLATION

PREPARATION FOR USE

Although the generator has been carefully inspected and tested in operation prior to shipment from the factory, it is recommended that the generator be thoroughly inspected. Check all bolts for tightness and examine the insulation on lead wires for chafing prior to proceeding with installation. Remove all shipping tapes, bags, skids and rotor support blocking. For two bearing units, rotate the shaft by hand to ensure that it rotates smoothly without binding.

Marathon MagnaPlus Generator

MAC800G Air Heater

WARNING

DISABLE AND LOCKOUT ANY ENGINE CRANKING DEVICES BEFORE ATTEMPTING TO INSTALL OR SERVICE THE GENERATOR. FOR ELECTRIC START SETS, DISCONNECT THE CRANKING BATTERY. FOR AIR START, DISCONNECT THE AIR SUPPLY. FOR MOTOR GENERATOR SETS, OPEN THE POWER SUPPLY TO THE DRIVE MOTOR. FAILURE TO COMPLY WITH THESE SAFETY PROCEDURES COULD RESULT IN SEVERE PERSONAL INJURY OR EQUIPMENT DAMAGE.

NEVER "BAR OVER" THE ENGINE GENERATOR SET USING THE GENERATOR'S FAN. THE FAN IS NOT DESIGNED FOR THIS PURPOSE. BARRING OVER THE SET WITH THE FAN COULD DAMAGE THE FAN AND RESULT IN PERSONAL INJURY OR EQUIPMENT DAMAGE.

GENERATOR MOUNTING

Single Bearing Units

Single bearing units are provided with an SAE flywheel housing adapter flange and flexible drive discs. Coupling the generator's shaft to the engine flywheel is accomplished with special steel drive discs bolted to the shaft. In addition to the drive discs, there may be a hub spacer, spacer discs, or a combination of hub spacer and spacer discs inserted between the drive discs and the shaft to achieve the proper shaft extension ("G" dimension per SAE J620c). Holes are provided in the periphery of the coupling discs which correspond to tapped holes in the prime mover's flywheel. The outside diameter of the drive discs fit in a rabbet in the flywheel so that concentricity is assured.

Grade 8 plate bolts and hardened washers are recommended to mount the drive discs to the flywheel. **DO NOT USE SPLIT TYPE LOCK WASHERS.** Split lock washers when biting into the drive disc cause stress risers which may result in the disc fracturing.

The SAE flywheel housing adapter ring and the engine flywheel housing are designed to match each other with no further alignment necessary. Use grade 5 or greater mounting bolts. MagnaPLUS® generator frames are constructed with two or three bolt holes per foot. The feet should be shimmed where necessary to obtain solid contact with the sub-base. With the frame securely bolted to the engine flywheel housing, there is no side thrust or pull on the generator frame, thus no need to secure the feet with more than one bolt per foot.

GENERATOR MOUNTING

Two Bearing Generators – Direct Drive

Two bearing generators are provided with a keyed shaft extension. For direct drive generators, the assembler furnishes a flexible coupling which is installed between the driver and the generator's shaft. Aligning the generator and its driver as accurately as possible will reduce vibration, increase bearing life, and ensure minimum coupling wear. It may be necessary to shim the generator feet for proper support and alignment. Secure the feet of the generator with grade 5 or greater bolts through the holes provided in the mounting feet. Consult the coupling manufacturer's instructions for alignment specifications and procedures.

GENERATOR MOUNTING

Two Bearing Units – Belt Driven

Two bearing MagnaPLUS® generators can be belt driven provided belts are sized and applied correctly. Please refer to your supplier of belts and sheaves for correct sizing and tensioning specifications. A bearing life calculation should be performed. Marathon Electric recommends a minimum 8-10 life of 40,000 hours. If cog type belts are used, a vibration may be introduced which could lead to premature failure of the bearings.

HYDRAULIC DRIVE WITH SHAFT SPLINE

Two-Bearing Units

All 280 PDL MagnaPLUS® two bearing hydraulic drive generators are equipped with a Zerk grease fitting mounted in the drive end of the shaft. Prior to assembly to the hydraulic drive motor, lightly coat the hydraulic drive motor shaft, and/or grease the generator spline per the greasing instructions in the MAINTENANCE section, page 12. **DO NOT assemble the generator to the hydraulic drive motor with the spline dry.**

END PLAY TESTING

Refer to the engine manual for recommended end play specifications and measurement procedures. If end play is not to specification, it is an indication that the generator shaft is not moving freely in the assembly, and normal life of the thrust bearing could be impaired. Probable causes of this problem are:

1. Improper seating of drive discs in the flywheel resulting in misalignment.
2. Improper mating of generator frame to engine flywheel housing resulting in misalignment.
3. Improper "G" dimension per SAE J620c on either the engine or generator.

Marathon Magnaplug Generator

MAC800G Air Heater

TORSIONAL VIBRATION

Torsional vibrations are generated in all rotating shaft systems. In some cases, the amplitude of these vibrations at critical speeds may cause damage to either the generator, its driver, or both. It is therefore necessary to examine the torsional vibration effect on the entire rotating system. IT IS THE RESPONSIBILITY OF THE GENERATOR SET ASSEMBLER TO ASSURE THE TORSIONAL COMPATIBILITY OF THE GENERATOR AND ITS DRIVER. Drawings showing pertinent dimensions and weights of the rotating assembly will be supplied by Marathon Electric upon request.

ENVIRONMENTAL CONSIDERATIONS

The MagnaPLUS® generator is designed for heavy duty industrial applications; however, dirt, moisture, heat and vibration are enemies of rotating electrical machinery. Excessive exposure to the elements may shorten generator life. The temperature of the cooling air entering the intake openings of the generator should not exceed the ambient temperature shown on the generator's nameplate. Generators intended for outdoor application should be protected with housings having adequate ventilation. Although the standard insulation systems are moisture and humidity resistant, space heaters are recommended for extreme conditions. If the generator is to be installed in an area where blowing sand and dust are present, the enclosure should be fitted with filters. Filters reduce erosion on the generator's insulation by blocking high velocity abrasive particles generated by the flow of cooling air through the generator. Consult the factory for appropriate filters and generator deratings required.

The generator conduit box construction allows cable entry from multiple sides. A hole saw or other appropriate tool may be used to provide for conduit entrance. Protect the interior of the generator from shavings when drilling or sawing. An approved connector must be used in conjunction with the conduit. To minimize the transmission of vibration, it is essential that flexible conduit be used for all electrical entrance to the generator conduit box.

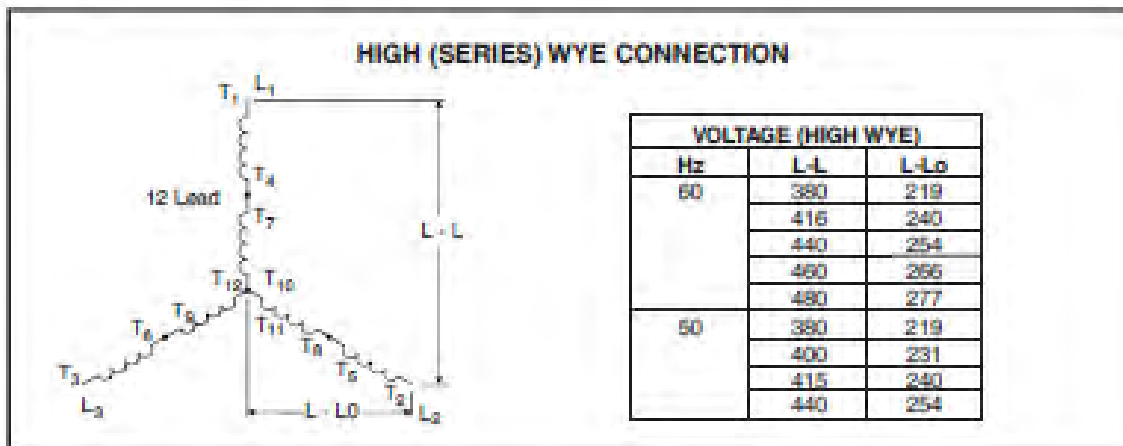
All MagnaPLUS® generators are equipped with link boards (terminal strips) for both internal and external connections. All connections made to the studs of the link board should be made with high quality ring terminals. Ring terminal sizes are: 6 mm (280 Series Frames) and 10 mm (360 and 430 Series Frames). Torque link board connections to the following specifications: 280 frame – 5.4 NM (4 Ft Lb); 360 & 430 frame – 27 NM (20 Ft Lb).

Refer to the connection diagram supplied with the generator and / or the proper diagrams shown in this manual. Install all inter component and external wiring in accordance with national and local electrical codes. The neutral in the following connection diagrams shown below may be either grounded (earthed) or left above ground potential (floating). See national and local codes and / or the system distribution wiring schematic diagram for the proper connection of the neutral.

The following connection diagrams are shown for twelve lead generators. Ten lead generators have the same terminal designations except for leads T10, T11, and T12. These three leads are internally connected inside the generator and brought out as a single lead (T0). Ten lead generators can only be connected in a wye configuration.

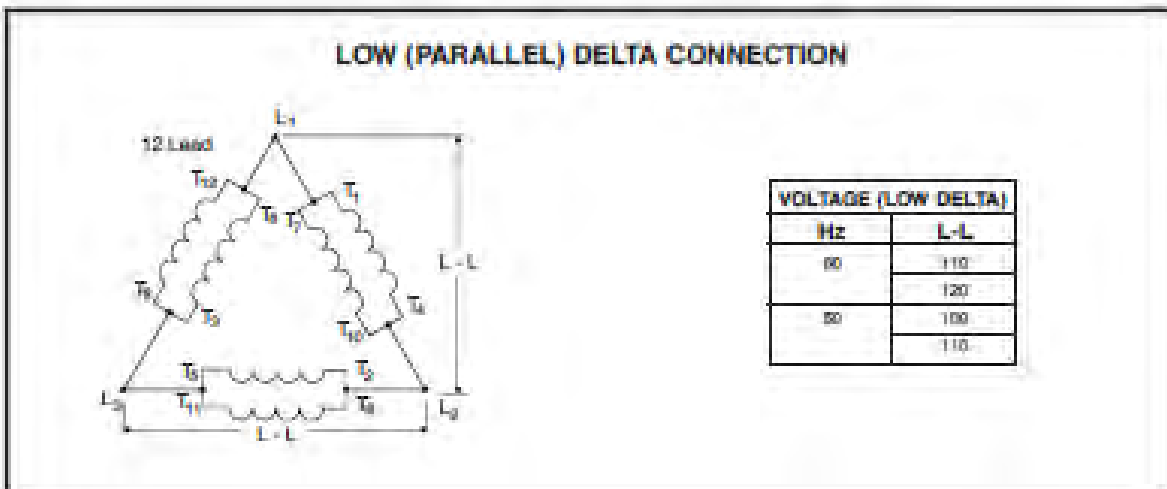
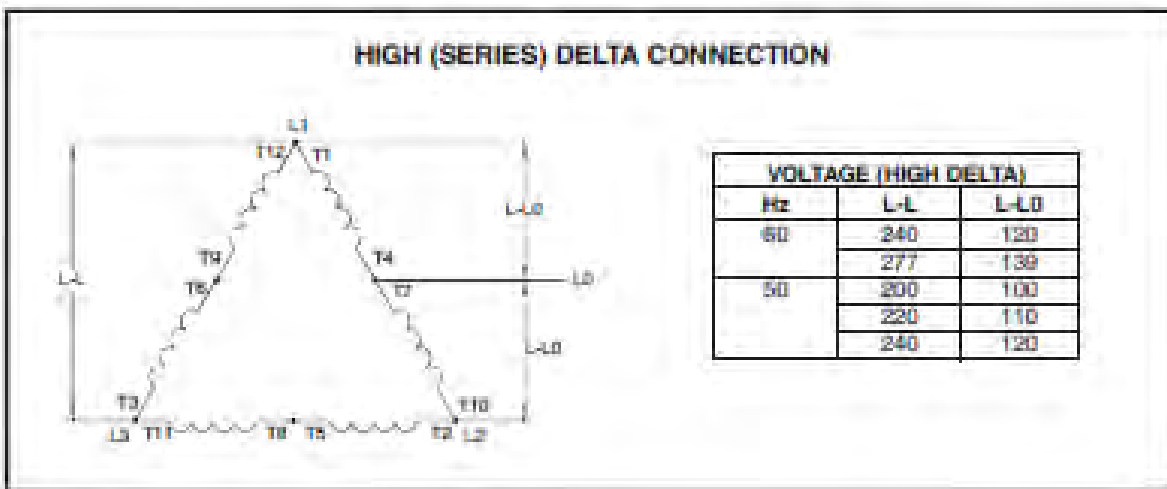
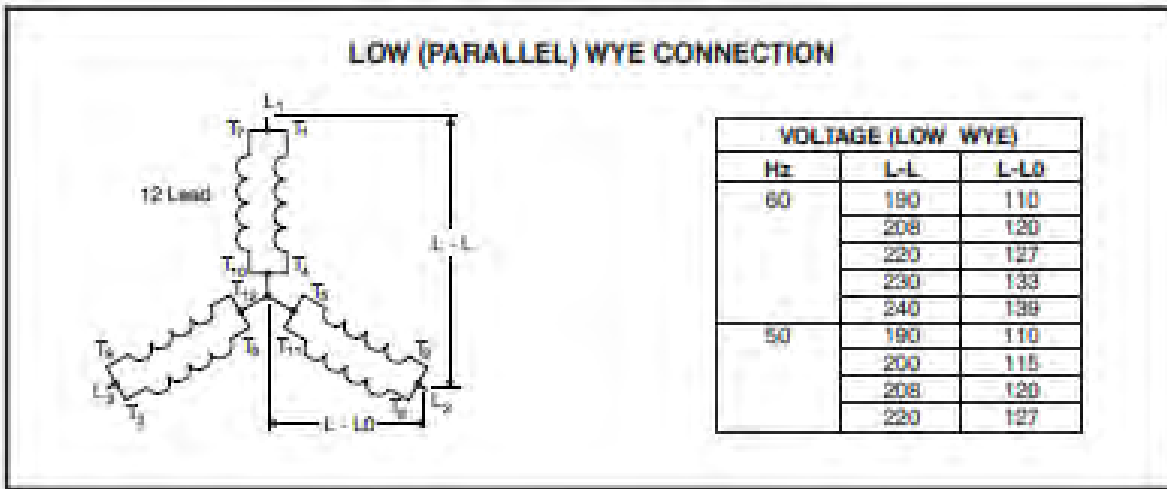
WIRING CONNECTIONS

Wiring of the generator and accessories should be done in accordance with good electrical practices. Follow government, industry and association standards.



Marathon Magnaplug Generator

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MAC800G Air Heater

DOUBLE DELTA – SINGLE PHASE CONNECTION

VOLTAGE (DOUBLE DELTA)		
Hz	L-L	L-LO
60	200	100
	220	110
	240	120
50	220	110

Note: Single phase KWKVA ratings are approximately equal to 50% of the generator's three phase ratings.

LOW ZIG ZAG – SINGLE PHASE (PARALLEL) CONNECTION

VOLTAGE (LOW ZIGZAG)		
Hz	L-L	L-LO
60	200	100
	220	110
	240	120
50	220	110

Note: Single phase KWKVA ratings are approximately equal to 50% of the generator's three phase ratings.

HIGH ZIG ZAG – SINGLE PHASE (SERIES) CONNECTION

VOLTAGE (HIGH ZIGZAG)		
Hz	L-L	L-LO
60	480	240

Note: Single phase KWKVA ratings are approximately equal to 50% of the generator's three phase ratings.

Marathon Magnaplus Generator

MAC800G Air Heater

**DEDICATED SINGLE PHASE CONNECTION
HIGH VOLTAGE - SERIES CONNECTED**

VOLTAGE (DEDICATED)		
Hz	L-L	L-N
60	240	120
	220	110
50	220	110
	200	100

SINGLE PHASE CONNECTION - SINGLE VOLTAGE PARALLEL

VOLTAGE	
	L-L
60 HZ	120
50 HZ	110

Note: For 120 volt only service, Use an AVC83-4A or a VR83-4C voltage regulator to replace the standard SE350 regulator.

Marathon Magnaplus Generator

MAC800G Air Heater

OPERATION

PRE-START INSPECTION

Before starting the generator for the first time, the following inspection checks are recommended:

1. A visual inspection should be made for any loose parts, bad connections, or foreign materials.
2. Bar the set over by hand for at least 2 revolutions to be sure that there is no interference and that the set turns freely. If the set does not turn freely, check for clearance in the generator and exciter air-gap.
3. Check all wiring against the proper connection diagrams, and ensure that all connections and terminations are tight and properly insulated.
4. Verify that all equipment is properly grounded (earthed).

WARNING

MAGNAPLUS® GENERATORS MAY HAVE VOLTAGE PRESENT AT THE LEAD TERMINALS WHEN THE SHAFT IS ROTATING. DO NOT PERMIT OPERATION OF THE GENERATOR UNTIL ALL LEADS HAVE BEEN CONNECTED AND INSULATED. FAILURE TO DO THIS MAY RESULT IN PERSONAL INJURY OR EQUIPMENT DAMAGE.

5. Clear the surrounding area of any materials that could be drawn into the generator.
6. Check all fasteners for tightness.
7. Check all access plates, covers, screens and guards. If they have been removed for assembly or inspection, reinstall and check for security.
8. Review all prime mover prestart up instructions, and ensure that all recommended steps and procedures have been followed.
9. Remove any masking materials affixed during painting. Inspect the generator, prime mover, and any accessory equipment to ensure that nameplates, and all safety warning / caution signs and decals provided with the equipment are in place and clearly visible.

Note: It is strongly recommended that the authority having jurisdiction over the installation site be consulted to determine if any additional warning or caution notices, or additional safety devices are required by local codes / standards. Any such required notices or devices should be installed prior to initial startup.

START-UP

The following procedure should be followed when starting the generator set for the first time.

1. The generator output must be disconnected from the load. Be sure that the main circuit breaker or fused disconnect is in the open position.
2. Open the input power to the automatic voltage regulator. Remove the fuse or disconnect and insulate one of the regulator input power leads. (See separate regulator manual)
3. Verify that all prime mover start-up procedures have been followed.
4. If the unit is provided with space heaters, ensure that they are de-energized. In some installations, a set of auxiliary contacts on the main circuit breaker or transfer switch will automatically open the space heater circuit when the generator is connected to the load.
5. Start the prime mover, and adjust it for proper speed. See generator nameplate.
6. The purpose of this initial test with the regulator out of the circuit is to detect any wiring mistakes without exposing the unit to undue risk. Check all line to line and line to neutral voltages for balanced voltage. If voltages are balanced, shut down the set and reconnect the regulator. If voltages are unbalanced, shut down the equipment and check for improper wiring. If the problem persists, consult the factory.

With the regulator de-energized, the residual voltage should be 10 - 25% of rated value. It is recommended that this residual voltage and driver RPM be recorded for use as a future troubleshooting benchmark.

WARNING

THE FOLLOWING TEST MUST BE CONDUCTED BY QUALIFIED ELECTRICAL PERSONNEL. LETHAL VOLTAGE MAY BE PRESENT AT BOTH THE GENERATOR AND VOLTAGE REGULATOR TERMINALS DURING THIS PROCEDURE. CAUTION MUST BE EXERCISED NOT TO COME INTO PERSONAL CONTACT WITH LIVE TERMINALS, LINKS, OR STUDS. SERIOUS INJURY OR DEATH COULD RESULT.

7. Start the set and adjust the terminal voltage to the desired value by means of the regulator voltage adjustment. If the regulator is equipped with a stability adjustment, follow the instructions in the regulator manual to adjust the stability. Again, check all line to line and line to neutral voltages for balance. It is

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recommended practice to record the no load excitation (DC voltage to the exciter stator), generator terminal voltage, and driver speed as a benchmark for future troubleshooting.

8. Close the main circuit breaker to the load.
9. Monitor the generator output current to verify that it is at or below nameplate value.
10. Check generator speed (frequency) under load. Adjust as necessary. (Refer to prime mover or governor manuals)

SHUTDOWN PROCEDURE

There are no specific instructions for shutting down the generator; however, several good practices should be observed to prolong equipment life.

1. It is advisable to disconnect all loads (open main circuit breaker or disconnect) prior to shutdown. This is especially important if loads can be damaged by low voltage or low frequency conditions during generator "coast down".
2. Isolate all conditions that could apply voltage to the generator terminals while the generator is at rest. Failure to comply could result in personnel injury or equipment damage.
3. If the unit is equipped with space heaters, verify that the heater circuit is energized.

MAINTENANCE

The following maintenance procedures should be followed to ensure long equipment life and satisfactory performance. Maintenance intervals will depend upon operating conditions.

1. Routinely check intake and exhaust air screens to ensure that they are clean and free of debris. Clogged intake air screens will reduce cooling air flow and result in higher operating temperatures. This will reduce generator life and may result in generator damage.
2. All MagnaPLUS[®] generators are equipped with double shielded ball bearings lubricated for the life of the bearing. Every 1,000 hours check the bearing(s) for smooth, quiet operation. For continuous duty generators, recommended practice is to replace the bearing during major overhauls of the engine.
3. Periodically inspect the unit for any buildup of contamination (dirt, oil, etc.) on the windings. If the wind components have become coated with heavy concentrations of oil and grime, the unit should be disassembled and thoroughly cleaned. This operation is not one that can be accomplished effectively on site, but

rather one that should be conducted by an authorized service center equipped with the appropriate apparatus and solvents necessary to properly clean and dry the generator.

WARNING

THE FOLLOWING TEST MUST BE CONDUCTED BY QUALIFIED ELECTRICAL PERSONNEL. LETHAL VOLTAGE MAY BE PRESENT AT BOTH THE GENERATOR AND VOLTAGE REGULATOR TERMINALS DURING THIS PROCEDURE. CAUTION MUST BE EXERCISED NOT TO COME INTO PERSONAL CONTACT WITH LIVE TERMINALS, LINKS, OR STUDS. SERIOUS INJURY OR DEATH COULD RESULT.

4. Every 2,000 operating hours or in conjunction with scheduled engine maintenance, check the DC no load excitation voltage per item #7 in the startup procedure. Compare this voltage with the value recorded during initial startup. If this value of no load excitation voltage is markedly higher than the bench mark reading, it is an indicator of problems in either the exciter, main field, or the rotating rectifier assembly. Ensure that RPM is the same as initial test.
5. Monitor and record insulation resistance with a 500 volt mega-ohm meter. The minimum acceptable reading is 2 mega-ohms. If the reading drops below the minimum, the generator should be cleaned and dried at an authorized service shop. Consult Marathon Electric for more information.

DRYING WINDINGS

Generators in service may inadvertently have their windings exposed to splashing or sprayed water. Units that have been in transit or storage for long periods of time may be subjected to extreme temperature and moisture changes causing excessive condensation. Regardless of the source of moisture, wet windings should be thoroughly dried out before operating the unit. If this precaution is not taken, serious damage to the generator can result. The following procedures may be utilized in drying the generator's windings. The method selected will be influenced by winding wetness and situation limitations.

Space Heaters

An electric heater may have been supplied with the generator. When energized from a power source other than the generator, the heater will gradually dry the generator. This process can be accelerated by enclosing the unit with a covering and inserting additional heating units. A hole should be left at the top of the covering to permit the escape of moisture. Care should be taken not to overheat various accessory equipment mounted with the generator.

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Forced Air

Another method to dry the generator is to run the set with no excitation (see startup procedure item #2). The natural flow of ambient air through the generator will tend to dry the windings. This method can be accelerated by adding a source of heat at the air intake to the generator. Heat at point of entry should not exceed 80 °C (180° F).

HYDRAULIC DRIVE GENERATORS, SHAFT SPLINE LUBRICATION

The shaft spline should be greased prior to initial assembly to the driver, and every three (3) months to reduce maintenance, and prolong the life of the spline coupling per the following procedure:

1. Material: Molybdenum Disulfide - sometimes referred to as "Moly Grease."
2. Turn the rotor assembly so that the Zerk fitting is in line with the access hole in the top of the drive and bearing bracket as illustrated in Figure 3.
3. Using a hand held grease gun with a soft coupling, apply a small amount of grease into the fitting. **DO NOT OVER GREASE.** Limit the amount of grease to one (1) trigger pull of the grease gun.

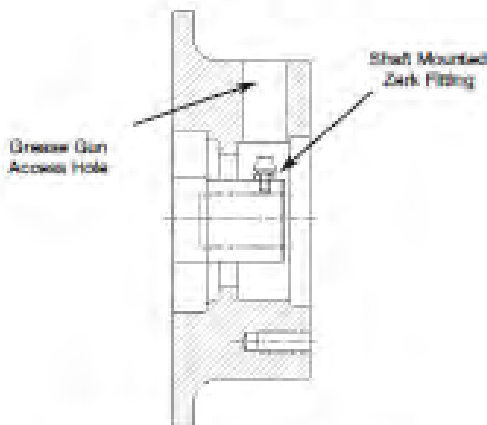


Figure 3—Drive End Bearing Bracket

TESTING

Visual Inspection

Remove covers and look for any obvious problems: burnt windings, loose connections, broken wires, frayed insulation, cracked brackets, missing hardware, etc. Check for foreign objects which may have been drawn into the generator. Verify

that the generator's air gaps (main rotor and exciter) are free from obstructions. If possible, rotate the generator manually to ensure free rotation. Never "bar over" the engine generator set using the generator fan.

⚠WARNING

THE FOLLOWING TEST MUST BE CONDUCTED BY QUALIFIED ELECTRICAL PERSONNEL. LETHAL VOLTAGE MAY BE PRESENT AT BOTH THE GENERATOR AND VOLTAGE REGULATOR TERMINALS DURING THIS PROCEDURE. CAUTION MUST BE EXERCISED NOT TO COME INTO PERSONAL CONTACT WITH LIVE TERMINALS, LINKS, OR STUDS. SERIOUS INJURY OR DEATH COULD RESULT.

CONSTANT EXCITATION TEST (12V BATTERY TEST)

The generator "no load" voltage is dependent on exciter input voltage and generator speed. With the generator operating at rated speed and 12 volts dc applied to the exciter field, the generator terminal voltage will be near rated value.

1. Shutdown the generator set and connect a voltmeter on the generator terminals.
2. Disconnect the regulator's F+ (F1) and F- (F2) leads and connect them to a 12V battery. Caution should be taken to ensure that the battery is not exposed to any potential arcing.
3. With no load on the generator (main breaker open) run the generator at rated speed. Measure the generator's terminal voltage and compare this value with values recorded during installation.

If voltage readings are normal, the main generator and excitation are operating properly. Troubleshooting should continue with the regulator. If readings are not normal the problem is in the generator. Continue testing diodes, surge suppressor, and windings.

Continuity / Resistance Test

The generator has four components which can be checked using an ohm meter: exciter stator, exciter rotor, main stator and main rotor. Each of these components are comprised of various windings which form a complete electrical path of relatively low resistance. Using an ohm meter measure the loop resistance of each component. Compare these measured values with the values listed in the specification section of this manual. Note that very small resistance values require precision equipment to make accurate measurements; however, a standard ohm meter will provide a good indication of winding continuity.

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Insulation Test

Insulation resistance is a measure of the integrity of the insulating materials that separate the electrical windings from the generator's steel core. This resistance can degrade over time or be degraded by contaminants: dust, dirt, oil, grease, and especially moisture. Most winding failures are due to a breakdown in the insulation system. In many cases, low insulation resistance is caused by moisture collected when the generator is shutdown.

Insulation resistance is measured with a megger (mega-ohm meter). A megger measures insulation resistance by placing 500 volts between the winding and the frame of the generator. Caution must be taken to remove all electronic devices (regulators, diodes, surge protectors, capacitors, protective relays, etc.) from the winding circuit before checking the insulation. Winding insulation can be checked on the main stator, main rotor, exciter stator, and exciter rotor. Minimum resistance is 2 mega-ohms. If the winding resistance is low it must be dried (see maintenance section) or repaired.

DIODE TESTING

If the generator is close coupled to an engine, it may be necessary to "bar over" the engine in order to gain access to a given area of the rectifier assembly. NEVER use the generator's fan as a fulcrum to accomplish this. Use the engine manufacturer's recommended practice to manually turn over the engine. To prevent possible injury to personnel, and damage to the equipment, ensure that the engine cannot start during this procedure.

Remove the two main rotor leads and the three exciter rotor leads from the rectifier assembly (Figure 5). The rectifier assembly is now electrically isolated from the generator. The diodes remain mounted and the diode leads remain connected to the terminal posts. Using an ohmmeter or a battery light continuity tester, place one test probe on the diode lead terminal post. In succession, touch the other test probe to the lead screw hole in each heat sink. Reverse the probes and repeat the procedure. You have now tested the three diodes connected to this terminal post in both the forward and reverse direction. Repeat the procedure using the other diode terminal post.

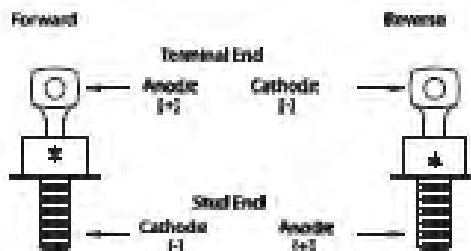


FIGURE 4: DIODE POLARITY

When the positive test probe is connected to the diode's anode and the negative test probe is connected to the diode's cathode (forward biased), the diode will switch on and conduct electricity (Figure 4). This is observed by a low resistance reading when using an ohm meter or the lighting of the bulb when using a battery light continuity tester. Reversing the test leads (reverse biased) will result in the diode switching off and no electricity will be conducted. The results of these tests should indicate one of three conditions:

1. **Good diode:** Will have a much greater resistance in one direction than the other. Typical reverse biased resistance will be 30,000 ohms or greater, while forward biased resistance will be less than 10 ohms. The battery light tester will have the light "on" in one direction and "off" in the other.
2. **Shorted condition:** Ohmmeter reading will be zero, or very low in both directions. The continuity tester will have the light "on" in both directions.
3. **Open condition:** Ohmmeter will have a maximum (infinity) reading in both directions. Continuity tester light will be off in both directions.

Diode failure after a 25 hour "run in" period is generally traceable to external causes such as a lightning strike, reverse current, line voltage spikes, etc. All 8 diodes are essentially in the same circuit. When a diode is stressed to failure, there is no easy method to determine remaining life in the other diodes. To avoid possible continued failures, it is recommended that the entire rectifier assembly be replaced rather than replacing individual diodes.

SERVICE

GENERAL

The service procedures given in this section are those which can reasonably be conducted on-site with a minimum number of special tools and equipment. All service procedures should be conducted by qualified maintenance personnel. Replacement parts may be ordered through an authorized service center or directly from the factory.

FIELD FLASHING

Restoring Residual Magnetism
(not applicable on PMG equipped generators)

To restore residual magnetism to the generator, connect a 12 volt battery to the exciter field while the generator using the following procedure:

1. Shutdown the generator set. Remove the exciter field leads F+ and F- from the regulator.

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Failure to remove the exciter field leads from the automatic voltage regulator during flashing procedures may destroy the regulator.

2. Connect the F+ and F- leads to the battery's corresponding positive and negative terminals. This should be done using an appropriate length of lead wire to separate the battery from the point of connection (batteries may explode when exposed to an electric arc). After 3 to 5 seconds, remove the F- lead. An inductive arc should result. If no arc is drawn, repeat the procedure.
3. Reconnect the F+ and F- leads to the regulator. Restart the generator and verify that terminal voltage is developed. If terminal voltage does not develop, repeat the field flashing procedure and / or consult the trouble shooting section.

BEARING REMOVAL

Prior to performing this operation, it is suggested that the alternator's shaft be rotated until two of the main rotor poles are in a vertical position. Once the bearing bracket is backed out, the rotor will drop on the main stator core. Having the rotor in this position will limit the amount of rotor drop to that of the air gap. Visually inspect the bearing bore for damage or wear. If worn or damaged, replace prior to reassembly.

Opposite Drive End Bearing Bracket Removal.

Prior to proceeding with bracket removal, disconnect exciter field leads F+ and F- from the automatic voltage regulator and ensure that they are free to move when the bearing bracket is removed. Remove the bearing bracket retaining bolts. Using a pair of screw drivers, wedge the bracket off the frame. After approximately 1/8 inch, the bracket will clear the locating register on the frame and will drop until the rotor is resting on the main stator core. Continue to pull the bracket free from the bearing. Visually inspect the bearing bore and o-ring (if equipped) for damage or wear. If worn or damaged, repair or replace prior to reassembly.

Drive End Bearing Bracket Removal, Two Bearing Units.

Remove any drive arrangement from the generator shaft extension. Remove the bearing lock ring retaining screws. There is no o-ring in the drive end bearing bracket. The shaft extension must be supported before proceeding further. A hoist and sling, jack, or some other means of support with a capacity of 2 tons should be used.

Remove the bearing bracket retaining cap screws. Using a flat bladed screw driver or chisel, pry the bracket back from the frame. After approximately 1/8 inch, the bracket will clear the locating register on the frame. Lower the shaft extension until the rotor is resting on the main stator core. Continue to pull the bracket free from the bearing. Visually inspect the bearing bore for damage or wear. If worn or damaged, sleeve or replace prior to reassembly.

Reassembly note: Before the bearing bracket is seated against the frame, a threaded rod may be used to help align the inner bearing cap with the bearing bracket.

BEARING REPLACEMENT

Using a bearing puller, remove the existing bearing. It is strongly recommended that the bearing be replaced any time the it is removed from the shaft. **ALWAYS** install the same type and size bearing that was supplied as original equipment. Order by part number from the parts list, and include the unit serial number and part number when ordering. Heat the bearing to a maximum of 100°C (212°F) in an oven. Apply a thin coat of clean lubricating oil to the press fit area of the rotor shaft. Using suitable heat resistant gloves, install the bearing over the end of the shaft until it seats against the shaft shoulder. The bearing should slide on the shaft and be seated without excessive force. Should the bearing bind on the shaft prior to being seated against the shoulder, a piece of tubing slightly larger than the press fit area can be used to drive the bearing to its final position. Using light taps with a soft mallet, apply pressure to the inner race only.

RECTIFIER ASSEMBLY REMOVAL

The rectifier assembly cannot be removed until the opposite drive end bearing bracket and bearing have been removed (see bearing removal procedure). Remove the three exciter rotor leads from the heat sinks and the two main rotor leads from the main rotor posts (see Figures 5). Remove the screws securing the rectifier assembly and pull the assembly free from the shaft.

DIODE REPLACEMENT

Prior to installing a replacement diode on the heat sink, apply a thin film of conductive heat sink compound around the base of the diode (do not coat the threads). When installing a diode on the heat sink, care should be taken not to over torque the retaining nut which could cause damage to the device. Torque to 28 pound inches. If not damaged, the existing diode lead wire may be unsoldered from the failed diode, and resoldered on the replacement.

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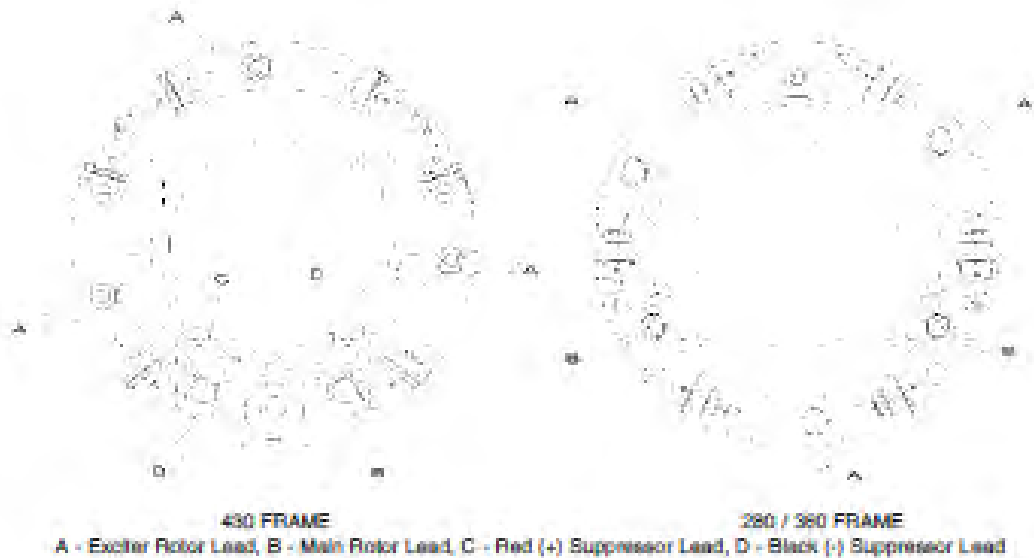


FIGURE 5: ROTATING RECTIFIER ASSEMBLY

RETURNED GOODS

Contact Marathon Electric Manufacturing Corporation for authorization before returning any product. We can not be responsible for any items returned without authorization.

CAUTION

Single bearing generators must have their rotor assembly properly secured to prevent damage during transit to the factory, or to an authorized service center.

TROUBLESHOOTING

This section is intended to suggest a systematic approach to locating and correcting generator malfunctions. The section is arranged according to the symptoms of the problem. The steps have been arranged in an attempt to do the easy checks first and prevent further damage when troubleshooting a disabled machine.

The first step of troubleshooting is to gather as much information as is possible from operating personnel and individuals present during the failure. Typical information includes: how long the unit had been operating; what loads were on line; weather conditions; protective equipment that did or did not function. In addition, information as to the operating condition of the generator's prime mover is vital. Has the prime mover been maintaining constant speed? If not, have there been extended periods of under speed operation? Has the prime mover experienced an over-speed condition? If yes, what was the maximum speed, and how long did the unit operate at that elevated speed?

The generator speed should be maintained at rated nameplate value during all operating tests. The frequency of the generator depends upon rotational speed. Most regulators used with MagnaPLUS[®] generators have built in under frequency protection such that if the speed is reduced more than 5%, the voltage will drop off rather rapidly with further reductions in speed.

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HIGH VOLTAGES MAY BE PRESENT AT THE GENERATOR'S TERMINALS WHEN THE UNIT IS RUNNING. SOME ACCESSORY EQUIPMENT SUCH AS SPACE HEATERS MAY BE ENERGIZED FROM AN OUTSIDE POWER SOURCE WHEN THE UNIT IS AT REST. TOOLS, EQUIPMENT, CLOTHING AND YOUR BODY MUST BE KEPT CLEAR OF ROTATING PARTS AND ELECTRICAL CONNECTIONS. SPECIAL PRECAUTIONS MUST BE TAKEN DURING TROUBLESHOOTING SINCE PROTECTIVE COVERS AND SAFETY DEVICES MAY BE REMOVED OR DISABLED TO GAIN ACCESS AND PERFORM TESTS. BE CAREFUL. SERIOUS PERSONAL INJURY OR DEATH CAN RESULT FROM THESE HAZARDS. CONSULT QUALIFIED PERSONNEL WITH ANY QUESTIONS.

CAUSE	GENERATOR PRODUCES NO VOLTAGE CHECK AND REMEDY
Voltmeter off or defective	Check voltage with a separate meter at the generator terminals.
Incorrect or defective connections	Verify generator connections. See drawings supplied with the generator or lead connection diagrams in this manual. Inspect all wiring for loose connections, open circuits, grounds, and short circuits.
Loss of residual	Flash the field. Refer to field flashing in the service section. If the generator is equipped with a PMG, field flashing is not necessary – check regulator fuse and input power from the PMG.
Defective diodes, suppressor, or windings	Test the generator using the 12 volt battery test as specified in the testing section. If the results indicate generator problems, perform insulation, continuity, and diode tests as specified in the testing section.
Regulator protection operating	Adjust regulator. Consult regulator manual.
Regulator inoperative	Adjust or replace regulator. Consult regulator manual.

CAUSE	GENERATOR PRODUCES LOW VOLTAGE, NO LOAD CHECK AND REMEDY
Underspeed operation	Check speed using a tachometer or frequency meter.
Voltmeter off or defective	Check voltage with a separate meter at the generator terminals.
Incorrect or defective connections	Verify generator connections. See drawings supplied with the generator or lead connection diagrams in this manual. Inspect all wiring for grounds, open circuits and short circuits.
Loss of regulator power	Check regulator fuse and input power. Input power is produced by the generator's residual voltage or from an optional PMG.
Regulator adjustment	Adjust regulator settings. Consult regulator manual.
Regulator incorrectly connected	Review the generator connection diagram or reference the regulator manual.
Defective diodes, suppressor, or windings	Test the generator using the 12 volt battery test as specified in the testing section. If the results indicate generator problems, perform insulation, continuity, and diode tests as specified in the testing section.
Regulator inoperative	Adjust or replace regulator. Consult regulator manual.

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GENERATOR PRODUCES LOW VOLTAGE WHEN LOAD APPLIED

CAUSE	CHECK AND REMEDY
Excessive load	Reduce load. The load on each leg should be evenly balanced, and rated current should not be exceeded on any leg.
Large motor starting or low load power factor	Motor starting currents are too large for the generator. When starting multiple motors, sequence the motors and start the largest motors first. Reduce lagging power factor load.
Driver speed droop or belt slip	Check driver. If belt driven, check belt tension. Check under frequency setting on regulator. Under frequency voltage roll-off may be activated.
Reactive droop	If the generator is equipped for parallel operation, some droop is normal as reactive load increases. When operating as a single unit, the parallel CT can be shorted to eliminate this effect. Refer to Regulator manual.
Line drop	If voltage is proper at generator terminals but low at load terminals, increase external wire size.
Defective diodes, suppressor, or windings	Test the generator using the 12 volt battery test as specified in the testing section. If the results indicate generator problems, perform insulation, continuity, and diode tests as specified in the testing section.

GENERATOR PRODUCES FLUCTUATING VOLTAGE

CAUSE	CHECK AND REMEDY
Fluctuating engine speed	Check engine and governor systems for malfunctions. Check load for fluctuation.
Regulator stability	Adjust Regulator stability. Refer to Regulator manual.
Regulator external rheostat	Replace defective or worn rheostat. Use shielded cable to minimize electrical noise.
Defective rectifier assembly	Check assembly for loose connections. Test the diodes as specified in the test section.
Loose terminal or load connections	Improve connections both mechanically and electrically.
Defective regulator	Replace regulator.

GENERATOR PRODUCES HIGH VOLTAGE

CAUSE	CHECK AND REMEDY
Faulty metering	Check voltage with separate meter at generator terminals.
Incorrect connections	Verify generator connections. Refer to drawings supplied with the generator or connection diagrams in this manual.
Regulator adjustments	Adjust regulator. Consult regulator manual.
Leading power factor	Check the power factor of the load. If power factor is leading, change load configuration. Excessive leading power factor (capacitors) can cause voltage to climb out of control.
Incorrect regulator connection	Verify regulator voltage sensing is connected correctly. Consult regulator manual.
Defective regulator	Replace regulator.

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GENERATOR BUILDS VOLTAGE FROM STARTUP, THEN GOES TO LOW (RESIDUAL) VOLTAGE

CAUSE	CHECK AND REMEDY
Regulator protective circuit operating	Check indicators on regulator. Correct problems and adjust regulator as is required. Refer to regulator manual.

GENERATOR IS OVERHEATING

CAUSE	CHECK AND REMEDY
Generator is overloaded	Reduce load. Check with ammeter and compare with nameplate rating.
Clogged ventilating screens	Clean air passages.
High room temperature or altitude	Improve ventilation or reduce load.
Insufficient circulation of cooling air	Generator location and enclosure design must provide adequate air flow and minimize recirculation of hot air.
Unbalanced load	The load on each leg should be as evenly balanced as possible and should not exceed rated current on any one leg.

GENERATOR PRODUCES MECHANICAL NOISE

CAUSE	CHECK AND REMEDY
Defective bearing	Replace bearing.
Loose or misaligned coupling	Tighten, realign, or replace coupling.
Belt slip or loose guards	Check belt tensioning. Check belt guard fasteners.

EQUIPMENT RUNS NORMALLY ON UTILITY POWER, BUT WILL NOT RUN ON GENERATOR SET

CAUSE	CHECK AND REMEDY
Distorted voltage waveform	Analyze load. Excessive SCR (thyristor) loading will cause distortion. Some equipment may be sensitive to distorted waveforms. Refer to Marathon Electric.
Improper generator voltage or frequency	Check name plates of devices comprising the load. Compare required voltage and frequency with that of the generator. Adjust driver speed and/or generator voltage as necessary to match generator output to load requirements.

⚠ CAUTION

Compare required voltage, frequency, and KVA with generator nameplate to ensure adequate generator capacity. If in doubt, consult Marathon Electric for information regarding generator capacity.

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SPECIFICATIONS

MODEL / FRAME SIZE	EXCITER RESISTANCE	
	STATOR	ROTOR
281, 282, 283, 284, 285, 286, 287	18.0	.120
381, 382, 383 – three phase	23.5	.120
381, 382, 383 – dedicated single phase	23.0	.135
431, 432, 433 – three phase	18.5	.120
431, 432 – dedicated single phase	18.0	.105

MODEL	GENERATOR RESISTANCE		EXCITER FIELD NO LOAD VOLTS 480 V / 60 HZ
	STATOR*	ROTOR	
281PSL1500	4.20	.400	11.0
281PSL1501	4.15	.400	11.0
281CSL1502	0.47	0.72	6.40
281PSL1502	3.20	.438	9.0
282PSL1703	1.07	0.34	14.70
282CSL1504	1.24	0.80	8.20
282PSL1704	1.07	0.34	14.70
282CSL1505	0.87	0.90	5.80
282PSL1705	0.74	0.37	14.35
283CSL1506	0.54	1.00	8.20
283PSL1706	0.45	0.40	12.95
283CSL1507	0.44	1.18	8.20
283PSL1707	0.39	0.46	11.20
284CSL1508	0.29	1.38	10.00
284PSL1708	0.27	0.52	14.18
284CSL1542	0.27	1.38	8.30
284PSL1742	0.22	0.54	14.00
285PSL1700	0.20	0.58	11.90
286PSL1701	0.14	0.72	10.58
287PSL1702	0.12	0.79	10.9
381CSL1600	.381	.750	11.8
381CSL1601	.364	.810	12.5
381CSL1602	.181	.990	14.1
382CSL1604	.138	1.05	12.2
382CSL1606	.098	1.20	10.8
383CSL1607	.089	1.37	12.2
431CSL6202	.021	.811	15.1
431CSL6204	.048	.837	13.5
431CSL6206	.037	.879	13.82
431CSL6208	.013	.715	12.20
432PSL6210	.021	.811	15.1
432PSL6212	.023	.886	14.1
432PSL6216	.012	1.087	16.2
433PSL6220	.012	.874	15.5

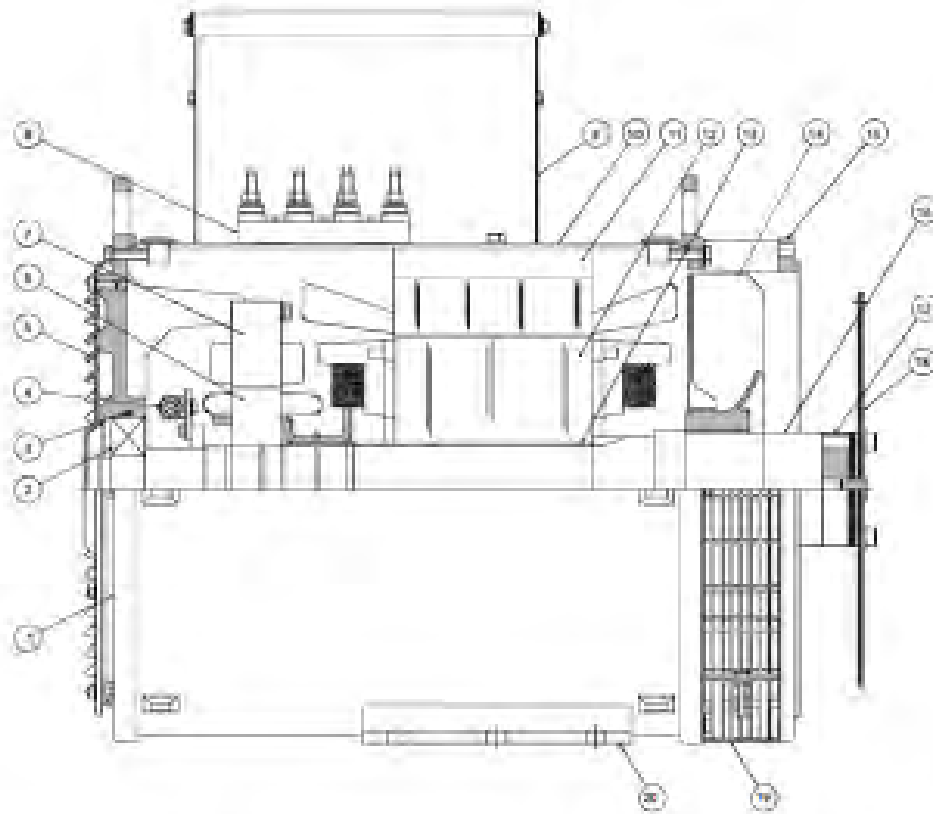
* Stator resistance measured line to line in a high wye connection.

DEDICATED SINGLE PHASE	GENERATOR RESISTANCE		EXCITER FIELD NO LOAD VOLTS 480 V / 60 HZ
	STATOR	ROTOR	
281PSL1500	4.20	.400	11.0
281CSL1512	0.47	0.72	6.4
281PSL1511	1.420	.381	8.3
281PSL1512	1.105	.385	8.1
281PSL1513	.632	.430	8.7
282CSL1515	0.21	0.82	8.2
282PSL1714	0.19	0.35	13.0
282PSL1715	0.19	0.35	13.0
282PSL1716	0.11	0.38	12.4
282CSL1517	0.08	1.14	12.7
282PSL1717	0.5	0.41	11.8
282PSL1718	0.07	0.48	10.1
284CSL1518	0.06	1.41	12.5
284CSL1550	0.05	1.48	16
284PSL1750	0.05	0.50	11.1
285PSL1711	0.04	0.58	11.0
285PSL1712	0.03	0.71	9.7
287PSL1713	0.02	0.78	12.3
381PSL1611	.070	.750	17.5
381PSL1612	.043	.857	18.1
381CSL1613	.037	.925	13.8
382CSL1615	.019	1.20	17.0
383CSL1617	.012	1.35	23.0
431PSL6222	.025	.518	9.9
431PSL6224	.013	.815	13.8
431PSL6226	.009	.840	15.1
432PSL6228	.007	.892	11.2

Marathon Magnaplug Generator

MAC800G Air Heater

PARTS LIST – SINGLE BEARING Typical Generator Cross Section



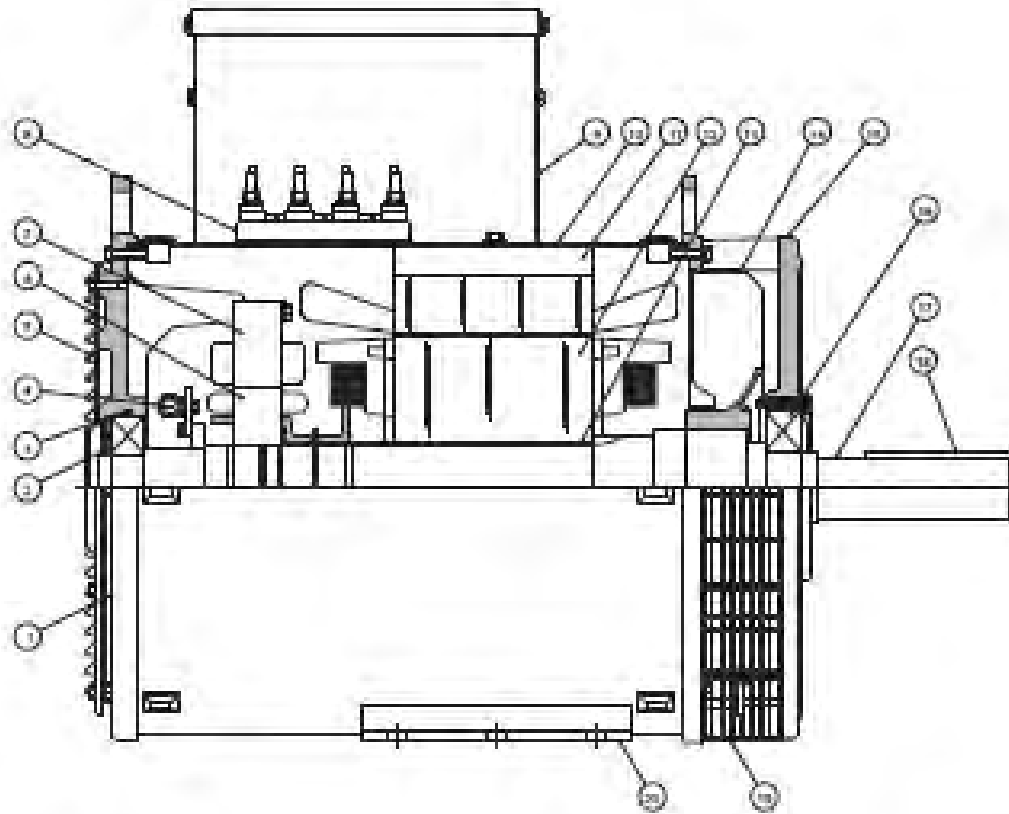
Reference Number	Part Name	Reference Number	Part Name
1	End Bracket (under and cover 360 & 430 frames)	11	Main Stator
2	Bearing	12	Main Rotor
3	O-ring (280 and 360 frame only)	13	Rotor Integral Keyway
4	Rectifier Assembly	14	Fan
5	Air Intake Cover	15	Mounting Adapter (SAE)
6	Exciter Rotor	16	Shaft
7	Exciter Stator	17	Drive Hub
8	Link Board (terminal block)	18	Drive Disk (SAE)
9	Conduit Box	19	Exhaust Screen (drip cover not shown)
10	Generator Frame	20	Mounting Base

Note: Illustration above is a 360 frame MagnaPLUS®. Other Frame sizes are typical. Optional PMG not shown. The generator model and serial numbers are required when ordering parts.

Marathon Magnaplug Generator

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PARTS LIST – DUAL BEARING Typical Generator Cross Section



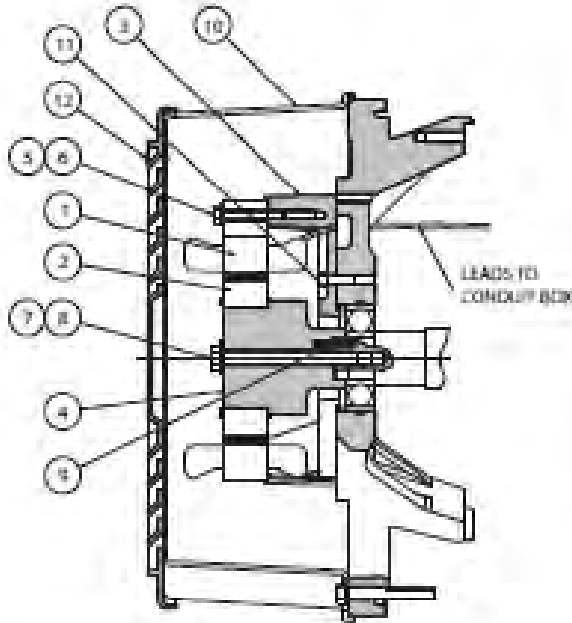
Reference Number	Part Name	Reference Number	Part Name
1	End Bracket (under end cover 380 & 430 frames)	11	Main Stator
2	Bearing (non-drive end)	12	Main Rotor
3	O-ring (280 and 380 frame only)	13	Flange Integral Keyway
4	Rectifier Assembly	14	Fan
5	Air Intake Cover	15	End Bracket (drive end)
6	Exciter Rotor	16	Bearing (drive end)
7	Exciter Stator	17	Shaft
8	Link Board (terminal block)	18	Key
9	Conduit Box	19	Exhaust Screen (DIP cover not shown)
10	Generator Frame	20	Mounting Base

Note: Illustration above is a 380 frame MagnaPLUS®. Other Frame sizes are typical. Optional PMG not shown. The generator model and serial numbers are required when ordering parts.

Marathon Magnaplug Generator

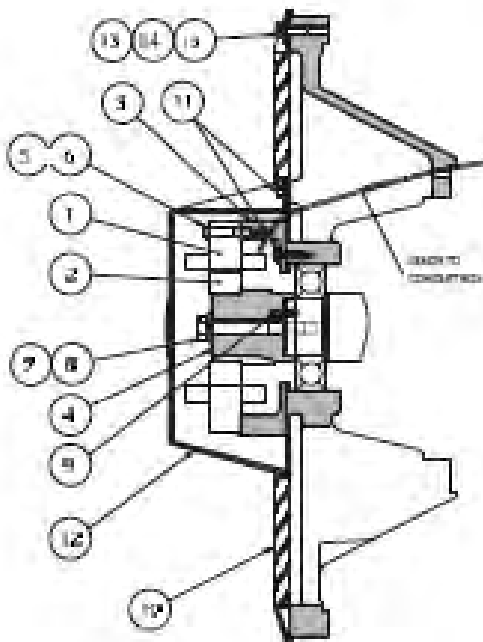
MAC800G Air Heater

PARTS LIST – PMG GENERATORS



Typical 280 and 360 Frame Add-On PMG

Item	Description	Qty
1	PMG Stator Assembly	1
2	PMG Rotor Assembly	1
3	Stator Adaptor	1
4	Shaft, PMG rotor	1
5	Screw, Hex Hd Fg Lock 1/4 - 20	4
6	Washer, Belleville - 1/4	4
7	Hex Hd Cap Screw, 1/2 - 13 x 4"	1
8	Washer, Belleville - 1/2	4
9	Roll Pin 0.25 x .88	1
10	Drip Cover - PMG Add-on	1
11	Screw, Hex Hd Fg Lock 1/4-20	4
12	Pushpin	4



Typical 430 Frame Add-On PMG

Item	Description	Qty
1	PMG Stator Assembly	1
2	PMG Rotor Assembly	1
3	Stator Adaptor	1
4	Shaft, PMG rotor	1
5	Screw, Hex Hd Fg Lock 1/4 - 20	4
6	Washer, Belleville, 1/4	4
7	Hex Hd Cap Screw, 1/2 - 13 x 4"	1
8	Washer, Belleville, 1/2	1
9	Roll Pin 0.25 x .88	1
10	Air Intake - PMG Add-on	1
11	Screw, Hex Hd Fg Lock 1/4 - 20	4
12	PMG Cover	1
13	Hex Hd Cap Screw, 3/8 - 16	6
14	Washer, flat - 3/8	6
15	Washer, split lock - 3/8	6

THERMOSTAT CONTROL

1. Press and hold "**MENU**" until the display changes to "**SP**".
2. Press "**UP**" or "**DOWN**" arrows to reach desired function.
 - a. "**SP**" – Set Point Temperature
 - b. "**DIF**" – Differential

Example: SP – 180 degrees – DIF – 10 degrees.

Temperature rises to 180 degrees, burner shuts off, it cools down 10 degrees to 170 degrees and the burner comes back on.

3. Press "**MENU**" to display functions current value.
4. Press "**UP**" or "**DOWN**" arrows until desired value is reached.
5. Press "**MENU**" to SAVE new value. Display returns to sensor temperature.

IMPORTANT: If "**MENU**" is not pressed after changing the settings, the new settings are **NOT** saved.

Temperature Control

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A419 Series Electronic Temperature Controls with Display and NEMA 1 or NEMA 4X Watertight Enclosures

The A419 series controls are single-stage, electronic temperature controls with a Single-Pole, Double-Throw (SPDT) output relay. They feature a lockable front-panel touchpad for setup and adjustment, and a Liquid Crystal Display (LCD) for viewing the temperature and status of other functions. A Light-Emitting Diode (LED) indicates the controls' output relay On/Off status. The A419 controls are available in 24 VAC or 120/240 VAC powered models.

The A419 controls have heating and cooling modes, adjustable setpoint and differential, an adjustable anti-short cycle delay, and a temperature offset function. The setpoint range is -30 to 212°F (-34 to 100°C). The controls feature remote sensing capability and interchangeable sensors. The A419 controls are available in either NEMA 1, high-impact plastic enclosure suitable for surface or DIN rail mounting or NEMA 4X watertight, corrosion-resistant surface-mount enclosures.



Figure 1: A419 Temperature Control with NEMA 1 Enclosure and A39 Temperature Sensor

Features and Benefits	
Easy-to-Read Front-Panel Liquid Crystal Display	Displays the sensed temperature and control-function status clearly; custom icons on the display indicate the control and system status at a glance
Wide Temperature Differential Adjustment Range (1 to 30F° or C°)	Allows the user to set a precise (1F° or C°) temperature differential from 1 to 30F° or C°; providing a much tighter differential than electromechanical controls
Adjustable Anti-Short Cycle Delay (0 to 12 Minutes in 1-Minute Increments)	Ensures that the output relay remains off for a user-set time delay, which helps avoid hard starts, nuisance overload outages, and unnecessary equipment wear
Switch-Activated Temperature Offset Function	Allows the user to shift the cut-in and cutout setpoints by an adjustable offset based on the status of a user-installed, external switch, such as a time clock
High-Impact, Thermoplastic NEMA 1 or NEMA 4X Watertight, Corrosion-Resistant Enclosures	Increase application options, allowing surface and snap-fit DIN rail mount, or Watertight surface mount
Lockable Front Panel Touchpad	Allows easy set up and adjustment of the A419 control setpoint, differential, and other functions; a concealed jumper locks the touchpad, and deters unauthorized adjustment of the control settings
Low- and Line-Voltage Models	Provide options for most refrigeration and HVAC control-voltage applications

Temperature Control

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Application

IMPORTANT: The A419 Series Temperature Controls are intended to control equipment under normal operating conditions. Where failure or malfunction of an A419 Series Control could lead to an abnormal operating condition that could cause personal injury or damage to the equipment or other property, other devices (limit or safety controls) or systems (alarm or supervisory) intended to warn of or protect against failure or malfunction of the A419 Series Control must be incorporated into and maintained as part of the control system.

The A419 Electronic Temperature Control can be used to control a wide variety of single-stage refrigeration or Heating Ventilating, and Air Conditioning (HVAC) equipment. Typical applications include:

- retail store display freezers and reach-in coolers
- supermarket display cases for produce/meats
- retail store walk-in coolers and freezers
- boiler operating control (used as a thermostat)
- condenser fan cycling or staging
- cooling tower pump and fan control
- space and return air temperature control

FCC Compliance

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class A digital device pursuant to Part 15 of FCC rules. These limits are designed to provide reasonable protection against harmful interference when this equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his or her own expense.

Canadian Compliance Statement

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

Dimensions

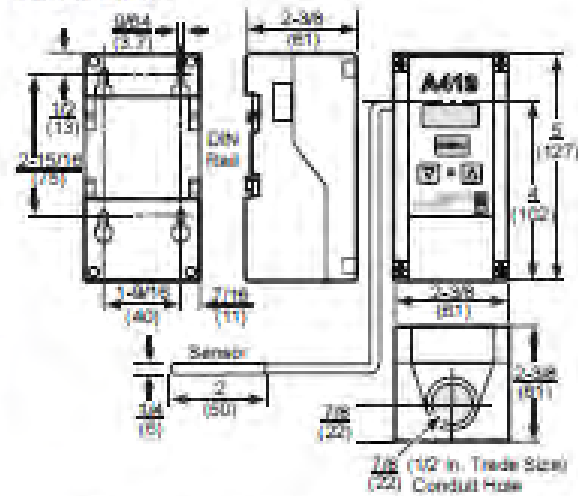


Figure 2: A419 Temperature Control with NEMA 1 Enclosure, Dimensions, in./mm

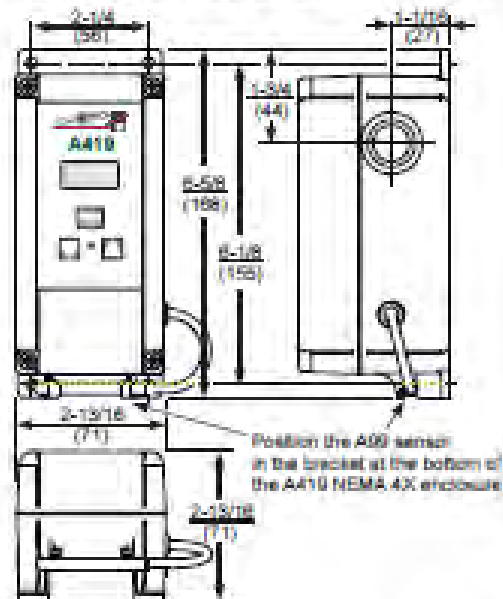


Figure 3: A419 Temperature Control with NEMA 4X Watertight, Corrosion-resistant Enclosure, Dimensions, in./mm

Temperature Control

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Figure 4: A419 Temperature Control with NEMA 4X Enclosure and A99 Temperature Sensor

Operation Overview

The A419 control's front-panel, LCD, LED, and the A419 control functions are described below. See the Adjustments section for instructions on setting up and adjusting the A419 control.

A419 Control Front-Panel

The front panel of the A419 control has a three-button touchpad and LCD for adjusting control function values, and an LED indicator that displays the On/Off status of the SPDT output relay. See Figure 5.

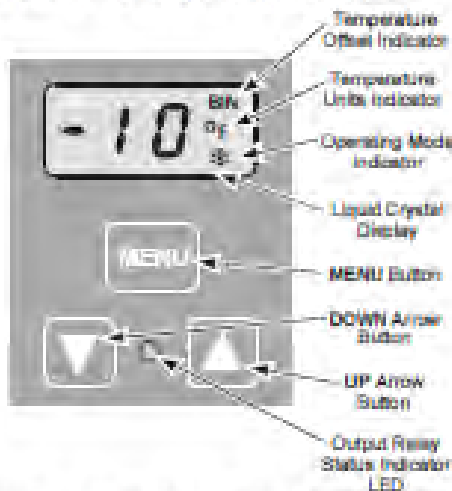


Figure 5: A419 Control Front-Panel with Display

Liquid Crystal Display

During normal operation, the LCD displays the temperature at the sensor, the units of temperature ($^{\circ}\text{F}$ or $^{\circ}\text{C}$), and an icon indicating if the control is set for Heating (\heartsuit) or Cooling (\heartsuit) mode. The LCD also displays **BN** if the Temperature Offset function is activated. See Figure 5.

During control set up or adjustment, the LCD displays the control functions and their values (settings). After 30 seconds of inactivity, the display returns to the sensed-temperature display. See the Adjustments section to adjust the control setting.

Output Relay Status Indicator LED

A green LED on the control's front panel illuminates when the SPDT output relay is energized and the Normally Open (N.O.) contacts are closed. See Figure 5.

A419 Control Definitions

Cut-In is the temperature at which the N.O. contacts on the SPDT output relay close.

Cutout is the temperature at which the N.O. contacts on the SPDT output relay open.

A419 Functions Set at the Front-Panel

Setpoint (SP) establishes the temperature value that energizes or de-energizes the output relay, depending on the user selected mode of operation. The control may be set either to cut in or to cut out at Setpoint. See the Cooling/Heating and Setpoint Modes. The Setpoint range is -30 to 212°F (-34 to 100°C).

If Setpoint mode is Cut-In, Setpoint is the temperature value that closes the N.O. contacts. If Setpoint mode is Cutout, Setpoint is the temperature value that opens the N.O. contacts. See Figure 7 and Figure 8.

Differential (dIF) establishes the difference in temperature (in $^{\circ}\text{F}$ or $^{\circ}\text{C}$) between the cut-in and cutout values. The differential is set relative to Setpoint and may be set from 1 to 30°F or $^{\circ}\text{C}$. See Figure 7 and Figure 8.

Anti-Short Cycle Delay (ASd) establishes the minimum time that the N.O. contacts remains open (after reaching cutout) before closing again. The delay overrides any Load Demand and does not allow the N.O. contacts to close until the set time-delay value has elapsed. See Figure 6. When the delay is activated, the LCD alternately flashes the sensor temperature and ASd. The delay may be set for 0 to 12 minutes in 1-minute increments.

Temperature Control

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For example, if the anti-short cycle delay is set for 7 minutes, the A419 control will not restart the equipment for 7 minutes after the equipment has cut out, even if the cut-in temperature value is reached during the delay. If the temperature reaches the cut-in value during the delay period, the display flashes between the sensed temperature and ASd, indicating that the next On-cycle is being delayed. After the set delay time has elapsed, the A419 control returns to normal operation, restarts the equipment (if cut-in has been reached), ASd stops flashing, and the LCD reverts to the normal operating display.

Note: Any Interruption in supply power to the A419 control activates the anti-short cycle delay.

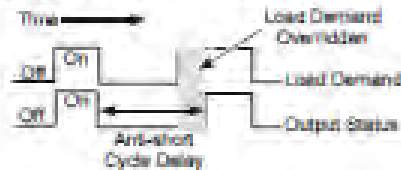


Figure 6: Anti-short Cycle Delay

Sensor Failure Operation (SF) establishes how the A419 control operates the equipment in the event of a sensor or sensor-wiring failure. The A419 control may be set to run the equipment continuously or to shut it down if the sensor or sensor wire fails. When a failure is detected the LCD flashes SF alternately with OP if the sensor circuit is open, or SF and SH if the sensor circuit is shorted. The control implements a 1-minute delay before initiating a failure response to allow for verification of the failure condition and to avoid nuisance failure indications.

Temperature Units establishes the units of temperature (F° or C°) displayed on the LCD.

Temperature Offset (OFS) establishes the value of setpoint-shift (In F° or C°) applied to Setpoint (and Differential) when a (user-installed) circuit is closed between the binary input (BIN) and common (COM) terminals. The offset value may be set from 0 to 50F° or C°.

The **Temperature Offset** function is used to reset the Heating Setpoint to a lower temperature (secondary) setpoint or reset the Cooling Setpoint to a higher temperature (secondary) setpoint by the temperature value set in Temperature Offset.

The BIN and COM terminals may be connected to a (user-supplied) external switching device, such as a time clock, that has a set of Single-Pole, Single-Throw (SPST) contacts. Closing a circuit between the BIN and COM terminals activates the Temperature Offset. See *Wiring*.

This function enables the control to alternate between two temperature setpoints based on the position of the binary input switch. The difference between the primary and secondary setpoints (In F° or C°) is set in the Temperature Offset function (OFS) using the touchpad. See *Setting Other Functions*.

Table 1 shows an example of Temperature Offset.

Table 1: Temperature Offset Example

Mode of Operation	Setpoint	Temperature Offset Value	Secondary Setpoint*
Cooling	70°	8°	78°
Heating	70°	8°	62°

* Setpoint when circuit between binary input terminals (BIN and COM) is closed

When the circuit is closed between the binary input (BIN) common (COM) terminals, the offset function is enabled and the A419 control cycles on the secondary setpoints. BIN is displayed on the LCD above the °F or °C symbol when the offset is enabled. See Figure 5.

A419 Control Functions Set by Jumper Position

For instructions on positioning jumpers, see *Positioning the Jumpers* in the *Adjustments* section. Refer to Figure 12 and Figure 13.

Touchpad Lock: The jumper at P5 establishes whether the touchpad is locked or unlocked. Locking the touchpad deters accidental or unauthorized changes to all of the function parameters.

Heating/Cooling Mode is established by positioning the jumper on the top two pins of the P4 jumper. See Figure 13.

Setpoint Mode: Removing or installing the lower jumper at P4 establishes whether Setpoint is the cut-in temperature or cutout temperature. See Figure 13.

Cooling/Heating and Setpoint Modes

The A419 control may be in four operating modes: **Cooling/Cut-In**, **Cooling/Cutout**, **Heating/Cut-In**, and **Heating/Cutout**. Position the jumpers located on the circuit board under the A419 control cover to set the desired mode of operation. See *Positioning the Jumpers*.

In **Cooling/Cut-In** mode the differential is below Setpoint. The output relay energizes and the LED illuminates when the temperature rises to Setpoint. When the temperature drops to Setpoint minus the differential value, the relay and LED de-energize.

Temperature Control

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In **Cooling/Cutout** mode the differential is above Setpoint. The output relay energizes and LED illuminates when the temperature rises to Setpoint plus the differential value. When the temperature drops to Setpoint, the relay and LED de-energize.

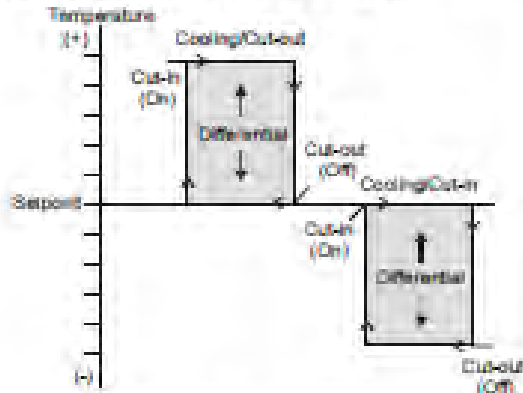


Figure 7: Cooling Modes

When the **Heating/Cut-In** mode is selected, the differential is above Setpoint. The output relay energizes and LED Indicator illuminates when the temperature drops to Setpoint. When the temperature rises to Setpoint plus the differential value, the output relay and LED de-energize.

When **Heating/Cutout** mode is selected, the differential is below Setpoint. The output relay energizes and LED Indicator illuminates when the temperature drops to Setpoint minus the differential value. When the temperature rises to Setpoint, the output relay and LED Indicator de-energize.

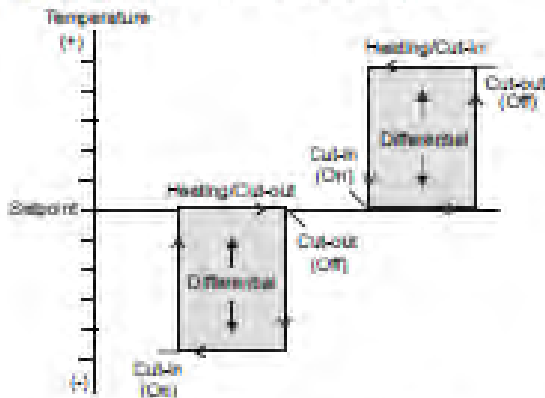


Figure 8: Heating Modes

Mounting

An A419 control has either a standard high-impact plastic NEMA 1 or a NEMA 4X corrosion-resistant, watertight enclosure.

The A419 control is not position sensitive but should be mounted for convenient wiring and adjustment.

Note: When mounting the control to rigid conduit, attach the hub to the conduit before securing the hub to the control enclosure.

The mounting hole pattern of the NEMA 1 enclosure is identical to that of the System 350™ controls, and most models of the A19 control. The NEMA 1 enclosure may also be mounted on 35 mm DIN rail. See Figure 1 and Figure 2.

The NEMA 4X models may be mounted to flat vertical surfaces using the four screw holes at the enclosure corners. See Figure 3 and Figure 4. To maintain the watertight and corrosion resistant integrity of the NEMA 4X enclosure, use a conduit fitting rated for the environment in which the control is installed.

An additional (low-voltage) two-wire cable is required to operate the temperature offset function. On NEMA 4X enclosures you must install a suitable liquid-tight fitting in an available knockout to pass the two-wire cable through the enclosure wall.

IMPORTANT: The short-lead A99 sensor, included with A419 NEMA 4X model controls, must be mounted on the bottom of the control in the bracket molded on the NEMA 4X housing. Mounting the sensor on top of the control may reduce the accuracy of the displayed temperature. See Figure 3 and Figure 4 for proper sensor position.

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Wiring

WARNING: Risk of Electrical Shock.
To avoid the risk of electrical shock, disconnect all power sources to the control before wiring any connections. More than one disconnect may be required to completely de-energize the control and equipment.

IMPORTANT: All wiring must conform to local, national, and regional regulations. Use copper conductors only for all wire connections. Do not exceed the electrical ratings for the A419 control or the equipment it is wired to.

Refer to Figure 9, Figure 10, and Figure 11 for typical examples of wiring an A419 control to the controlled equipment.

Use wire no larger than 12 AWG when connecting to the two lower terminal blocks (TB1 and TB2).

Note: Terminal block TB2 is an isolated SPDT switch (dry contacts). The TB2 terminals have no internal electrical connection to the A419 control.

Use wire no larger than 16 AWG when connecting to the upper sensor terminal block (TB3).

Wire insulation rating must be 90°C, minimum.

A99 temperature sensors are not polarity sensitive. Wire the leads to (+) SEN and (-) COM on the sensor terminal block (TB3). See Figure 9, Figure 10, and Figure 11.

Keep the leads between the control and sensor as short as possible/practical in your application. The additional resistance in long sensor leads creates error between the actual temperature and the displayed temperature. Refer to Table 1 when extending sensor leads.

Temperature sensor signals may be affected by electrical interference. When extending sensor cable beyond 50 ft (15.2 m) use a twisted-pair, shielded cable to reduce electrical interference.

If the Temperature Offset function is used, wire a switch (such as a switching time clock) between the binary input terminal (BIN) and the common terminal (COM). See Figure 9, Figure 10, and Figure 11 for terminal strip location.

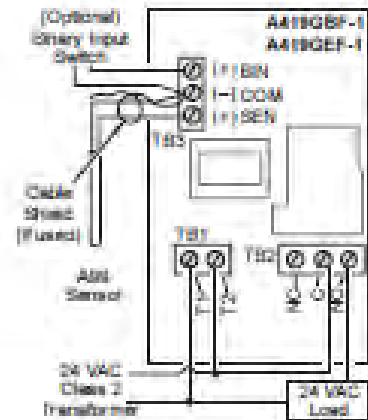


Figure 9: Wiring the 24 VAC A419 Control

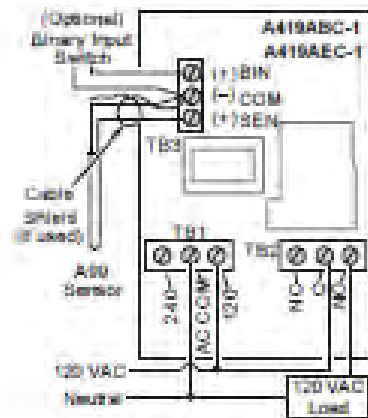


Figure 10: Wiring the 120 VAC A419 Control

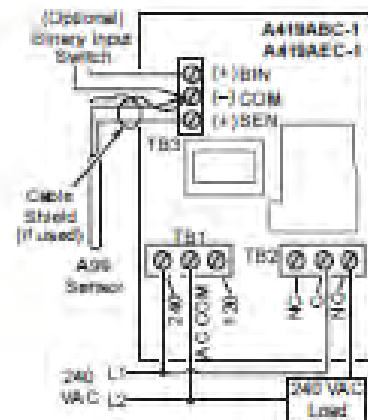


Figure 11: Wiring the 240 VAC A419 Control

Temperature Control

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Adjustments

This section provides instructions for setting up and adjusting the A419 controls using the jumpers and touchpad.

Positioning the Jumpers

The P5 Jumper Pin Block has a single set of jumper pins and is used to lock or unlock the touchpad. The P4 Jumper Pin Block has two sets of jumper pins.

The top set of pins at P4, labeled JUMP1, is used to set the control for Heating or Cooling mode. The bottom set of pins, labeled JUMP2, is used to establish Setpoint at cut-in or at cutout. See Figure 12.

To position a jumper in the Installed position, place the jumper on both pins. To position a jumper in the Removed position, place the jumper on only one pin. (Save the jumper in case it is required in the future.) See Figure 12.

Position the jumpers as follows. Refer to Figure 12, Figure 13, and Table 2.

1. Verify that all power sources to the A419 control have been disconnected.
2. Remove the control's cover by loosening the four captive cover screws.
3. Position the jumpers to set Cooling/Heating, Setpoint, and Touchpad Lock functions.
4. Replace the cover and fasten in place with the four screws.
5. Restore power to the control.

IMPORTANT: Verify that the Cooling/Heating jumper is positioned properly before powering the A419 control, to ensure that the relay operates as intended. See Figure 13 and Table 2.

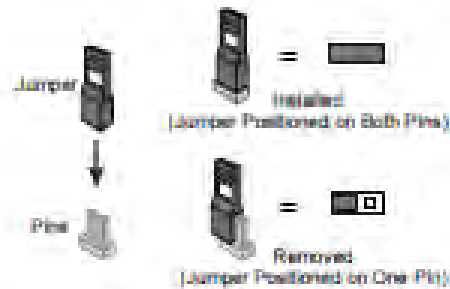


Figure 12: Positioning the Jumpers

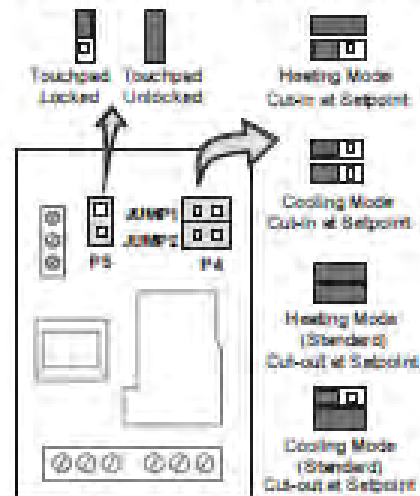


Figure 13: Jumper Positions and Control Settings

Table 2: Jumper Designations, Jumper Positions and Control Settings

Function	Jumper Pins Designation on Control	Setting	Jumper Position*	Factory Default Setting (and Jumper Position)
Operating Mode Cooling/Heating	JUMP1 (Top Pair of Pins on Block P4)	Cooling	Removed	Cooling (Removed position)
		Heating	Installed	
Setpoint	JUMP2 (Bottom Pair of Pins on Block P4)	At Cut-In	Removed	Cut-In (Removed Position)
		At Cut-out	Installed	
Touchpad Lock	P5-Touchpad Unlock	Locked	Removed	Unlocked (Installed Position)
		Unlocked	Installed	

Note: The touchpad cannot be unlocked without a jumper. Do not discard any jumpers in case they are required in the future.

Temperature Control

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Changing Temperature Units

The A419 control is set at the factory to display in Fahrenheit temperature units.



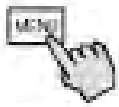
To convert to Celsius units, press the Up and Down buttons simultaneously. Press them again to return to Fahrenheit units.

Notes: Make sure the Touchpad Lock jumper is in the unlocked (Installed) position before adjusting the control. See Figure 13.

Verify that the A419 control is displaying the desired temperature units (F° or C°) before establishing the setpoint value.

Setting the Setpoint

To view and adjust the temperature setpoint, follow these steps and refer to Table 3:



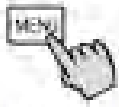
1. Press and hold the **MENU** button until the display changes to flashing **SP**. This will take about 2 seconds.



2. Press the **MENU** button again. The current setpoint is displayed.



3. Press the **Up** or **Down** button to adjust the setpoint temperature.



4. Press the **MENU** button to save. The display then returns to the sensor temperature.

Notes: If no entries are made for 30 seconds while programming is in progress, the control reverts to the normal temperature display.

If the **MENU** button is not pressed after changing the setpoint value, the new value is not saved and the A419 control reverts to the previously saved setpoint value.

Any saved A419 control setting values are non-volatile and remain in the control's memory during power interruptions.

Table 3: Function Ranges and Settings

Function	Range	Factory Setting
SP: setpoint	-30 to 212°F (-34 to 100°C)	30
dIF: Differential	1 to 30° (F or C)	5
ASd: Anti-short Cycle Delay	0 to 12 minutes	1
OFS: Temperature Offset	0 to 50° (F or C)	0
SF: Sensor Failure Operation	0 = output de-energized 1 = output energized	1

Operation at Extremes: If the combination of setpoint plus or minus the differential falls outside the temperature range (-30 to 212°F [-34° to 100°C]), the A419 control operates as follows:

Cooling/Cut-In: If the control is operating in Cooling/Cut-In mode and setpoint minus differential is less than -30°F, the control switches on at setpoint and off when the temperature drops below -30°F (-34°C).

Heating/Cut-In: If the control is operating in Heating/Cut-In mode and setpoint plus differential is greater than 212°F (100°C), the control switches on at setpoint and off when the temperature exceeds 212°F (100°C).

Cooling/Cutout: If the control is operating in Cooling/Cutout mode and setpoint plus differential is greater than 212°F (100°C), the control switches on when the temperature exceeds 212°F (100°C) and off at setpoint.

Heating/Cutout: If the control is operating in Heating/Cutout mode and setpoint minus differential is less than -30°F (-34°C), the control switches on when the temperature drops below -30°F (-34°C) and off at setpoint.

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Setting Other Functions

To set the Differential (dIF), Anti-short Cycle Delay (ASd), Temperature Offset (OFS), or Sensor Failure (Sf) operation, use the method illustrated and outlined below.

Figure 14 illustrates the order of functions shown using the Up or Down button. The Up button accesses functions in the clockwise direction; the Down button accesses functions in the counterclockwise direction. Refer to Table 3 for function ranges and factory settings.

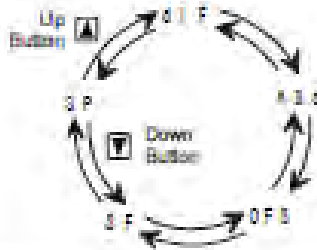


Figure 14: Order of the Functions



1. Press and hold the MENU button until the display changes to flashing SP. This will take about 2 seconds.



2. Press the Up or Down button repeatedly until the desired function is displayed. See Table 3.



3. Press the MENU button to display the function's current value.



4. Press the Up or Down button until the desired value is displayed.



5. Press the MENU button to save the new value. The display then returns to the sensor temperature.

Notes: If no entries are made for 30 seconds while programming is in progress, the control reverts to the normal temperature display.

If the MENU button is not pressed after setting a new value, the new value is not saved and the A419 control reverts to the previously saved value for that function.

Any saved A419 control setting values are non-volatile and remain in the control's memory during power interruptions.

Checkout

Before applying power, make sure installation and wiring connections are according to job specifications. After necessary adjustments and electrical connections have been made, put the system in operation and observe the control for at least three complete operating cycles before leaving the installation.

Troubleshooting

If the control system does not function properly, verify that the unit is wired, configured, and set properly. If the problem persists, use the following procedures to determine the cause of the problem:

1. Check for proper supply voltage to the A419 control.
 - a. Remove the cover by loosening the four captive cover screws.



WARNING: Risk of Electrical Shock.

High voltages may be present at electrical terminals and other exposed internal metal surfaces. Avoid contact with all metal surfaces on control when cover is removed.

- b. Use a reliable AC voltmeter to check the voltage between the COM and 120V or 240V terminals on line voltage models and the two 24V terminals on low-voltage models. Refer to Figure 9, Figure 10, and Figure 11.
- c. The voltage must be between: 20 and 30 VAC for 24 volt applications, 102 and 132 VAC for 120 volt applications, 177 and 264 VAC for 208/240 volt applications

Notes: If the voltage reading is within the required range, proceed to Step 2.

If the voltage reading is not within the required range, check the power source and input power wires for problems.

Temperature Control

MAC800G Air Heater

2. Check for proper sensor operation.

Disconnect all power sources to control.

- a. Take a temperature reading at the sensor location, using an accurate thermometer.
- b. Disconnect the sensor from the control.
- c. Use a reliable ohmmeter, to measure the resistance across the two sensor leads while the sensor is at the temperature taken in Step b.
- d. Refer to Figure 15 to verify that the measured temperature and resistance conform to established temperature and resistance values.
- e. If the measured values conform to the values in Figure 15, proceed to Step 3.
- f. If the sensor's measured resistance value is substantially different from the expected value for that temperature, check the sensor wiring. If sensor wiring is okay, replace the sensor.

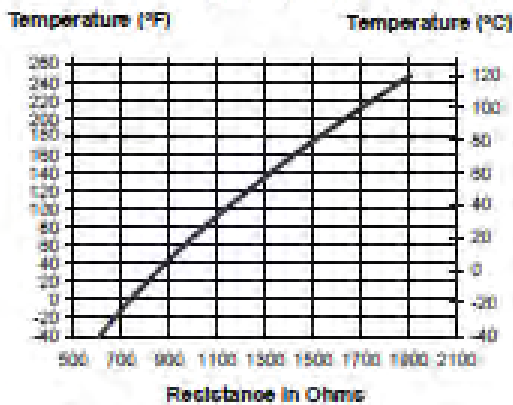


Figure 15: Nominal Temperature vs. Sensor Resistance

3. Check the A419 for proper operation.

- a. Perform Troubleshooting Steps 1 and 2 before performing this step.
- b. Disconnect the load from the output relay terminals.
- c. Ensure that the Touchpad Lock Jumper is installed, so that the touchpad is unlocked.
- d. Reconnect the sensor leads and supply power to the control.
- e. Replace the cover.
- f. Check the control settings for proper values.

g. Press and hold the MENU button until Setpoint appears (occurs in about 2 seconds).

h. Use the Up and Down buttons to change the Setpoint temperature above and below the current sensor temperature until the output relay energizes and de-energizes as shown in Table 4.

If the anti-short cycle delay has a time greater than 0 minutes, the relay will not energize until the timed delay has elapsed.

i. If the output relay does not perform as indicated in Table 4, replace the A419 control.

j. If proper operation of the A419 control is verified, reconnect the load and consult the equipment manufacturer's instructions for troubleshooting the controlled equipment.

Table 4: A419 Output Relay Operation

Setpoint Mode	Operating Mode	Output Relay Energized at...	Output Relay De-energized at...
Cutout	Cooling	Setpoint plus differential	Setpoint
	Heating	Setpoint minus differential	Setpoint
Cut-in	Cooling	Setpoint	Setpoint minus differential
	Heating	Setpoint	Setpoint plus differential

Note: When the relay is energized, the N.O. contacts are closed and the LED is illuminated.

Temperature Control

MAC800G Air Heater

Fault Codes

A419 controls are programmed to display certain fault codes on the LCD as described in Table 5.

Table 5: Fault Codes Defined

Fault Code	Definition	System Status	Solution
8F flashing alternately with 0P	Open temperature sensor or sensor wiring	Output functions according to the selected sensor failure mode (8F setting)	See Troubleshooting section. Cycle power to reset the control.
8F flashing alternately with 8H	Shorted temperature sensor or sensor wiring	Output functions according to the selected sensor failure mode (8F setting)	See Troubleshooting section. Cycle power to reset the control.
EE	Program failure	Output is off	Reset the control by pressing the Menu button. If problems persist, replace the control.

Repairs and Replacement

Do not attempt to repair or recalibrate the A419 Control. In case of a defective or improperly functioning control, contact your nearest Authorized Johnson Controls/PENNM® Distributor or Sales Representative.

When contacting your Johnson Controls/PENN distributor, have the model number of the control available. This number can be found on the label inside the cover of the control.

Ordering Information

Refer to Table 6 to order controls and accessories.

Table 6: Ordering Information

Product Code Number	Item	Description
A418ABC-1C	Line Voltage, NEMA 1 Enclosure A419 Series Electronic Temperature Control with Display, A99 Sensor Included	Supply Voltage: 120 or 240 VAC Range: -30 to 212°F (-34 to 100°C) Differential: 1 to 30F° (1 to 30C°) Sensor Lead Length: NEMA 1 Models 6-1/2 ft (2 m), NEMA 4X Models 9 in (0.25 m)
A418AEC-1C	Line Voltage, NEMA 4X Enclosure A419 Series Electronic Temperature Control with Display, A99 Sensor Included	
A418GBF-1C	24 VAC, NEMA 1 Enclosure A419 Series Electronic Temperature Control with Display, A99 Sensor Included	Supply Voltage: 24 VAC, Class 2 Range: -30 to 212°F (-34 to 100°C) Differential: 1 to 30F° (1 to 30C°) Sensor Lead Length: NEMA 1 Models 6-1/2 ft (2 m), NEMA 4X Models 9 in (0.25 m)
A418GEF-1C	24 VAC, NEMA 4X Enclosure A419 Series Electronic Temperature Control with Display, A99 Sensor Included	
A88BB-200C A88BA-200C A88BB-26C	Replacement Temperature Sensors	PTC Sensor with 6-1/2 ft (2 m) Leads PTC Sensor with 6-1/2 ft (2 m) Shielded Leads PTC Sensor with 9 in (0.25 m)
BKT287-1R BKT287-3R PLT344-1R	Accessory Mounting Hardware	12 in. (305 mm) long DIN Rail 36 in. (914 mm) long DIN Rail Two End Clamps for DIN Rail Mounting
CLK350-2C	Digital Clock	7-Day Programmable Digital Clock for controlling Temperature Offset Function
WEL11A-801R	Immersion Well	Immersion Well for applying sensor in fluid applications

Temperature Control

MAC800G Air Heater

Technical Specifications

Product	A419 Series Electronic Temperature Controls with NEMA 1 General Purpose or NEMA 4X Watertight, Corrosion-Resistant Enclosures			
Setpoint Range	-30 to 212°F (-34 to 100°C)			
Differential Range	1 to 30°F (1 to 30C°)			
Supply Voltage	24 VAC, 60 Hz, Class 2:	A419GBF-1 (NEMA 1 Enclosure Model) A419GEF-1 (NEMA 4X Watertight Enclosure Model)		
	120 or 240 VAC, 60 Hz:	A419ABC-1 (NEMA 1 Enclosure Model) A419AEC-1 (NEMA 4X Watertight Enclosure Model)		
Power Consumption	1.8 VA Maximum			
Output Relay Contacts Electrical Ratings	24 VAC Models:	A419GBF-1 (NEMA 1 Enclosure) A419GEF-1 (NEMA 4X Watertight Enclosure) 100 VA, 30 VAC maximum, Class 2		
	120/240 VAC Models:	A419ABC-1 (NEMA 1 Enclosure) A419AEC-1 (NEMA 4X Watertight Enclosure)		
	Applied Voltage:	120 VAC	208 VAC	240 VAC
	Horsepower N.O. (N.C.):	1 (0.25) hp	1 (0.33) hp	1 (0.5) hp
	Full Load Amperes N.O. (N.C.):	16 (5.8) A	9.2 (4.0) A	8.0 (4.9) A
	Locked Rotor Amperes N.O. (N.C.):	96 (34.8) A	55.2 (24) A	48 (29.4) A
	Non-inductive Amperes N.O. (N.C.):	15 (10) A	10 (10) A	10 (10) A
	Pilot Duty:	125 VA (N.O. contacts) @ 24 to 240 VAC 125 VA (N.C. contacts) @ 120 to 240 VAC 50 VA (N.C. contacts) @ 24 VAC		
Sensor Type	A99BB Type PTC Sensor (See Table 6)			
Control Ambient Temperature	Operating:	-25 to 140°F (-32 to 60°C)		
	Shipping:	-40 to 185°F (-40 to 85°C)		
Ambient Humidity	0 to 95% RH Non-condensing; Maximum Dew Point: 85°F (29°C)			
Control Material	Case and Cover:	NEMA 1 High-Impact Thermoplastic NEMA 4X Watertight, Corrosion-Resistant, High-Impact Noryl® Thermoplastic		
Agency Listings	UL: File E27734; CEN's XAPX (US), XAPX7 (Canada) FCC: CFR 47, Part 15, Class A, DOC, Class A			

The performance specifications are nominal and conform to acceptable industry standards. For application at conditions beyond these specifications, contact Application Engineering at 1-800-275-5876. Johnson Controls, Inc. shall not be liable for damages resulting from misapplication or misuse of its products.

Air Pressure Switch

MAC800G Air Heater

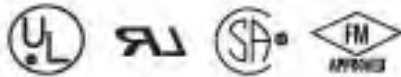


Model SMD

Antunes Controls is one of the leading manufacturers of pressure control switches. Our sheet metal air differential switches are compact, sensitive, and reliable. Their design is based on the same principles of reliability, repeatability, and accuracy that have made all of our air pressure switches so successful.

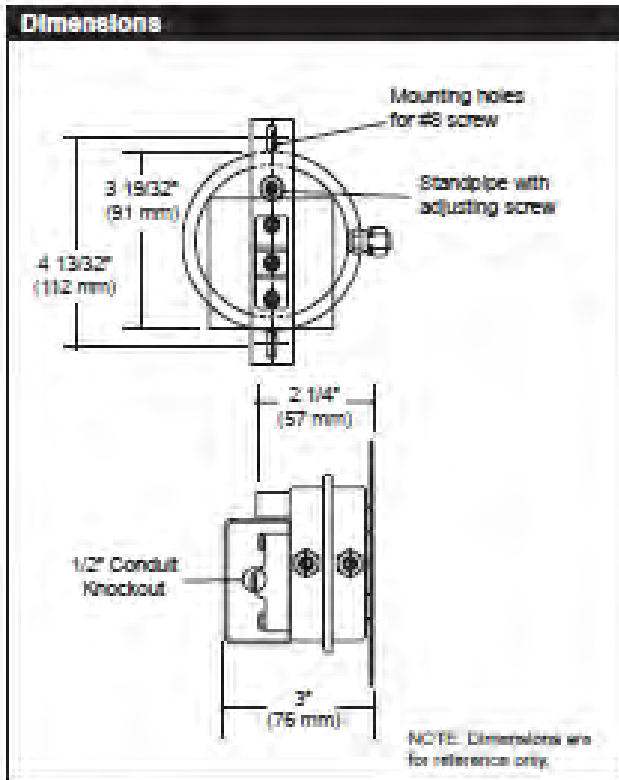
Features:

- Sensitive diaphragm.
- Snap-action electrical switch S.P.D.T rated at 10 amps.
- Industrial combustion.
- Three range scales—from .17" W.C. to a maximum of 12" W.C.
- Easy to install.
- Cost-effective pricing.



Air Pressure Switch

MAC800G Air Heater



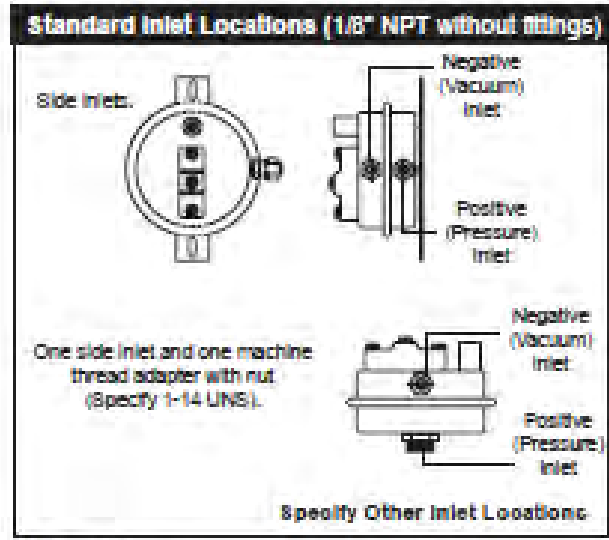
Specifications

Electrical Ratings: 10A @ 125 VAC.; 8A @ 250 VAC.; TA @ 277 VAC.; 1/8HP @ 125 VAC.; 1/4HP @ 250 VAC.
 Pilot Duty, 125 VA @ 125/277 VAC.
 Shipping Weight: 1 lb. (.45 kg)

All Models	Optional Fittings
Max. Surge Pressure: 20" W.C.	1/4" Barb
Max. Ambient Temp.: 176°F (77°C)	1/4" Tube
Max. Ambient Temp.: -40°F (-40°C)	1/4" Compression

Switch Differential @ 70° F

Differential	Operating Pressure Range
.015" to .03" W.C.	.17"-1" W.C.
5" W.C.	.17"-5" W.C.
1.0" W.C.	.17"-12" W.C.



Mounting

Standard mounting bracket is shown. For other mounting arrangements, contact factory.

Limitation of Liability: It is understood and agreed that seller's liability whether in contract, in tort, under any warranty, in negligence or otherwise, shall not exceed the return of the amount of the purchase price paid by purchaser and under no circumstances shall seller be liable for special, indirect or consequential damages. The price stated for the equipment is a consideration in limiting seller's liability. No action, regardless of form, arising out of the transactions may be brought by purchaser more than one year after the cause of action has accrued.

Air Pressure Switch

MAC800G Air Heater

SMD Installation Information

⚠ IMPORTANT ⚠

Please read these instructions carefully to assure correct installation. This equipment must be installed only by a licensed electrician who is experienced with combustion safeguard control systems and understands the functions of interlocking switches, such as gas pressure switches. Prior to being put into operation in conjunction with the combustion safeguard systems, all switches should be tested for proper range setting and proper wiring. Check piping connections and switch house for leaks with a soap bubble test. All exhaust fans and blowers should be inspected and checked for proper rotation prior to starting up.

SMD Switches

You are installing one of the finest switches of its type on the market. You will find this switch has many superior features that ensure dependable, accurate, long life operation. This switch is highly sensitive and fully approved. It is UL and CSA listed and has FM approval (optional).

Specifications

Electrical Ratings: 10A @ 125 VAC, 6A @ 250 VAC, 7A @ 277 VAC, 1/8 HP @ 125 VAC, 1/4 HP @ 250 VAC
Pilot Duty: 125 VA @ 125/277 VAC

Max. Surge Pressure: 20" W.C.

Max. Ambient Operating Temperature: 170°F (77°C)

Min. Ambient Operating Temperature: -40°F (-40°C)

Shipping Weight: 1 lbs. (.45 kg)

Optional Fittings:

1/4" Barb

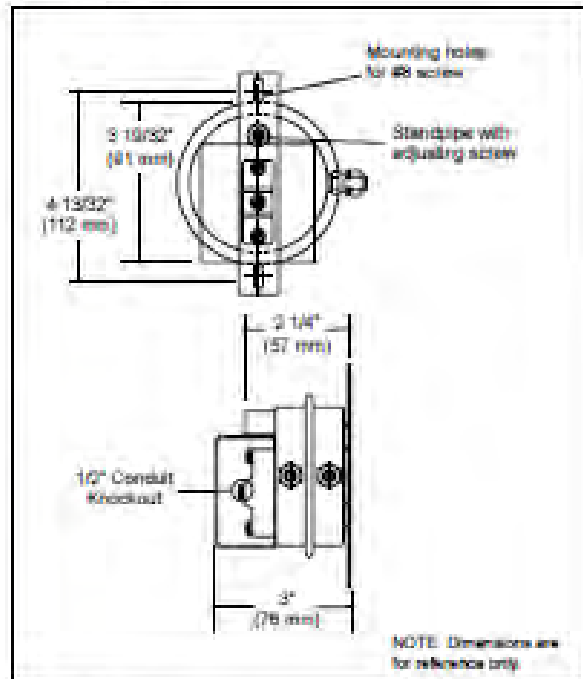
1/4" Tube

1/4" Compression

Switch Differential

Switch Differential @ 70° F	
Differential	Operating Pressure Range
.015" to .03" W.C.	.17"-.1" W.C.
.5" W.C.	.17"-.6" W.C.
1.0" W.C.	.17"-.12" W.C.

Dimensions



Installation

Models may be mounted in the horizontal or vertical position. All switches are tested at the factory in a vertical position. Mounting diaphragm in vertical position is the preferred method.

If mounting in horizontal position, the micro switch must be on top. When mounted in this position, the minimum sensitivity may be higher than that specified.

Range Adjustment

All settings are made with the diaphragm in a vertical position. The switch is shipped with the adjustment at minimum .17" W.C.

To adjust, turn adjusting screw with screwdriver. To increase pressure setting, turn adjustment screw in a clockwise direction. To decrease pressure setting, turn adjusting screw in a counterclockwise direction.

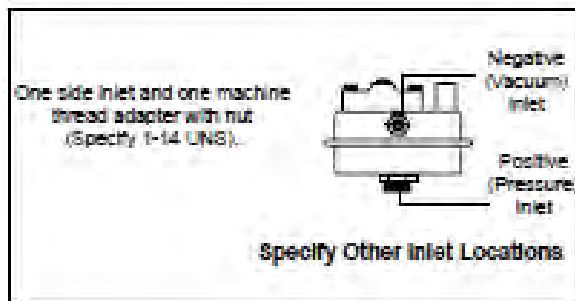
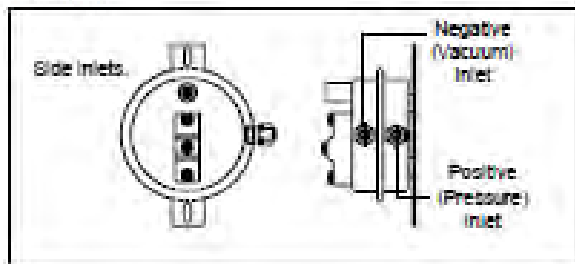
If adjusting screw is removed, apply a non-hardening pipe compound to the threads before replacing. Check for leaks with a soap bubble test using maximum 20" W.C.

Air pressure Switch

MAC800G Air Heater

SMD Installation Information

Standard Inlet Locations (1/8" NPT without fittings)

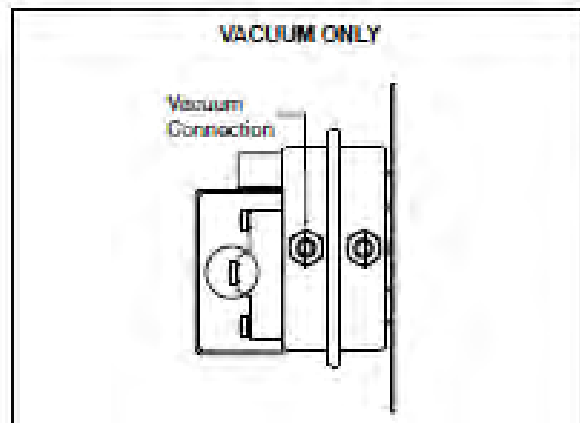
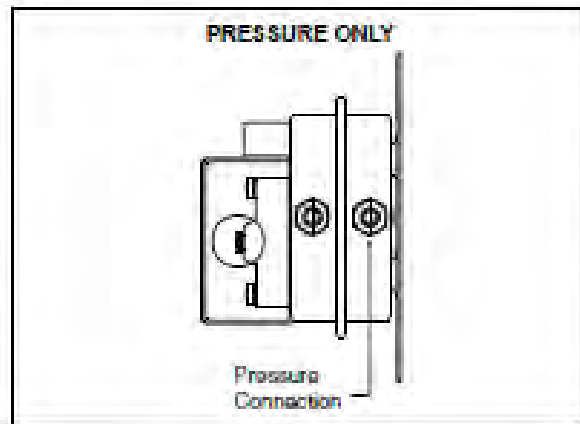
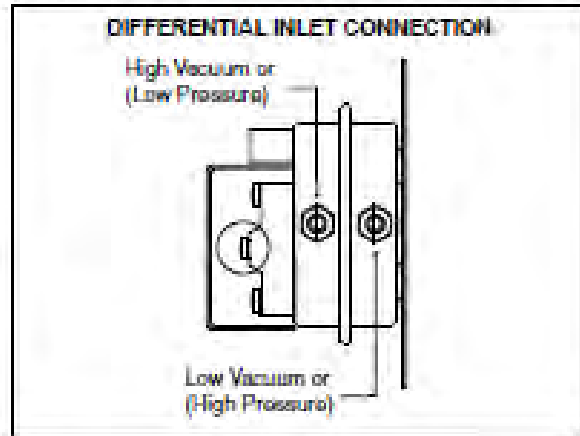


Air Connections

Tubing recommended as minimums: 1/4" copper or aluminum tubing, or 1/8" pipe. All tubing and pipe must be clean and free from oil, dirt, and chips. If piping runs over five feet long, use a larger size tubing or pipe, and reduce size at switch.

Air Supply

Should be connected as shown in the drawings below. Always leave unused ports open to the atmosphere.



Air Pressure Switch

MAC800G Air Heater

SMD Installation Information

Warranty

1. Antunes Controls products are guaranteed to be free from mechanical and electrical defects for a period of one year from date of shipment under normal use and service provided installation is made in accordance with manufacturers' recommendations.
2. Parts deemed defective shall be repaired or replaced at manufacturers option and at manufacturers expense but shall not include foreign or federal excise taxes, state or municipal sale or use taxes, all such taxes not limited to the foregoing being responsibility of the purchaser.
3. No charge for travel and/or mileage will be allowed to purchaser.
4. Antunes Controls reserves the right to make changes in design or make any improvements on any products. The right is always reserved to modify our equipment because of new technology, underwriter's requirements and/or government regulations.
5. The following are not covered under warranty:
 - a. Failure from neglect, abuse, careless handling and mis-application of unit.
 - b. Failure to observe guidelines for installation or improper voltage hook-up.
 - c. Failure caused by improper maintenance.
 - d. Unless specifically allowed by Antunes Controls, no other charges may be included under warranty.

Limitation of Liability: If it is understood and agreed that seller's liability whether in contract, in tort, under any warranty, in negligence or otherwise, shall not exceed the return of the amount of the purchase price paid by purchaser and under no circumstances shall seller be liable for special, indirect or consequential damages. The price stated for the equipment is a consideration in limiting seller's liability. No action, regardless of form, arising out of the transactions may be brought by purchaser more than one year after the cause of action has accrued.

Fan and Limit Controller

MAC800G Air Heater

APPLICATION

The L40540 controls the on and off operation of the heating unit's fan motor and provides high limit control of the main burner. It is suitable for all types of forced air heating systems.

The L40540's bimetal sensing element turns fan on and off according to plenum temperature.

The L40540 has a manual switch to provide continuous fan operation, mounting adapters for replacing competitive devices, adapters for wiring convenience, and a strain relief bushing for protecting the wiring from damage due to field abuse.

Limit contacts are suitable for line voltage, low voltage or millivoltage circuits.

The fan-on timing can vary depending on applied voltage and switch ambient.

INSTALLATION

When installing this product...

1. Read these instructions carefully. Failure to follow them could damage the product or create a hazardous condition.
2. Check the ratings given in the instructions and on the product to make sure the product is suitable for your application.
3. Installer must be a trained, experienced service technician.
4. After installation is complete, check out product operation as provided in these instructions.



WARNING

Failure to remove brake jumper, if limit switch is in low voltage circuit, can cause electrical shock hazard or damage low voltage controls.



CAUTION

1. Disconnect power supply before connecting wiring to prevent electrical shock or equipment damage.
2. When connecting cable or conduit to control, avoid straining the control case.

Follow furnace or burner manufacturer's instructions, if available. The L40540 has a maximum switch temperature of 190°F (88°C), maximum element temperature of 250°F (177°C). Do not exceed these temperatures or the following electrical ratings (amperes):

	120 Vac		240 Vac	
	FAN	LIMIT	FAN	LIMIT
Full Load	16	6	7	4
Locked Rotor	16	48	42	24

Pilot Duty: 2 A at 24 Vac; 0.25 A at 0.25 to 12 Vdc.
Maximum Combined Connected Load: 2000 VA.
75°C (167°F) (min.) field wiring required. Wiring must conform to NEC Class 1 requirements.

LOCATION

If this is a replacement installation, locate the L40540 in the same location as the control being replaced. Sensing tube length should be same as old control. If this is a new installation, the element should be installed only by a trained, experienced service technician according to the furnace manufacturer's instructions. The element must not touch any internal part of the furnace.

NOTE:

The electrical rating is at maximum switch temperature of 190°F (88°C). If plenum surface temperature exceeds 190°F (88°C), heat insulating material or a mounting bracket must be used.

MOUNTING

The device may be mounted either on the plenum surface or with a bracket (rigid or self).

SURFACE MOUNTING

Hole in plenum should be just large enough to accommodate the 3/4 in. (19.1 mm) diameter element tube, Fig. 1. For adequate clearance, a 13/16 in. (20.6 mm) diameter hole is recommended.

1. Remove cover by squeezing sides and pulling off. Insert element in plenum and mark location of mounting holes. Make sure the case is snug against the plenum before marking the mounting screws.
2. Punch or drill holes for mounting screws.
3. Place insulation between plenum and case if necessary.
4. Fasten controller securely with mounting screws.

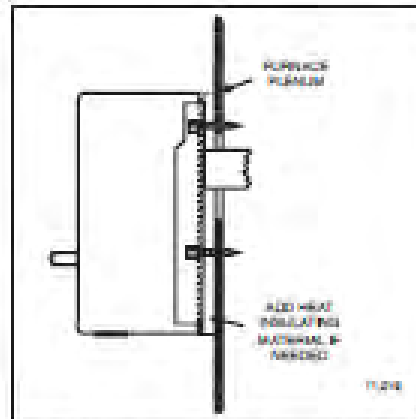


Fig. 1 - Surface mounting requires a hole 13/16 in. (20.6 mm) diameter for element insertion.

Fan and Limit Controller

MAC800G Air Heater

SWIVEL MOUNTING

L4064 may also be swivel-mounted. The swivel bracket requires a 1-3/16 in. (26.7 mm) hole in the plenum (Fig. 2).

1. Use bracket as a template to mark the location of mounting holes in plenum. Drill or punch holes for mounting screws.
2. Fasten the brackets in place with furnished screws. Start the screws but do not tighten.
3. Insert element tube through bracket, straighten controller, and fasten. Tighten the mounting screws securely. It may be necessary to rotate the bracket to tighten all screws securely.

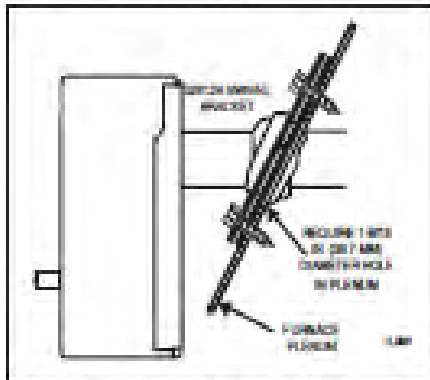


Fig. 2 - Swivel mounting requires a 1-3/16 in. (26.7 mm) diameter mounting hole for element insertion.

RIGID BRACKET MOUNTING



WARNING

When mounting control on bracket, setscrew must strike tube frame or retaining element to prevent bypassing the safety limit function.

L4064 may be mounted using a rigid bracket. The rigid bracket requires a hole 13/16 in. (20.6 mm) diameter for element insertion (Fig. 3).

1. Use bracket as a template to mark the location of mounting holes in plenum. Drill or punch holes for mounting screws.
2. Fasten bracket in place with furnished screws. Tighten the screws securely.
3. Insert element tube through bracket, straighten controller and fasten by tightening setscrew. Be sure screw strikes tube frame and does not strike sensing element.

4. For replacement installations with existing 1 in. (25.4 mm) diameter hole: SUPER TRADELINE models are supplied with split steel bushings and wire snap ring. Follow the instructions below for using the steel bushing adapter.

STEEL BUSHING ADAPTER

1. Insert one-half of the split steel bushing (Fig. 4), through the wire ring. It may be necessary to spread the ring slightly.
2. Insert the other half of the steel bushing into the ring making sure bits and ends are at the same ends.
3. Place bushing assembly on element, air and find.
4. Holding bushing at seams, push firmly to the control end of element.

5. Insert element tube with adapter through bracket, straighten controller and fasten. Tighten setscrew. Be sure screw strikes bushing not called bimetal sensing element.

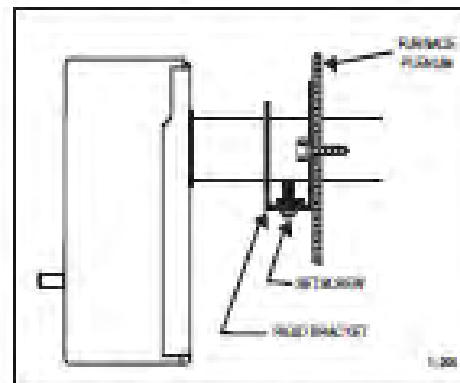


Fig. 3 - Rigid bracket mounting requires a hole 13/16 in. (20.6 mm) diameter for element insertion.

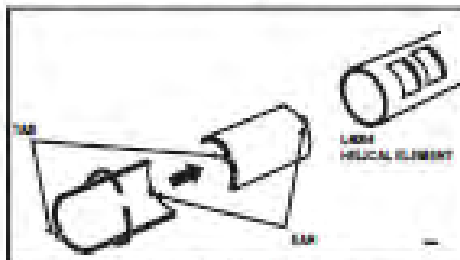


Fig. 4 - Using SUPER TRADELINE adapter.

WARNING

Disconnect power supply before beginning installation to prevent electrical shock or equipment damage.

All wiring must comply with local electrical codes and ordinances or in the absence of local codes with the National Electrical Code ANSI C1-1981-NFPA 70. Follow burner or furnace manufacturer's instructions if available; otherwise, see Fig. 10 and proceed as follows:

IMPORTANT

The brass jumper is the breakaway type. It must be removed when the limit is used in the low voltage circuit. To remove jumper, break with a needlenose pliers and remove completely. Once removed, it is not replaceable. See Fig. 8 for location.

The slotted knockouts on the bottom of the case and the strain relief bushing are provided to simplify the installation procedure and to protect the wiring.

1. To remove the slotted knockout(s), use a needlenose pliers as shown in Fig. 5 and pull straight down.
2. If cable is used, we recommend using a strain relief bushing in the knockout (Fig. 6). Feed the wires through bushing before connecting.

Fan and Limit Controller

MAC800G Air Heater



Fig. 5 - Removing slotted knockouts.



Fig. 7 - Closing the strain relief bushing.



Fig. 8 - Insert strain relief bushing.

3. Refer to the following section for type of wiring connections (standard wire push-in terminals or female receptacle).

WIRING CONNECTIONS

When connecting cable or conduit to this controller, use care to avoid strain on the control cable. Connections can be made to standard wire push-in terminals or female receptacles for 1/4 in. (6.4 mm) male flag connectors on both the fan and limit switches (Fig. 8).

FOR STANDARD WIRE PUSH-IN TERMINALS

Connect wires to the terminals as follows:

1. Use Nos. 14, 16, or 18 solid wire or Nos. 14 or 16 stranded wire, depending on electrical requirement.
2. Strip insulation from wires the distance shown by the strip gauge on the controller.
3. Solid wire may be inserted directly into the terminal holes. If stranded wire is used, insert a small screwdriver into the slot next to the terminal. Push screwdriver in and hold while inserting wire into terminal (Fig. 8). Remove screwdriver. If stranded wire is solder-dipped, it can be pushed directly into terminal holes.

FOR FEMALE RECEPTACLES-

It is recommended that the female receptacles be used for wiring accessory equipment, i.e., electronic air cleaner, humidifier, etc.

Connect wires to the receptacles as follows:

1. Use Nos. 14 to 18 size wire, depending on electrical requirement.
2. Attach 1/4 in. (6.4 mm) male flag connector to each wire. Two male connectors with leadwires are supplied.
3. Push male flag connector directly into the female receptacle. Make sure that the flag is forced to the bottom of cavity and wire is in the channel (Fig. 8).

IMPORTANT

Make certain all wires are clear of rotating escalators.

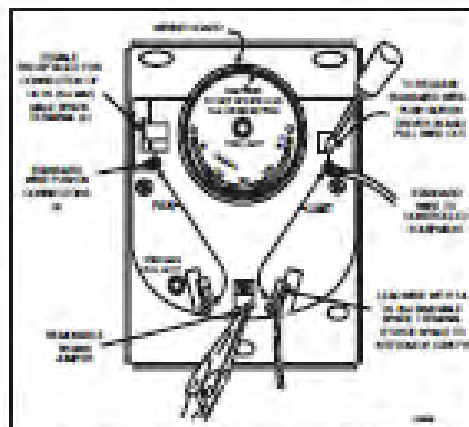


Fig. 8 - Location of wiring connections.

Fan and Limit Controller

MAC800G Air Heater

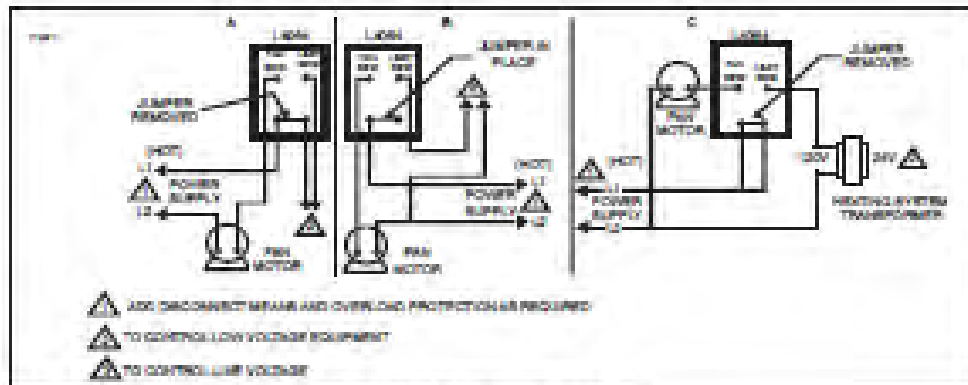


Fig. 9 - A: Limit in low voltage circuit.
B: Limit in line voltage circuit.
C: Limit in line voltage circuit without jumper.

SETTINGS AND ADJUSTMENTS

CAUTION

When adjusting the fan and limit set point levers (Fig. 10), hold the scaleplate dial to keep it from turning and straining the sensing element. Move each indicator lever to the control point recommended by the burner or furnace manufacturer. Use gentle finger pressure.

FAN SETTING ADJUSTMENT

1. Move the FAN OFF lever to the temperature at which the fan is to stop to prevent circulation of cool air.
2. L4084B - Move the FAN ON lever to the temperature at which the fan is to come on.

MANUAL FAN SWITCH

For constant fan operation, push the FAN switch button in. For fan to cycle automatically, pull button out.

LIMIT SETTING ADJUSTMENT

These controllers have a limit stop which prevents the limit indicator lever from being adjusted beyond the equipment manufacturer's specifications.

1. Push the small end of Limit Adjust Tool (196722) through hole in scaleplate (located at caution marking) to depress the stop disc, not more than 1/16 in. (1.5 mm) to release stop lock (Fig. 10). Stop disc is on back of scaleplate.
2. While depressing the stop disc, insert the long end of Limit Adjust Tool next to limit stop (Fig. 10) and move the stop to desired setting. *If the L-4084 is a replacement control, high limit stop setting should be the same as that of the control being replaced.* (Move stop clockwise ⤴ to lower the setting; counterclockwise ⤵ to raise it.) Then remove the limit stop adjust tool.
3. Set the LIMIT OFF lever to the temperature at which the high limit switch is to open to stop the burner. If the high limit stop has been properly set, the LIMIT OFF lever should be as high as the stop permits.

OPERATION

As the plenum temperature rises, the bimetal sensing element of the control trips and mechanically makes

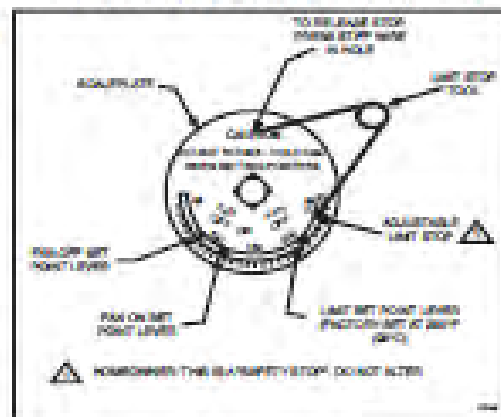


Fig. 10 - Changing the high limit stop.

the fan contacts (at the FAN ON temperature setting). During normal operation, the call for heat ends before the LIMIT setting is reached, and the fan contacts break as the plenum temperature falls and the FAN OFF setting is reached.

If the call for heat continues until the temperature in the plenum rises to the LIMIT setting, the bimetal element will mechanically break the limit contacts and de-energize the gas control circuit.

CHECKOUT

When installation is complete, disconnect the fan motor circuit at the L4084. Turn on power and set thermostat to call for heat. Burner should come on and limit controller should shut burner off when plenum temperature reaches the limit set point. Turn off power, reconnect the fan switch, turn on power and again set thermostat to call for heat. Fan should come on when plenum temperature has reached fan-on setting.



MODEL F15 INSTALLATION MANUAL

**RIELLO 40
SERIES**

OIL BURNERS

RETROFIT APPLICATIONS ONLY

NON-RETROFIT APPLICATIONS

If this burner is being installed in a packaged unit (i.e. burner comes with a boiler or furnace), follow the installation and set-up instructions supplied with the heating unit, as settings may differ from those shown in this manual.

Riello Burners

MAC800G Air Heater

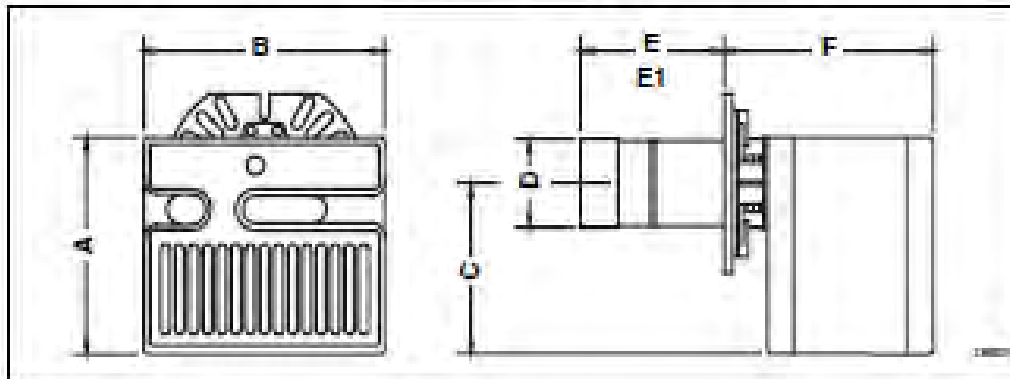
PARTS LIST

Your Riello 40 F15 burner should include the following parts. Please check to make sure all parts are present before beginning the installation.

QTY. DESCRIPTION (parts bag)	QTY. DESCRIPTION (carton)
2 - Mounting flange bolts (short)	1 - Burner chassis with cover
2 - Semi-flange bolts (long)	1 - Universal Mounting Flange
4 - Nuts	2 - Semi-flanges
2 - Chrome nuts	1 - Mounting gasket
1 - Oil pump connector (supply)	1 - Installation Manual
1 - Oil pump connector (return)	1 - By-pass plug
2 - Female 1/4" NPT adapter	1 - 2.5 mm Allen key
1 - Male 3/8" NPT adapter	* (separate carton)
	1 - Combustion head

* OEM burners shipped with combustion head mounted.

**RIELLO 40 F15
TECHNICAL DATA**



DIMENSIONS

MODEL F15	A	B	C	D	E	F
Inches	11 3/4	13 25/32	9 1/16	4 11/16	5	11 27/32
mm	298	350	230	119	127	301

E1: 10 Inch long (254 mm) tubes also available.

SPECIFICATIONS

FUEL: No. 2 Fuel Oil

FIRING RATE: 2.55 to 5.75 GPH 8.2 to 18.6 kg/h

EFFECTIVE OUTPUT: 357,000 to 805,000 BTU/h 104.6 to 235.8 kW
89,960 to 202,860 kcal/h

VOLTAGE (Single Phase): 120V 60 Hz (+10% -15%)

ABSORBED ELECTRICAL POWER: 516 Watts

MOTOR (rated): 3250 rpm Run Current 4.0 AMP

CAPACITOR: 16 Microfarads 260V

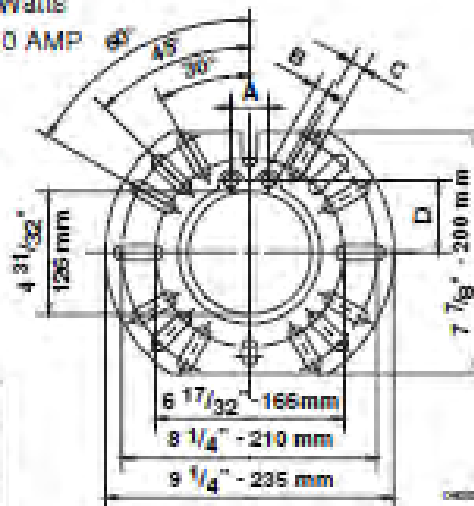
PUMP PRESSURE: 130 to 200 PSI

PRIMARY CONTROL: RIELLO 530 SE/C

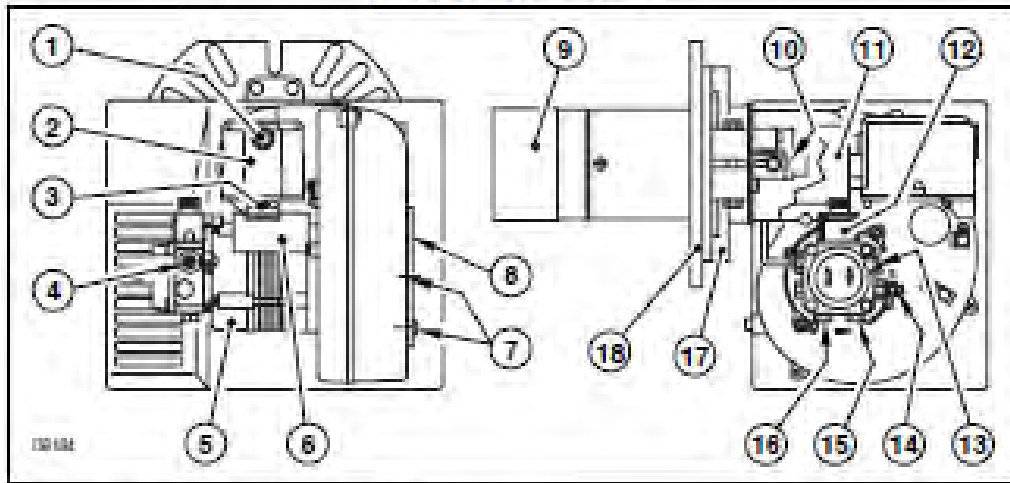
IGNITION TRANSFORMER: 8kV 16 mA

MOUNTING FLANGE DIMENSIONS

MODEL F15	A	B	C	D
Inches	1 1/2	1/4	7/16	2 7/8
mm	38	6	11	73



**OIL BURNER COMPONENTS IDENTIFICATION
RIELLO 40 SERIES**

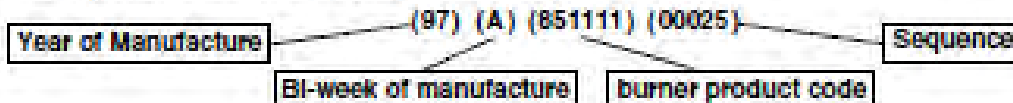


F15 BURNER COMPONENTS

- | | |
|---|-------------------------------------|
| 1. Lockout indicator lamp and Reset button | 9. End cone |
| 2. Primary control | 10. Turbulator adjustment screw |
| 3. Primary control sub-base | 11. Air tube cover |
| 4. Pump pressure regulator adjustment screw | 12. Coil |
| 5. Motor | 13. Vacuum gauge connection port |
| 6. Capacitor | 14. Pressure gauge and bleeder port |
| 7. Air adjustment fixing screws | 15. Return fuel line port |
| 8. Air shutter | 16. Supply fuel line port |
| | 17. Adjustable collar |
| | 18. Mounting flange with gasket |

SERIAL NUMBER IDENTIFICATION

The Riello 15 character serial number, example, 97 A 8511111 00025, is identified as follows: 97 – last two digits of the year of manufacture; A – BI-week of manufacture; 8511111 – burner product code; 00025 – increment of 1 for each burner produced - specific to product code - reset to zero each January 1st.



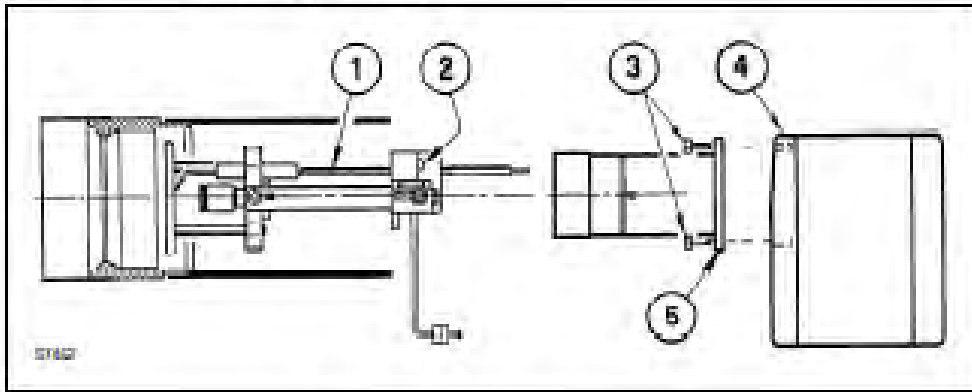
INITIAL SET - UP

- A)** Remove burner and air tube from cartons. Check parts list (inside cover) to ensure all parts are present.
- B)** Remove burner cover by loosening the three screws securing it. Remove control box and air tube cover (see page 7).
- C)** Remove drawer assembly from air tube, insert nozzle and set turbulator adjustment for specific input required (see pages 7 & 8), then set aside.
- D)** Mount air tube to burner chassis (see page 3).

ASSEMBLY OF AIR TUBE TO BURNER CHASSIS

The air tube and drawer assembly are shipped in a carton separate from the burner chassis. Choose the proper air tube length to obtain the tube insertion for the specific installation.

- A) Remove the AIR TUBE and BURNER CHASSIS from their respective cartons.
- B) Remove the DRAWER ASSEMBLY (1) from inside the AIR TUBE by loosening the screw (2). Carefully pull the DRAWER ASSEMBLY out of the AIR TUBE, install the required nozzle (see page 7) and set aside.
- C) Remove the two BOLTS (3) from FRONT PLATE (4) of the BURNER CHASSIS. Align the two holes on the AIR TUBE HOLDING PLATE (5) with the two holes left open on the BURNER CHASSIS FRONT PLATE when the BOLTS (3) were removed. Replace the BOLTS and finger tighten only. Re-install DRAWER ASSEMBLY into AIR TUBE. Tighten SCREW (2) securely (see page 7).
- D) Tighten the two bolts (3) securely.



MOUNTING THE BURNER TO THE BOILER OR FURNACE

There are three possible methods to mount the burner, depending on the individual application. These are:

- 1) Universal flange bolted to Boiler/Furnace unit.
- 2) Semi-flange collar bolted to Boiler/Furnace unit.
- 3) Universal flange mounted to optional Pedestal mount, where flange-mounting direct to appliance is not possible. Pedestal kit must be ordered separately.

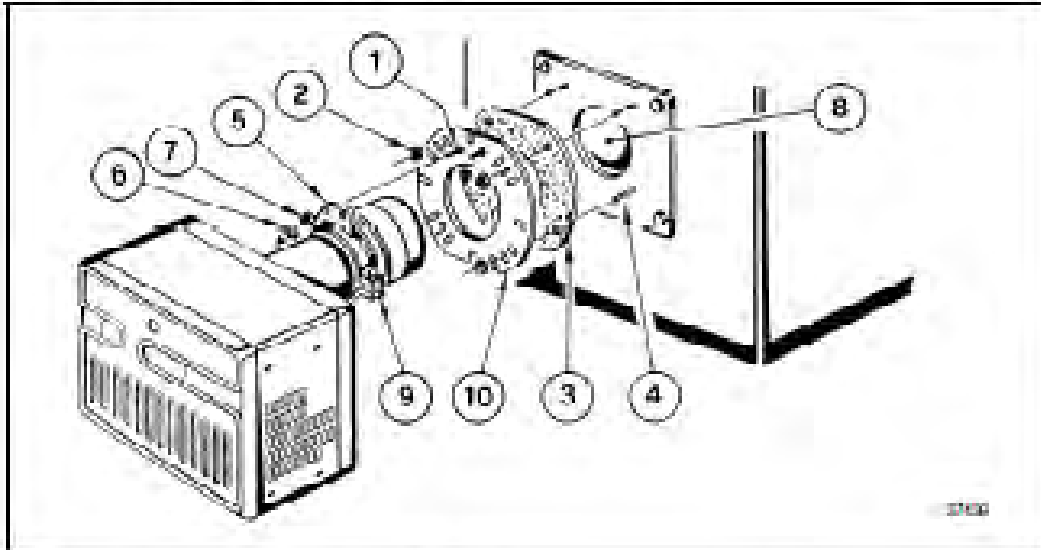
METHOD 1 - UNIVERSAL MOUNTING FLANGE

A) Insert the two BOLTS (1) into the UNIVERSAL MOUNTING FLANGE (10) from the flat side, ensuring the bolt heads are flush with the flat surface. Secure in place using two special CHROME NUTS (2) provided.

Riello Burners

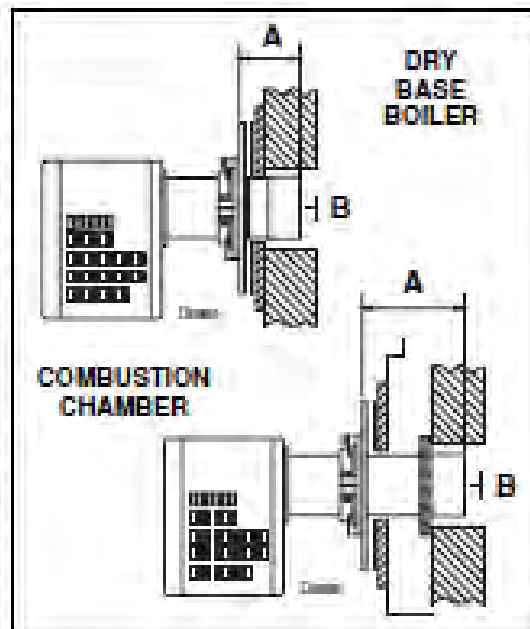
MAC800G Air Heater

B) Position the MOUNTING GASKET (3) between the flat surface of the UNIVERSAL MOUNTING FLANGE (10) and the appliance. Line up the holes in the UNIVERSAL MOUNTING FLANGE with the STUDS (4) on the appliance mounting plate and securely bolt the UNIVERSAL MOUNTING FLANGE to the plate.



C) Secure the two semi-flanges of the ADJUSTABLE COLLAR (9) to the AIR TUBE using the two long BOLTS (8). Be sure that the ADJUSTABLE collar is properly positioned so the outside edge of the END CONE will be at least 1/4 inch (6.5 mm) back from the inside wall of the refractory of the combustion chamber (see dimension B at right). The measured length (A), is to include MOUNTING GASKET and FLANGE, if used.

D) The burner may now be attached to the heating unit by inserting the AIR TUBE through the BURNER ACCESS HOLE (8) and into the appliance, making sure the BOLTS (1) line up with the two HOLES (5) in the ADJUSTABLE COLLAR. Secure the burner in place using two NUTS (7).



A visual verification of the air tube insertion into the combustion chamber of the heating unit is suggested. Dimension B should be at least 1/4" (see drawing).

NOTE: A suggested method for creating mounting bolt holes in the mounting gasket: Hold the gasket against the appliance mounting bolts using the mounting flange for proper positioning. Lightly tap the flange with a hammer to form the holes.

Riello Burners

MAC800G Air Heater

METHOD 2 - SEMI-FLANGE COLLAR

- A) Follow Item C from METHOD 1.
- B) Align the air tube and attached adjustable collar so air tube is centered in the burner access hole of the boiler/furnace unit. Mark the center of the two holes in the ADJUSTABLE COLLAR on to the front plate of the heating unit. Then drill 1/4 inch (6.5 mm) holes through the front plate of the unit, using marks as a guide.
- C) Install two short BOLTS (1) through the front plate of the heating unit from the inside, and secure on the outside using the two special CHROME NUTS (2).
- D) Follow Item D from METHOD 1.

METHOD 3 - PEDESTAL MOUNT

Secure the MOUNTING FLANGE to MOUNTING PEDESTAL using the hardware provided with the pedestal. Secure burner to MOUNTING FLANGE as in METHOD 1, items A, C and D.


NOTE: It is suggested that the pedestal be anchored in position on the floor by installing brackets over the pedestal tube and securing brackets to the floor.

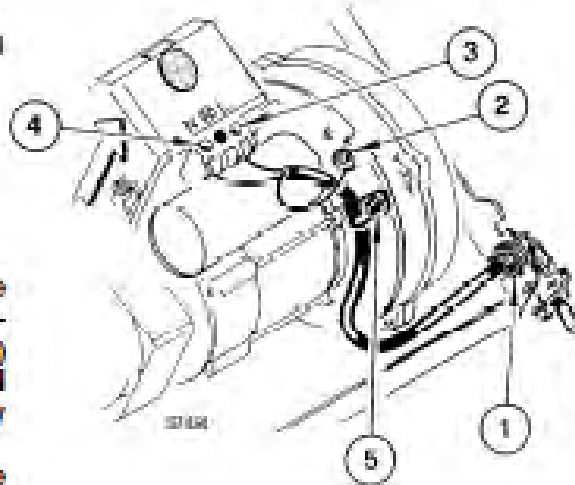
WARNING: WHEN THE COMBUSTION CHAMBER IS LINED WITH A REFRACTORY MATERIAL, IT IS IMPERATIVE THAT THE END CONE NOT PROTRUDE INTO THE CHAMBER AREA, AS EXCESSIVE HEAT AT BURNER SHUT-DOWN WILL DAMAGE THE END CONE.

ELECTRICAL CONNECTIONS

It is advisable to leave the control box off the sub-base while completing the electrical connections to the burner.

- 1) Wire access hole
(Use BX electrical connector)
- 2) Earth ground conductor terminal
(GREEN WIRE)
- 3) Hot conductor terminal
(BLACK WIRE)
- 4) Neutral conductor terminal
(WHITE WIRE)
- 5) Strain relief clamp

WARNING: The hot (black) wire must be connected to the L terminal and the neutral (white) wire must be connected to the N terminal or the primary safety control will be damaged. Do not connect either wire to the  Terminal.



Riello Burners

MAC800G Air Heater

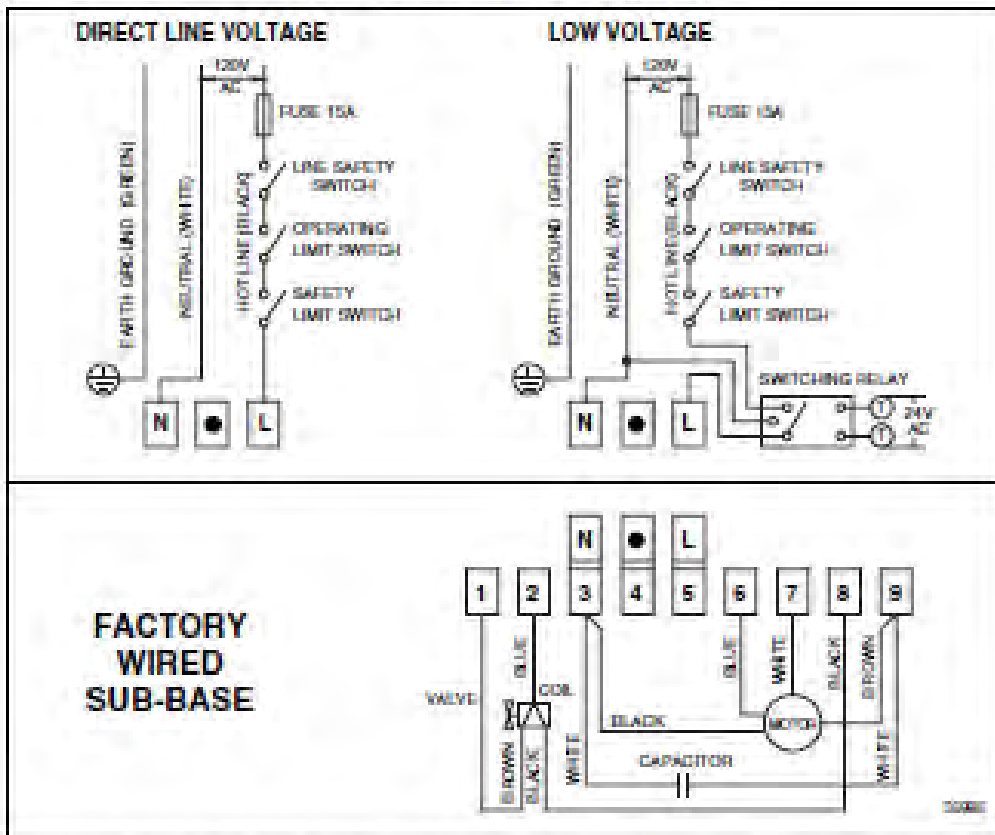
The burner may be controlled using either a DIRECT LINE VOLTAGE control circuit (120V AC 60 cycle) OR a LOW VOLTAGE control (24V AC 60 cycle) using a RB038A Honeywell switching relay or equivalent.

Using the appropriate diagram below, make electrical connections to burner. All wiring must be done in accordance with existing electrical codes, both national and local.

When all electrical connections have been made, the control box may be put back in place on the sub-base.

WARNING: DO NOT activate burner until proper oil line connections have been made, or failure of the pump shaft seal may occur.

APPLICATION FIELD WIRING



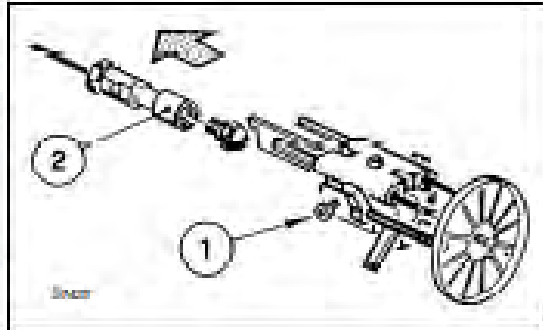
REMOTE SENSING OF SAFETY LOCKOUT: The SAFETY SWITCH in the 530SE CONTROL BOX is equipped with a contact allowing remote sensing of burner lockout. The electrical connection is made at terminal 4 (●) on the SUB-BASE. Should lockout occur the 530SE CONTROL BOX will supply a power source of 120Vac to the connection terminal. The maximum allowable current draw on this terminal (4) is 1 Amp.

WARNING: If a neutral or ground lead is attached to this terminal, the CONTROL BOX on the burner will be damaged should lockout occur.

NOZZLE PLACEMENT

A) Determine the proper firing rate for the boiler or furnace unit, considering the specific application, then use the Burner Set-up chart on page 12 to select the proper nozzle and pump pressure to obtain the required input from the burner.

B) Remove the NOZZLE ADAPTER (2) from the DRAWER ASSEMBLY by loosening the SCREW (1).



C) Insert the proper NOZZLE into the NOZZLE ADAPTER and tighten securely (Do not overtighten).

D) Replace adapter, with nozzle installed, into drawer assembly and secure with screw (1).

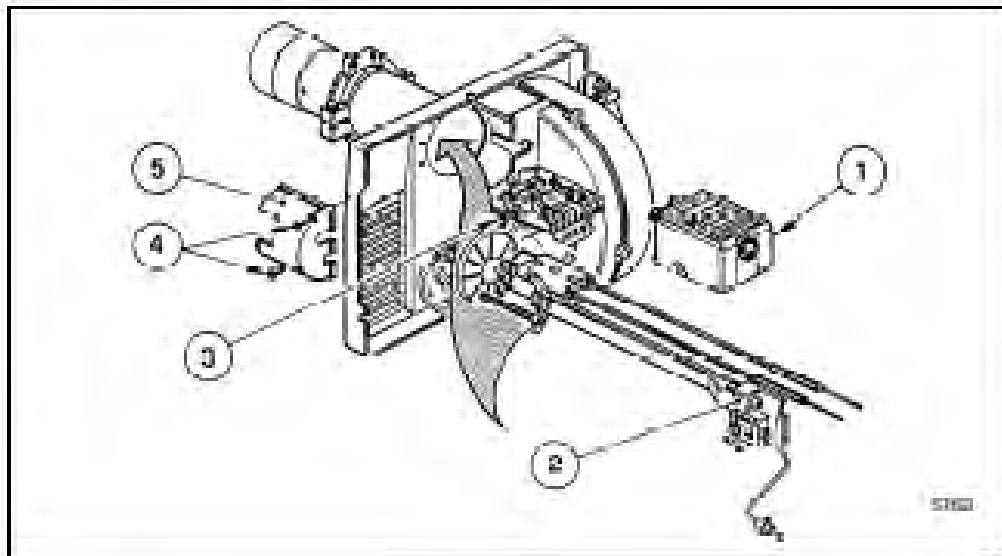
INSERTION/REMOVAL OF DRAWER ASSEMBLY

A) To remove drawer assembly, loosen SCREW (3), then unplug CONTROL BOX (1) by carefully pulling it back and then up.

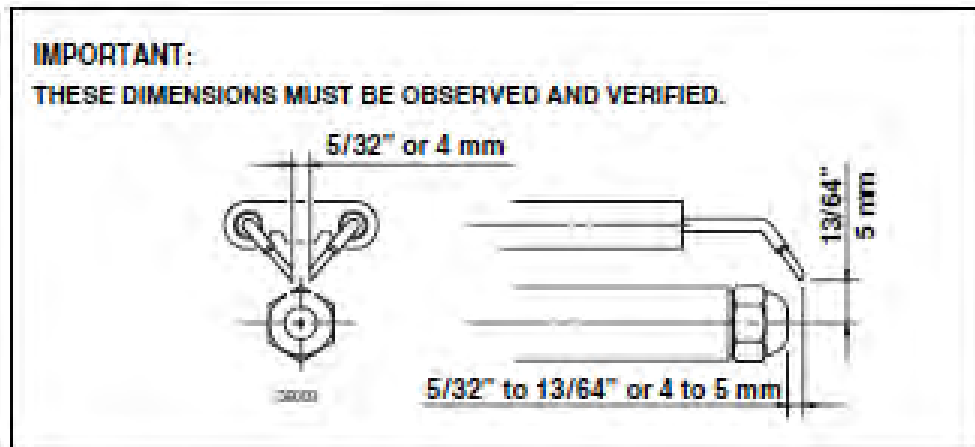
B) Remove the AIR TUBE COVER PLATE (5) by loosening the two retaining SCREWS (4).

C) Loosen SCREW (2), then slide the complete drawer assembly out of the combustion head as shown.

D) To Insert drawer assembly, reverse the procedure in items A to C above, then attach fuel line to the pump.



ELECTRODE SETTING

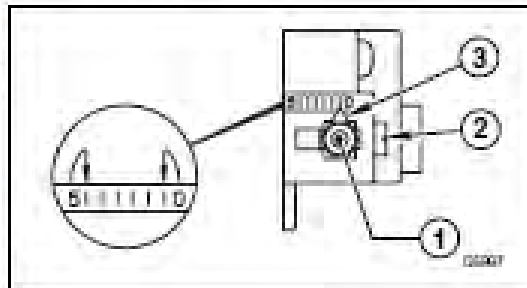


TURBULATOR SETTING

A) Loosen NUT (1), then turn SCREW (2) until the INDEX MARKER (3) is aligned with the correct index number as per the Burner Set-up chart, on page 12.

B) Retighten the RETAINING NUT (1).

NOTE: Zero and five are scale indicators only. From left to right, the first line is 5 and the last line 0.



OIL LINE CONNECTIONS

This burner is shipped with the oil pump set to operate on a **single** line system. To operate on a **two** line system the by-pass plug **must** be installed.

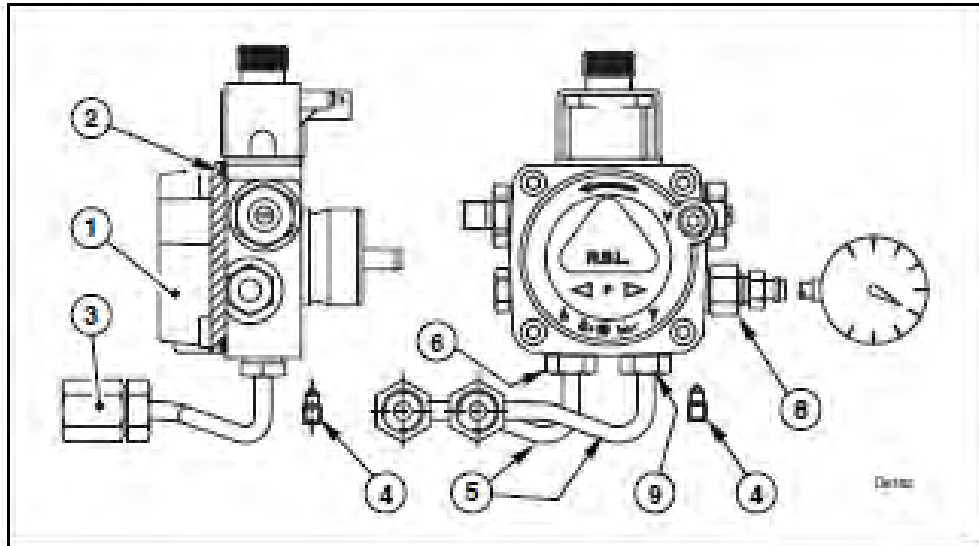
Warning: Do not operate a **single** line system with the by-pass plug installed. Operating a **single** line system with the by-pass plug installed will result in damage to the pump shaft seal.

Note: Pump pressure must be set at time of burner start-up. A pressure gauge is attached to the **PRESSURE PORT** (8) for pressure readings. Two **PIPE CONNECTORS** (5) are supplied with the burner for connection to either a single or a two-pipe system. Also supplied are two **ADAPTORS** (3), two female $1/4''$ NPT, to adapt oil lines to burner pipe connectors. All pump port threads are **British Parallel Thread** design. Direct connection of NPT threads to the pump **will damage** the pump body.

Riello Burners

MAC800G Air Heater

Riello manometers and vacuum gauges do not require any adaptors, and can be safely connected to the pump ports. An NPT (metric) adaptor **must** be used when connecting other gauge models.



SINGLE LINE (GRAVITY FEED SYSTEM)

A) The burner is shipped configured for use in single line applications. No changes to the oil pump are required for use in single line applications.

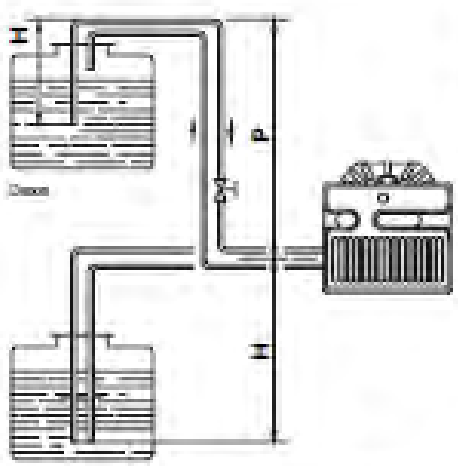
NOTE: If the **pump cover (1)** is removed for any reason, be sure the O-ring (2), is properly seated in the pump cover (1) before re-attaching the pump cover to the pump housing.

SINGLE LINE SYSTEM - PIPE LENGTHS					
H		3/8" OD		1/2" OD	
FT	M	FT	M	FT	M
1.5	0.5	33	10	65	20
3.0	1.0	65	20	130	40
5.0	1.5	130	40	260	80
6.5	2.0	195	60	325	100

NOTE: Do not exceed pipe lengths indicated in chart.

B) Connect the pipe connector to the SUPPLY PORT (8) of the pump. Attach the required piping to this pipe connector. Be sure that the plug in the RETURN PORT (9) is tightened securely.

TWO LINE (LIFT SYSTEM)



2 LINE (LIFT) SYSTEM - PIPE LENGTHS					
H		3/8" OD		1/2" OD	
FT	M	FT	M	FT	M
0.0	0.0	115	35	330	100
1.5	0.5	100	30	330	100
3.0	1.0	80	25	330	100
5.0	1.5	65	20	295	90
6.5	2.0	50	15	230	70
9.5	3.0	25	8	100	30
11	3.5	20	6	65	20

NOTE: Do not exceed pipe lengths indicated in chart.

A) If a two line system is required, install the By-pass plug (4) provided. The by-pass plug is installed in the return port (9) of the pump. A 2.5 mm hexagonal key provided with the by pass plug is to be used to install the plug. **DO NOT** use an inch size hexagonal key, damage to the by-pass plug may result. When operating on a two line system, supply and return lines should be the same diameter and both **should extend to the same depth inside the fuel tank**. Be sure there are no air leaks or blockages in the piping system.

Any obstructions in the return line will cause failure of the pump shaft seal. Do not exceed the pipe lengths indicated in the tables.

To install the by-pass plug:

- 1) Remove the return plug (9).
- 2) Install the by-pass plug (4) using the 2.5 mm hexagonal key.

B) Attach the two PIPE CONNECTORS (5) to the pump SUPPLY and pump RETURN PORTS (6 and 9). Attach the required piping to these two pipe connectors using the NPT/METRIC ADAPTERS that are supplied with the burner.

WARNING: Pipe dope or Teflon tape are **NOT** to be used on any direct oil connection to the fuel pump.

WARNING: The height "P" in Pipe Length charts on page 9 and 10 should not exceed 13 feet (4 m).

WARNING: The vacuum should not exceed 11.44 inches of mercury.

IMPORTANT: An external, appropriately listed and certified oil filter must be placed in the fuel line between the fuel tank and the burner pump.

PUMP PURGE

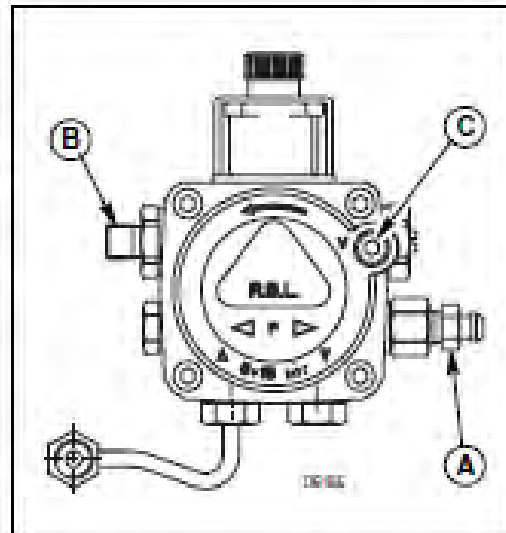
NOTE: to protect the pump gears, it is advisable to lubricate the pump prior to purging a lift system. Apply oil through the VACUUM PORT (C).

A) SINGLE LINE (GRAVITY FEED SYSTEM)

A) Loosen the bleeder valve (A) until oil flows out. Tighten the bleeder valve securely and start burner.

B) When bleeding the pump by pressure.

- 1) Loosen the bleeder valve (A).
- 2) Disconnect nozzle oil supply line at the pump nozzle port (B).
- 3) Attach a flexible plastic tube to the pump nozzle port, directing the oil flow into a bucket.
- 4) Loosen the screws securing the air tube cover, allowing it to be removed freely.
- 5) Holding the air tube cover in its proper location start the burner.
- 6) When the solenoid valve is engaged, approximately 10 seconds after starting, remove the air tube cover and shine a light source on the photo-cell, allowing it to see false light.



- 7) Run the burner until the fuel pump has been purged of air, then tighten the bleeder valve and immediately shut down the burner.
- 8) Reinstall the air tube cover and nozzle line.
- 9) The burner can now be started normally.

WARNING: Omitting steps 2 and 3 will result in a collection of unburned oil in the combustion chamber creating a hazardous situation upon burner startup.

B) TWO LINE (LIFT SYSTEM)

Turn off the main power source to the burner and remove the air tube cover. Shine a light source on the photo-cell (now visible where the air tube cover was removed), return power to the burner and activate the burner. With the light source in place, the burner will operate in prepurge only. Once the burner is purged, turn off the power source and replace the air tube cover. Return power to the burner. The burner is now ready to operate.

ATTENTION: It is important that the fuel line be completely sealed and free from air leaks or any internal blockages.

IMPORTANT! WHEN THE BY-PASS PLUG IS INSTALLED, A TWO PIPE SYSTEM MUST BE USED OR FAILURE OF THE PUMP SHAFT SEAL WILL OCCUR.

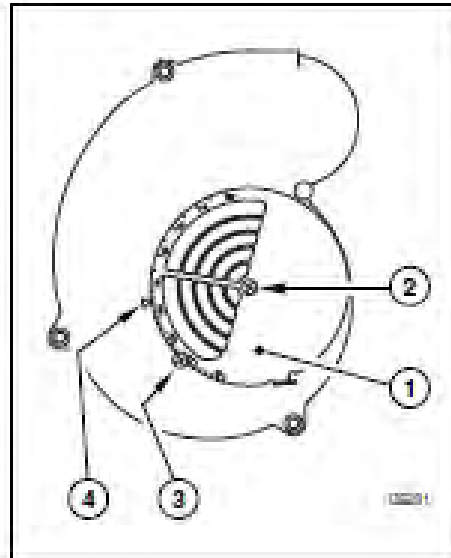
SETTING THE AIR ADJUSTMENT PLATE

A) Regulation of the combustion air flow is made by adjustment of the manual AIR ADJUSTMENT PLATE (1) after loosening the FIXING SCREWS (2 & 3). The initial setting of the air adjustment plate should be made according to Column 5 in the Burner Set-up Chart.

B) The proper number on the manual AIR ADJUSTMENT PLATE (1) should line up with the SETTING INDICATOR (4) on the fan housing cover. Once set, the air adjustment plate should be secured in place by tightening SCREWS 2 and 3.

C) The final position of the air adjustment plate will vary on each installation. Use instruments to establish the proper settings for maximum CO₂ and a smoke reading of zero.

NOTE: Variations in flue gas, smoke, CO₂ and temperature readings may be experienced when the burner cover is put in place. Therefore, the burner cover **must** be in place when making the final combustion instrument readings, to ensure proper test results.



BURNER SET-UP CHART

1		2	3		4	5
ACTUAL FIRING RATE ± 5%		NOZZLE SIZE	PUMP PRESSURE		TURBULATOR SETTING	AIR DAMPER SETTING
GPH	kg/h	GPH	PSI	BAR		
2.55	9.2	2.00 x 45°/60°	170	11.6	0.0	1.8
2.85	9.2	2.25 x 45°/60°	160	11	0.5	2.0
3.00	9.7	2.50 x 45°/60°	150	10	1.0	2.2
3.65	11.8	3.00 x 45°/60°	150	10	1.5	2.6
4.25	13.7	3.50 x 45°/60°	150	10	2.0	3.1
4.85	15.7	4.00 x 45°	150	10	3.0	4.5
5.45	17.6	4.50 x 45°	150	10	4.5	5.2
5.75	18.6	5.00 x 45°	140	9.6	5.0	5.5

Riello Burners

MAC800G Air Heater

NOZZLES: Monarch R-PLP, Delavan W-B, Danfoss S-B, Steiner SS-S, Hago P.

NOTE: A 45° degree nozzle is suggested, however, a 60° degree nozzle may be used in cases where the flame is unstable at light-off when operated at low ambient temperatures.

COMBUSTION CHAMBER

Follow the instructions furnished by the boiler/furnace manufacturer. Size retrofit application according to the appropriate installation codes (eg. CSA B139 or NFPA #31).

NON-RETROFIT APPLICATIONS

If this burner is being installed in a packaged unit (ie. burner comes with a boiler or furnace), follow the installation and set-up instructions supplied with the heating unit, as settings will differ from those shown in this manual.

SPARE PARTS LIST

NO.	CODE	DESCRIPTION
1	3007236	Burner Back Cover
2	3006711	3/8" NPT/Metric Adapter - Male
3	3006994	Pipe connector - Supply and Return
4	3006947	1/4" NPT/Metric Adapter - Female
5	3007077	Crushable Metal Washer
6	3007998	Bleeder
7	3007028	O-Ring - Pump Pressure Regulator
8	3007202	Regulator Screw
9	3007162	O-Ring - Pump Cover
10	3006719	Pump Screen
11	3006925	Valve Stem
12	3007203	Valve Stem Plate
13	3007029	O-Ring - Valve Stem Upper
14	3007166	O-Ring - Valve Stem Lower
15	3002278	Primary Control Sub Base
16	3007268	Nozzle Outlet Fitting
17	3007087	Crushable Metal Washer
18	3006853	Coil U-Bracket and Knurled nut
19	3006279	Coil
20	3007802	Pump
21	3000443	Pump Drive Key
22	3005845	Motor
23	3007318	Air Tube Cover
24	3002280	Photo-cell
25	3001167	Primary Control SENSE/IC
26	3005849	Semi-Flange
27	3005852	Mounting Gasket
28	3005851	Universal Mounting Flange
29	3007206	Manual Air Shutter
30	3007211	Air Intake Housing
31	3006799	Fan

NO.	CODE	DESCRIPTION
32	3007389	Acoustic Liner
33	3006846	Capacitor 15 µF
40	3449171	Short Combustion Head 8" (27412)
41	3005892	Short Air Tube
42	3005897	Turbulator Disc
43	3005895	Cross - casting
44	3006965	Nozzle Adapter
45	3006965	Nozzle Oil Tube - Short
46	3006900	Regulator assembly - Short
47	3005902	Electrode assembly - Short
48	3005899	Electrode Porcelain
49	3005895	End Cone
40	3449172	Long Combustion Head 10" (27412)
41	3005893	Long Air Tube
42	3006997	Turbulator Disc
43	3005896	Cross - casting
44	3006965	Nozzle Adapter
45	3006965	Nozzle Oil Tube - Long
46	3005901	Regulator assembly - Long
47	3005903	Electrode assembly - Long
48	3005959	Electrode Porcelain
49	3005905	End Cone
OPTIONAL		
60	3007816	Capillary Tube
61	3006911	Hydraulic Jack
62	3000990	Hydraulic Air Shutter

**FOR CANADA
PRECAUTIONS**

AIR FOR COMBUSTION

Do not install burner in room with insufficient air for combustion. Be sure there is an adequate air supply for combustion if the boiler/furnace room is enclosed. It may be necessary to create a window to permit sufficient air to enter the boiler/furnace room. The installer must follow local ordinances in this regard. Should local ordinances be lacking, it is suggested that the installer follow CSA standard B139.

CHIMNEY

Be sure chimney is sufficient to handle the exhaust gases. It is recommended that only the burner be connected to the chimney. Be sure that it is clean and clear of obstructions.

OIL FILTER

An external oil filter is **REQUIRED**, even though there is an internal strainer in the pump. The filter should be replaced at least once a year, and the filter container should be thoroughly cleaned prior to installing a new filter cartridge.

DRAFT

Follow the instructions furnished with the heating appliance.
The pressure in the combustion area should be kept as close to zero as possible.
The burner will operate with a slight draft or pressure in the chamber.

ELECTRICAL CONNECTIONS

All electrical connections should be done in accordance with the C.E.C. Part I, and a local codes. The system should be grounded.

CONTROL BURNER OPERATION

Check out the burner and explain its operation to the homeowner. Be sure to leave the Owner's Instruction sheet with the homeowner.

FIRE EXTINGUISHER

If required by local codes, install an approved fire extinguisher.

**FOR USA
PRECAUTIONS**

AIR FOR COMBUSTION

Do not install burner in room with insufficient air for combustion. Be sure there is an adequate air supply for combustion if the boiler/furnace room is enclosed. An opening of at least twice the area of the flue should be available, or one square foot of area for every gallon of firing rate. It is important to have one opening near the floor, and one near the ceiling. It may be necessary to create a window to permit a sufficient air to enter the boiler/furnace room. The installer must follow local ordinances in this regard. Should local ordinances be lacking, it is suggested that the installer follow NFPA manual # 31.

CHIMNEY

Be sure chimney is sufficient to handle the exhaust gases. It is recommended that only the burner be connected to the chimney. Be sure that it is clean and clear of obstructions.

OIL FILTER

An external oil filter is REQUIRED, even though there is an internal strainer in the pump. The filter should be replaced at least once a year, and the filter container should be thoroughly cleaned prior to installing a new filter cartridge.

DRAFT

Follow the instructions furnished with the heating appliance.

The pressure in the combustion area should be kept as close to zero as possible. The burner will operate with a slight draft or pressure in the chamber.

ELECTRICAL CONNECTIONS

All electrical connections should be done in accordance with the National Electrical Code, and all local ordinances. In most localities, a number 14 wire should be used inside a metal conduit. The system should be grounded. A service switch should be placed close to the burner on a fireproof wall in an easily accessible location.

CONTROL BURNER OPERATION

Check out the burner and explain its operation to the homeowner. Be sure to leave the Owner's Instruction sheet with the homeowner.

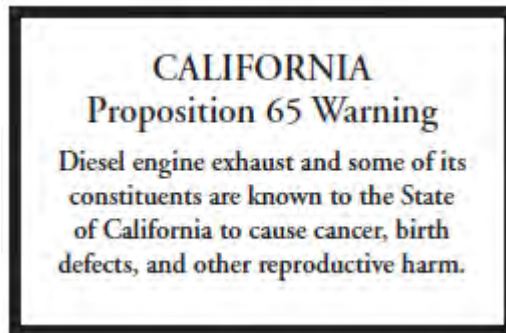
FIRE EXTINGUISHER

If required by local codes, install an approved fire extinguisher.

ISUZU DIESEL ENGINE 3CC1, 3CD1, 3CD1T, 3CE1

INSTRUCTION MANUAL

ISUZU MOTORS LIMITED



FOREWORD

The ISUZU industrial diesel engines are a product of ISUZU's long years of experience, advanced technology. ISUZU takes great pride in the superior durability and operating economy of these engines.

In order to get the fullest use and benefit from your industrial engine, it is important that you operate and maintain it correctly. This Manual is designed to help you do this.

Please read this Manual carefully and follow its operating and maintenance recommendations. This will ensure many years of trouble-free and economical engine operation.

Should your engine require servicing, please contact your nearest ISUZU engine outlet. He knows your engine best and is ready to meet your satisfaction.

All information, illustrations, and specifications contained in this Manual are based on the latest product information available at the time of publication.

ISUZU reserves the right to make changes in this Manual at any time without prior notice.

Thank you for purchasing the ISUZU product.

[INTRODUCTION]

- This Instruction Manual describes the operation, maintenance and inspection of the 3CC1 • 3CD1 • 3CD1T • 3CE1 diesel engines.
- Read this Instruction Manual carefully before operate the machine unit to ensure that the engine is used correctly and that it stays in the best possible condition.
- Keep this Instruction Manual in a convenient place for easy access.
- If this Instruction Manual is lost or damaged, order a new one from your dealer or Isuzu distributor.
- Make sure this manual is transferred to subsequent owners. This manual should be considered a permanent part of the engine and remain it.
- Constant efforts are made to improve the quality and performance of Isuzu products, so some details included in this Instruction Manual may differ slightly from your engine. If you have any questions about such difference, please contact your dealer or Isuzu distributor.
- The specifications and components (instrument panel, fuel tank, etc.) described in this manual may differ from ones installed in your machine unit. To obtain their information, please refer to the manual provided by the equipment manufacturers.

**California
Proposition 65 Warning**
Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

**California
Proposition 65 Warning**
Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.
Wash hands after handling.

Isuzu Diesel Engine

MAC800G Air Heater

The EPA (U.S. Federal) and Air Resources Board (ARB, California) Off-road Compression Ignition engines regulations

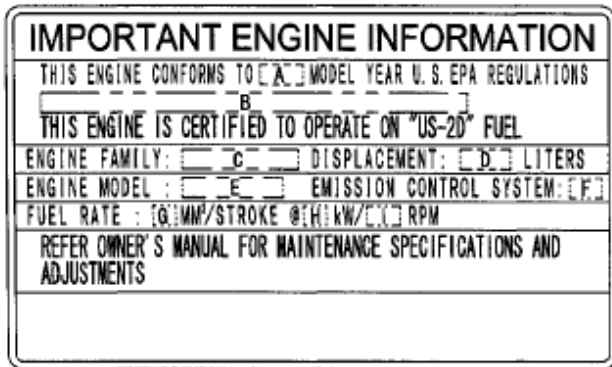
The engines for the EPA regulations will be used in the States, and the engines for the ARB regulations will only be used in the State of California.

The information on engines to comply with the EPA and ARB Regulations is released and you are kindly requested to make every effort to comply with them. Isuzu Engines of all "3C" series engine models are covered with these regulations.

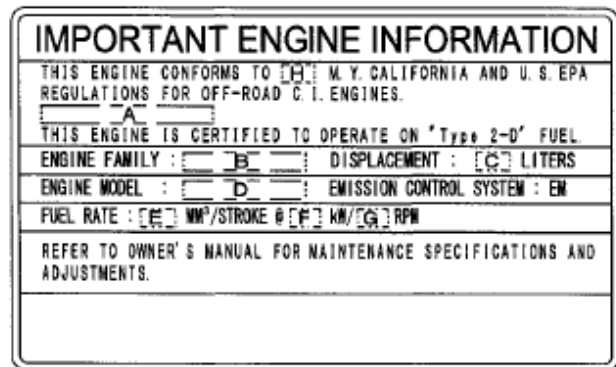
Engine identification

With the regulations on engine emission worldwide, it has become necessary to identify engines in a manner to determine which regulations they comply with, hence

- Emission control information label as shown below which will contain:

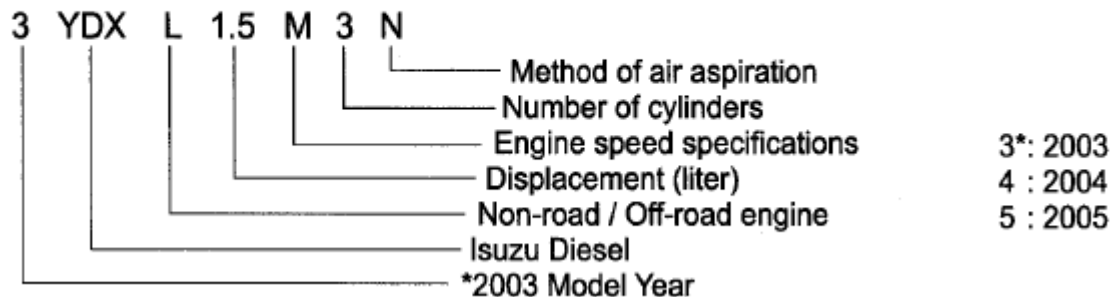


EPA Emission Control Label



EPA/ARB-OR Emission Control Label

- Engine family name as assigned by EPA and ARB identifying engine family group 3YDXL1.5M3N and this identifies

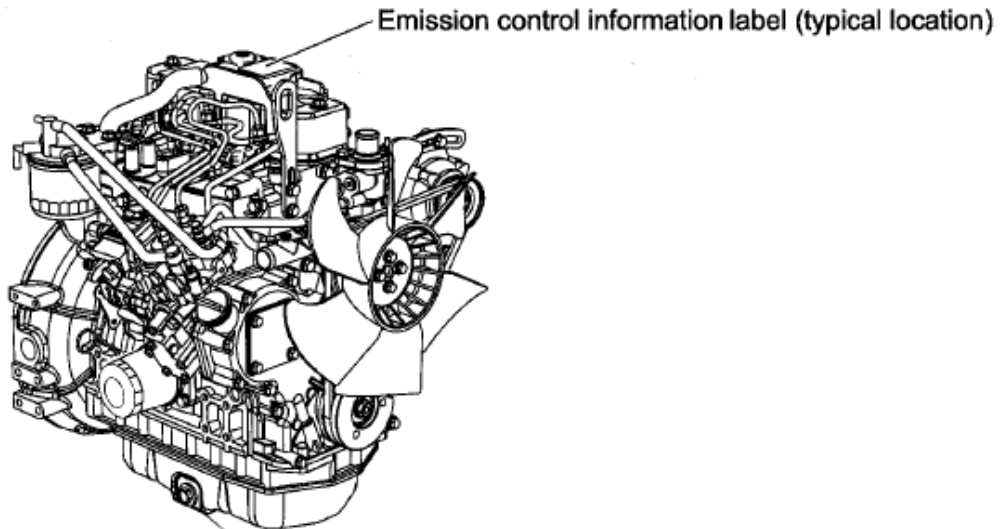


Isuzu Diesel Engine

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- **Label location:**

The typical location of this label for each engine is on the "top of rocker arm cover"
A supplemental label may be used in certain applications for improved visibility.



Requirements on engine installation condition

The followings are required from the point of view of engine installation in order to comply with the EPA and ARB regulations. Unless otherwise satisfying these, engines exhaust gas emission will not be within the regulated value of the EPA and ARB Regulations.

- Maximum Exhaust Gas Restriction shall be
15.29 kPa (1560mm H₂O) or less for 3CC1, 3CD1, 3CE1.
5.88 kPa (600mm H₂O) or less for 3CD1T.
- Maximum air intake restriction shall be 6.2kPa (635mm H₂O) or less and clean air cleaner element each time when air intake restriction exceeds the above mentioned value.

Emissions-related parts

The EPA and ARB regulates specific emissions-related parts to be warranted for the period in the following table. However, ultimate purchasers are obligated to use and maintain the engine correctly.

Warranty Periods

Power Range kW (Gross power)	Other than Constant-speed	Constant-speed
		Under 3000 min ⁻¹
Range < 19		1500 hours or 2 years
19 ≤ Range < 37		3000 hours or 5 years

*Actual hours or years of operation whichever occurs first is applied.

The specific emissions-related parts are

- Fuel injection nozzle
- Fuel injection pump
- Turbocharger

Isuzu Diesel Engine

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Maintenance schedule

To maintain optimum engine performance and compliance with the EPA Regulations Non-road Engines, it is necessary that the maintenance schedule is adhered to. Regular scheduled maintenance is a major key to engine service life and emissions regulations compliance. It is of utmost importance that scheduled maintenance, requirements are performed on a timely basis.

EPA allows to apply Maintenance schedule for Emission related parts as follows.

—	Check Fuel Injection Nozzle and clean	Adjust, cleaning and repair of Fuel Injection Pump and Fuel Injection Nozzle
kW \leq 130	1500 hours of use and at 1500-hour intervals thereafter	3000 hours of use and at 3000-hour intervals thereafter

Maintenance schedule not related to emissions is recommended in 5.2 List of Periodic Inspection.

Emission System Warranty Statement

U.S. EPA and CALIFORNIA EMISSIONS CONTROL WARRANTY STATEMENT

Isuzu Motors Limited warrants initial owner and each subsequent owner that the engine is designed, built and equipped so as to conform with applicable regulations for its warranty period.

Specific emissions-related parts and components are warranted for the period specified in "**Emissions-related parts**" whichever comes first, after the date of delivery to the initial owner. If any emissions-related part is defective during the warranty period, Isuzu will repair your engine at no cost to you including diagnosis, parts and labor.

To maintain engine performance and compliance with the regulations, the owner is responsible for the performance of the required maintenance listed in the instruction manual during the warranty period.

This emission warranty does not cover:

1. Failure caused by any of the following:

- Abuse, neglect, improper maintenance or use of non-genuine parts.
- Use of fuel oil and lubricating oil not recommended for the engine.
- Improper application and installation.

2. Add-on or modification affecting engine emissions.

The use of add-on or modified parts can be grounds for disallowing a warranty claim.

Isuzu is not liable to cover failures of the emission control system parts or components caused by the use of add-on or modified parts.

The 97/68/EC Directive Certified engines

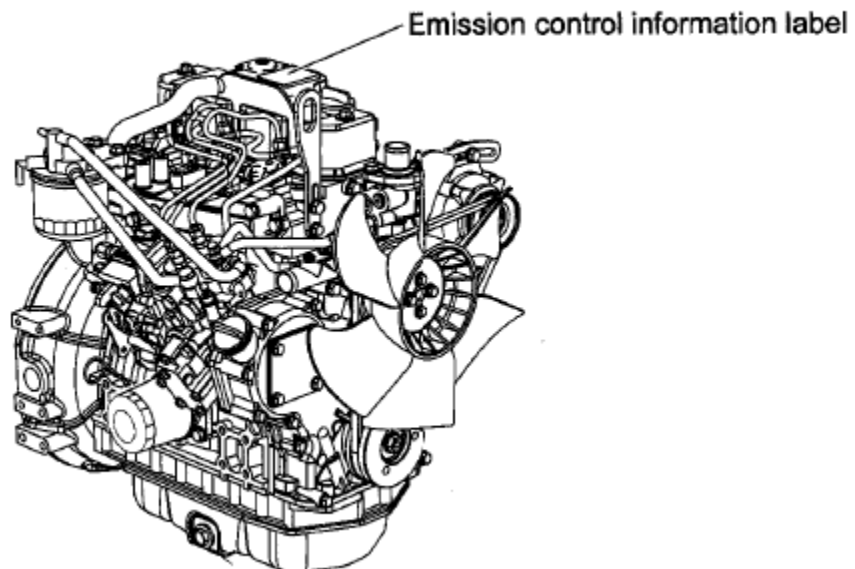
The engines in this manual have been certified by the 97/68/EC Directive.

To identify the engines, the following emission control label is affixed on the engines.

IMPORTANT ENGINE INFORMATION	
THIS ENGINE CONFORMS TO 97/68/EC DIRECTIVE	
ENGINE FAMILY :	Δ
ENGINE MODEL :	B
APPROVAL NUMBER :	C

EC Emission Control Label

- Label location:



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1. FOR YOUR SAFETY (Please make sure to read and fully understand the description for safety)

Following the precautions described in this manual will enable you to use this engine with complete satisfaction. Failure to observe any of the rules and precautions, however, may result in injury, burns, fires, and engine damage. Read this manual carefully and be sure fully understand it before beginning operation.

1.1 Warning Symbols

These are the warning symbols which are used in this manual and on the products. Symbols and their meanings are as follows.



DANGER- Indicates an imminently hazardous situation which, if not avoided, **WILL** result in death or serious injury.



WARNING- Indicates a potentially hazardous situation which, if not avoided, **COULD** result in death or serious injury.



CAUTION- Indicates a potentially hazardous situation which, if not avoided, **MAY** result in minor or moderate injury.

1. FOR YOUR SAFETY — 2

- The failure to comply with all relevant Safety Instructions could result in bodily injury.
- The descriptions captioned by **IMPORTANT** are particularly important cautions for handling. If you ignore them, the performance of your engine and machine unit may be deteriorated leading to trouble. It may also be used to alert against unsafe practices.

Warning indications on this engine (safety labels, etc.) are also shown on your machine unit side. Make sure to also observe warnings indicated on the machine unit and instructions contained in the instruction manual supplied from the machine unit manufacturer.

Keep the warning labels affixed on the engine and machine unit from becoming dirty or torn. If a warning label is missing, damaged or cannot be read, it must be promptly replaced, ordering it in the same way as for the service parts. Also, if a warning label is affixed on a part which is replaced, a new warning label must be affixed on the replaced part.

1.2 Safety Precautions

(These instructions should be strictly followed for the safety of you and others.)

1.2.1 Precautions for operation

⚠ DANGER



Preventing burns from scalding

- Never open the radiator filler cap shortly after shutting the engine down. Steam and hot water will spurt out and seriously burn you. Allow the engine to cool down before attempt to open the filler cap.
- Securely tighten the filler cap after checking the radiator. Steam can spurt out during engine running, if tightening loose.

⚠ DANGER



Sufficient ventilation of the battery area.

- Keep the area around the battery well ventilated, paying attention to keep sparks, open flame and any other form of ignition away. During engine running or charging battery, hydrogen gas is produced from the battery and can be easily ignited.

1. FOR YOUR SAFETY — 4



Preventing fire

- Be sure to use the proper diesel fuel. Filling with gasoline or the like by mistake will result in ignition.
- Be sure to stop the engine before refueling.
- If you spill fuel, wipe off such spillage completely.
- Never place oil or other flammable materials (such as straws, withered grass) close to the engine during running or shortly after shutting it down.
- Check fuel oil and engine oil for leakage from their piping lines to cause fires. Replace the rubber hoses with new ones every 2 years even if storing without use.
- Start the engine only from a starter switch without any load or in neutral position of the clutch of machine unit. Starting by means of connecting with the terminals of starter motor using a screwdriver or the like (jumping start) may cause fire due to spark at the terminals of starter motor. Also, the machine unit suddenly starts to move or generates power to cause serious personal injury.
- Keep the engine (machine unit) sufficiently away from a building and flammable materials during engine running. It may cause fires due to hot exhaust gas and engine body.
- Keep sparks, open flames or any other form of ignition (match, cigarette, etc.) away when fueling / refueling. Fire and or an explosion may result.

⚠ WARNING



Preventing exhaust fumes inhalation

- Never block up windows, ventilation ports, or other ventilation equipment such as ventilators of the engine room. Ensure good ventilation during engine operation. Inhaling the exhaust fumes is harmful.
- Never operate the engine in a closed room, tunnel, underground room, manhole or ship's hold. It is dangerous since exhaust fumes cannot get out.

⚠ WARNING



Keep away from moving / rotating parts

- Pay sufficient attention so as not to touch moving / rotating parts, or bring your hands or part of your body or clothes close to moving / rotating parts while the engine is running.
Otherwise, you may get injured by being caught by the cooling fan, fly-wheel or PTO shaft. Never operate the engine without covers on the moving / rotating parts. Also, always keep kids and pets away from the engine and machine unit.
- Check before starting the engine to see that any tools or cloths used in the maintenance have been removed from the area.

⚠ CAUTION



Preventing burn from contacting with hot surface

- Pay sufficient attention not to bring part of your hand and body or clothes in contact with the silencer, exhaust pipe, turbocharger and engine body during operation or shortly after stopping the engine.
The whole engine is hot and scalding / serious burns may result.
- Carry out cooling down engine running for 5 minutes without load before the engine has been stopped. Sudden shutting the engine down without any cooling down running causes the engine and around temperature to rise rapidly. Scalding / serious burns or fires may result.

⚠ WARNING

Never operate the engine while you are under the influence of alcohol

- Also, never operate the engine when you are ill or feel unwell as this results in unexpected accidents.

⚠ CAUTION



Safe work clothing

- Appropriate safety wear (gloves, special shoes / boots, eye / ear protection, head gear, harness' clothing, etc.) should be used / worn to match the task at hand. Avoid wearing jewelry, unbuttoned cuffs, ties or loose fitting clothes around moving machinery. A serious accident may occur if caught in moving / rotating machinery.
- Do not operate the engine and machine unit wearing earphone or head-phone to listen to music or radio. A serious accident may occur because it is difficult to hear a warning from outside.

1.2.2 Precautions for inspection

⚠ DANGER



Do not come in contact with battery electrolyte

- Batteries contain sulfuric acid. Do not allow it to come in contact with clothing, skin and or eyes, severe burns will result.
Always wear safety goggles and protective clothing when servicing the battery. If contact with the skin and or eyes should occur, flush with a large amount of water and obtain prompt medical treatment.

⚠ DANGER



- Do not intentionally make the battery spark by short-circuiting to check its remaining charge. It will cause fires.
Make sure to use a gravimeter to check the remaining charge of the battery.
- If the battery electrolyte frozen, recharge the battery after warming up to thaw it. It will cause explosion.

Do not expose your skin to high pressure fuel spray

- Be careful so as not to bring your skin in contact with high pressure fuel spray from broken fuel injection pipe to penetrate your skin to cause inflamed.

If exposing to the spray should occur, obtain prompt medical treatment.

When any leakage of high pressure fuel spray is found during engine running, intercept it with a wooden plate, etc. so as not to be exposed your skin to it and shut the engine down and ask your dealer or Isuzu distributor for repair.

⚠ WARNING



Preventing electric short-circuits

- Make sure to turn off the battery switch or disconnect the negative cable (-) before inspecting the electrical system. Failure to do so could cause short-circuiting and fires.
- Check the electric lead wires for any slackened, twisted, damaged and keep the connectors and terminals of wire harness clean. They may cause fires due to electric short-circuit.

⚠ WARNING



Keep off moving / rotating parts

- Stop the engine before starting service operation. If you must inspect while the engine is operating, never bring your hand, body or clothing in contact with or close to moving / rotating parts, as you may get injured by being caught by moving / rotating parts.

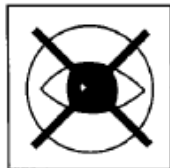
⚠ CAUTION



Preventing scald from draining hot oil and water

- If engine oil must be drained from the engine while it is still hot, take care not to let the oil splash on you to avoid scalding.
- Wait until the temperature goes down before draining the coolant. Hot water may splash to burn you.

⚠ CAUTION



Beware of dirt from air blowing

- Wear protective equipment such as goggles to protect your eyes when blowing compressed air or steam. Dust or flying debris can hurt eyes.

IMPORTANT:

Keep away from lifting up or traveling engine

- *Lifting up or traveling the engine for a repair by yourself could result in serious injury. If you need any repair, ask your dealer or Isuzu distributor.*
- *Be sure to keep away from the traveling engine or the area beneath the engine which is lifted up.*

IMPORTANT:

Modification not authorized

Never modify this product or release the limit devices (which limit engine speed, fuel injection quantity, etc.).

Such modification or release will impair the safety and performance of the product and functions and result in shorter engine life. And be sure to use Isuzu genuine part when replace the part with new one.

IMPORTANT:

Waste management

Observe the following instructions with regard to hazardous waste disposal. Negligence of these will have a serious impact on environmental pollution concerns.

- *Waste fluids such as engine oil, fuel and coolant shall be carefully put into separate sealed containers and disposed of properly.*
- *Do not dispose of waste materials irresponsively by dumping them into the sewer, overland or into natural waterways.*

Isuzu Diesel Engine

MAC800G Air Heater

1. FOR YOUR SAFETY ——— 12

- *Waste materials such as engine oil, fuel, coolant, solvents, filter elements and batteries, must be disposed of properly according to local ordinances. Consult the local authorities or reclamation facility.*

Never permit anyone to operate the engine and or machine unit without proper instruction.

- *Explain how to operate the engine and or machine unit to make fully understand the person from you when you let someone use it. At the same time, you let the one read this manual and the instruction manual for the machine unit to further understand how to operate.*

To keep the engine in the best condition

- *Avoid the engine running in the following surrounding conditions. Otherwise, the engine may cause to damage, to be not enough engine performance or to be shorten engine life.*
 - *In extreme dusty air.*
 - *In a harmful chemical gas or fumes.*
 - *In salty win (sea side).*
 - *Flooding place when raining.*
 - *Exposing the engine in raining.*
- *When steam cleaning or water cleaning the engine, protect the air cleaner and electric components from steam or water.*

- *It is essential to run your engine at the ambient temperature +45 ~ -15°C.
If the temperature is higher than the above, the engine may have overheating and get the extreme high temperature engine oil to cause engine trouble.
Contrarily, If the ambient temperature is lower than the above, the engine components made of rubber are hardened to cause damage.
When you run the engine at the temperature out of the above, contact your dealer or Isuzu distributor. Also when you run the engine on higher sea-level land, the engine output may not be enough and runs with poor exhaust gas due to lower atmospheric pressure and lean air intake.*

2. PRODUCT OVERVIEW

2.1 Intended Uses and Conditions

The environment friendly engine designed and controlled low exhaust gas emission, less noise and vibration has been delivered to you as a power source for civil, construction, agriculture, generator and other machine units.

- Easy starting with new developed fuel injection pump and combustion system.
- Economical running reduced fuel and engine oil consumption.
- Easy operation due to minimum maintenance and compact designed.
- Durable and reliable engine equipped with the new designed fuel injection valve and fuel injection pump.

We are sure that you will be satisfied with the above features.

Main power of this engine can be taken off from the flywheel end by means of "direct couple driving" or "belt driving". For direct couple drive engine, the flywheel housing or end plate to mount the engine to a machine unit is installed to the engine. For belt drive engine, the belt drive device equipped with a bearing is required so as not to damage the crankshaft and or main engine bearing. If you have need of the belt driving and or front power take-off device, please contact your dealer or Isuzu distributor.

The specifications of the main parts of the engine are standardized for multi-purpose application. Options (fuel tank, remote controller, instruments, alarms, etc.) are provided to meet various operating conditions. Since installation and fitting of the engine require special knowledge and skill, always consult your dealer or Isuzu distributor.

Isuzu Diesel Engine

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2. PRODUCT OVERVIEW — 16

- Please consult with us for selecting optional parts. Optional parts should be selected to best match the work conditions and environments.
- To obtain the maximum engine performance with a minimum risk of machine troubles and accidents, it is very important to match the engine with the machine unit.
- Carefully establish safe exhaust piping, electric wiring, ventilation and accurate engine installation.
- Certain applications may require an inspection by the authorities.

This manual describes operation based on the standard specifications. When coupled with the machine unit, operation procedures for options and accessories may vary depending on the structure of that machine unit.

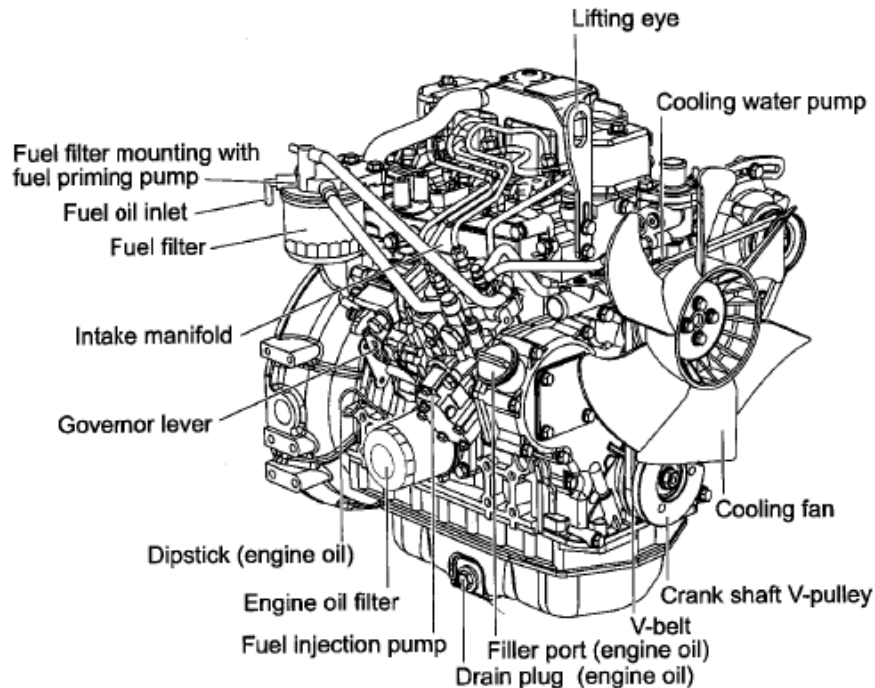
OPTION : Information for optional parts.

ENGINE NAME : Information for exclusive matter of the engine.

For optional parts or accessories refer to the instruction manual provided by the equipment manufacturer and observe the instructions and cautions given therein.

2. PRODUCT OVERVIEW — 17

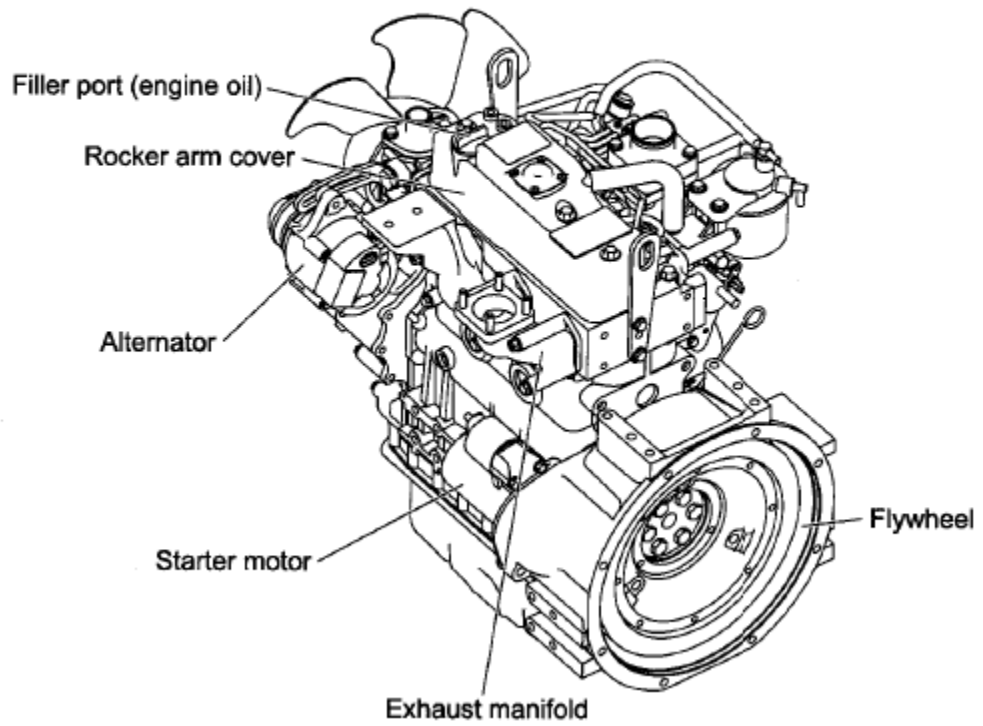
2.2 Names of parts



Isuzu Diesel Engine

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2. PRODUCT OVERVIEW — 18



2.3 Functions of Major Parts

Parts	Functions
Fuel filter	Removes dirt and water from the fuel oil. Periodic replacement of filter element is necessary before it is clogged with dirt. Replace the whole cartridge assembly for renewal.
Oil / water separator	Stand alone type (fitted on the machine unit)(engine maker supplies). Drain the dust and water periodically from the drain cock at the bottom of the separator fitted near the fuel tank of the machine unit.
Fuel priming pump	The priming pump on the top of the fuel filter mounting feeds the fuel by moving the knob of the priming pump up and down by hand to bleed the air from the fuel system. (The fuel filter mounting with priming pump is optional). The fuel priming pump position on the fuel filter mounting should be on the lower level than the fuel tank position. The electro-magnetic fuel feed pump provided as optional should be fitted on the fuel piping when installing the fuel filter mounting without fuel priming pump to bleed the air and feed fuel to the fuel injection pump.
Fuel feeding pump	Electro-magnetic fuel feeding pump (DC12V) (optional) should be fitted on the fuel piping to bleed air and feed fuel to the fuel injection pump when installing the fuel filter mounting without fuel priming pump.
Filler port (engine oil)	Filler port for engine oil.
Dipstick (engine oil)	Level gauge for engine oil in the oil pan.

Isuzu Diesel Engine

MAC800G Air Heater

2. PRODUCT OVERVIEW — 20

Parts	Functions
Engine oil filter	Filters fine metal fragments and carbon in the engine oil. The filter is a cartridge type and the filter element should be replaced before clogging occurs.
Air cleaner	Air intake device which drifting dust is prevented from entering the cylinder by means of the filter element, and it also serves to reduce the air intake noise. Periodic check (cleaning or replacement) of the filter element is necessary before it is clogged with dust.
[Cooling water system] •Radiator •Cooling fan and cooling water pump •Radiator cap •Sub-tank •Oil cooler (3CD1T)	<p>This engine is water-cooled system by means of radiator. Serves as cooling water storage tank and heat exchanger. The cooling fan is driven by the V-belt to cool the cooling water. The cooling water pump circulates the cooling water through the cylinder block and cylinder head to cool them, and returns the water into the radiator.</p> <p>The radiator cap is equipped with two pressure regulating valves: the release and vacuum valves. When the cooling water temperature rises, the radiator inner pressure gets higher and the release valve opens to release steam and overflowing thermally expanded hot water into the sub-tank through a rubber hose. (Note that the rubber hose connects the water supply port and the sub-tank.)</p> <p>Steam and hot water delivered to the sub-tank are cooled down to water again. When the load is reduced and the cooling water temperature drops, the radiator internal pressure becomes nearly negative, and vacuum valve on the radiator cap opens to suck back the water in the sub-tank to the radiator. This cycle minimizes the cooling water consumption.</p> <p>Cools engine oil by cooling water to minimize the deterioration.</p>
Starter motor	The starter motor pinion powered by battery engages with the ring gear installed on the flywheel and turn it to start the engine.

2. PRODUCT OVERVIEW — 21

Parts	Functions
Alternator	Driven by V-belt and generates electricity and charges the battery
Turbocharger (3CD1T)	The pressurized intake air feeding device to the cylinder. The turbine energized by exhaust gas rotates the blower.

2. PRODUCT OVERVIEW — 22

2.4 Control Equipment

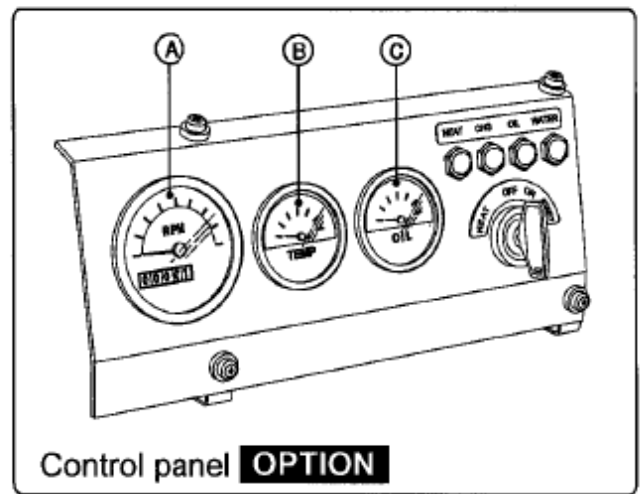
Control equipment described here includes monitoring the engine running conditions during operation, the devices for starting, adjusting the engine speed and stopping the engine.

2.4.1 Instruments and alarm devices

On the control panel for control equipment, following gauges and alarm devices could be installed.

(1) Instruments

- Ⓐ Tachometer (with integrated hour meter) **OPTION**
The needle shows the engine speed, Hour meter shows total operation hours in the window below the tachometer. Refer to the figure as a standard for periodic inspection.
- Ⓑ Cooling water temperature meter **OPTION**
The needle shows engine cooling water temperature.
- Ⓒ Engine oil pressure meter **OPTION**
The needle shows engine oil pressure.



(2) Lamps

OPTION

Ⓓ Heat up indicating lamp for air heater.

(HEAT: Blue)

When the key is turned to the HEAT position to energize the air heater, the lamp comes on. After keeping it at the HEAT position for approx. 15 seconds, the lamp goes off to turn the key to the START position.

Ⓕ Battery charge alarm lamp (CHG: Red)

The lamp is off while the battery is recharged. It comes on when the battery is not charged normally.

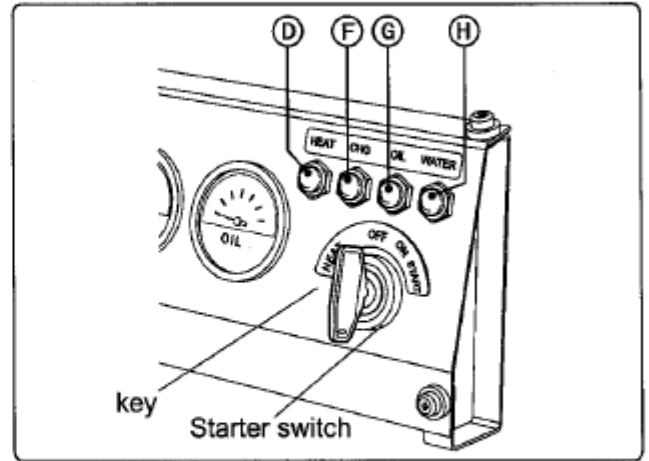
Ⓖ Engine oil pressure alarm lamp (OIL: Red)

The lamp comes on if engine oil pressure drops below the specified.

Ⓗ Cooling water temperature alarm lamp

(WATER: Red)

The lamp comes on if the cooling water temperature exceeds the specified (110°C or more).



2. PRODUCT OVERVIEW — 24

2.4.2 Operation Device

The devices for starting, adjusting the engine speed, and stopping the engine are as follows.

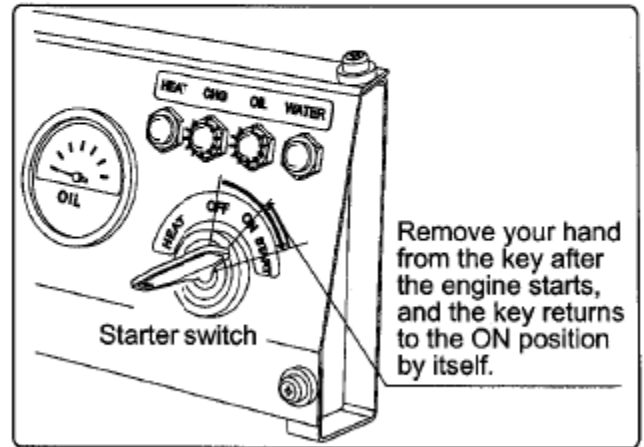
(1) Starter switch

OPTION

This is 3-stage rotary switch.

Position is changed by turning the key inserted to the slot of the starter switch.

- OFF: This is the engine stop position, and all electric current is cut off. The key can be inserted and removed at this position.
- ON: This position provides the normal operating condition.
Current flows to instruments and alarm devices.
- START: This is the starting position. The starter motor rotates to crank the engine.
The key returns automatically to the ON when it is released.
- HEAT: This position is used to energize the air heater.
The key returns automatically to the OFF when it is released.



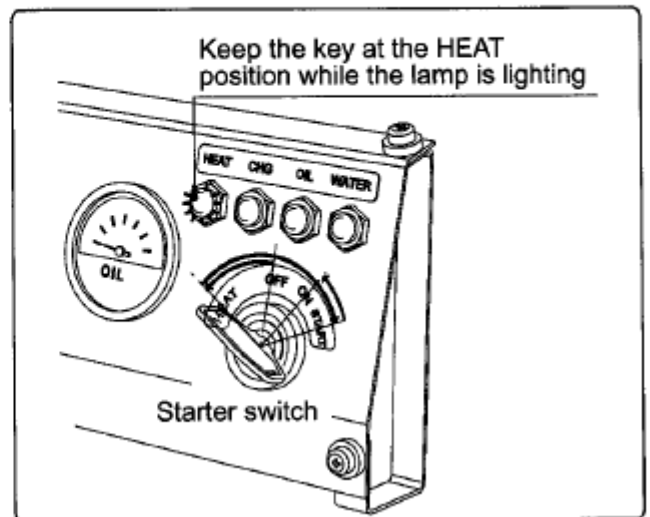
2. PRODUCT OVERVIEW — 25

(2) Air heater (cold starting aid)

OPTION

Located on the intake manifold inlet, the air heater is heated up to start the engine easily under low temperature conditions.

After keeping the key at the HEAT position for approx. 15 seconds, the lamp goes off to turn the key to the START position.



Isuzu Diesel Engine

MAC800G Air Heater

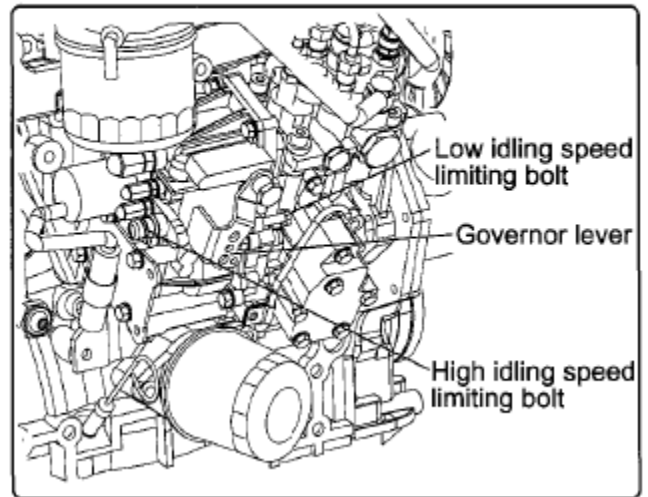
2. PRODUCT OVERVIEW — 26

(3) Governor lever

This lever controls the engine speed via the speed control device of the machine unit.

It is linked with the accelerator system on the machine unit side (accelerator handle and pedal to be procured by the equipment manufacturer) by means of an accelerator wire for remote control.

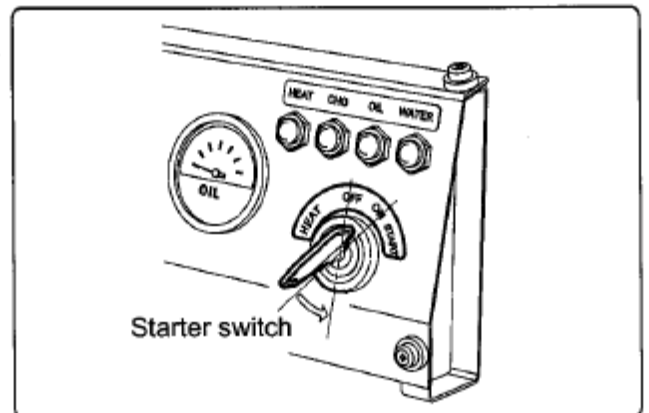
High idling and low idling speed are restricted by their limiting bolt.



2. PRODUCT OVERVIEW — 27

(4) Engine stopping device

When the key is turned to the OFF position, the engine stop solenoid actuates the valve of fuel injection pump to stop fuel.



2. PRODUCT OVERVIEW — 28

3. BEFORE OPERATION

Follow procedures in 3.1 through 3.5 for preparation before starting the engine.

The engine of no contained fuel oil, engine oil and cooling water will be delivered from Isuzu engine factory. If containing them in your engine equipped in the machine unit, read this section carefully to fully understand the required fuel oil, engine oil, cooling water and how to fill with them.

3.1 Fuel Oil, Engine Oil and Cooling Water

3.1.1 Fuel oil

IMPORTANT:

Only use the recommended fuel to obtain the best engine performance and prevent damage of parts, also prevent air pollution.

(1) Selection of fuel oil

Use the following diesel fuels for best engine performance:

BS 2869 A1 or A2

Fuels equivalent to Japanese Industrial Standard, JIS. No. K2204-2

Cetane fuel number should be 45 or greater

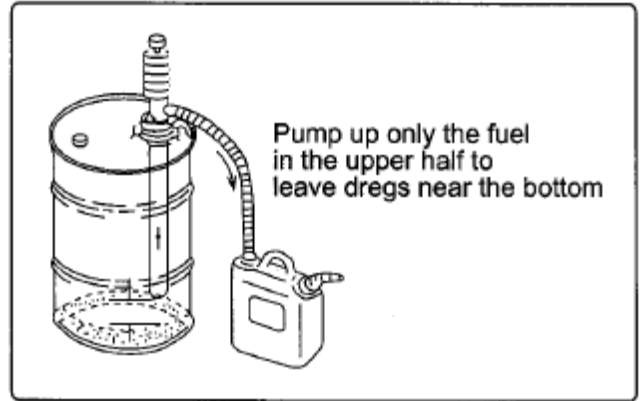
Isuzu Diesel Engine

MAC800G Air Heater

3. BEFORE OPERATION — 30

(2) Fuel handling

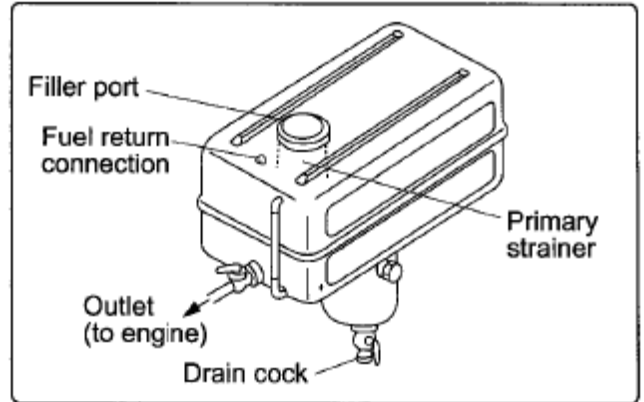
- Water and dust in the fuel oil can cause operation failure.
Use containers which are clean inside to store fuel oil. Store the containers away from rain water and dust.
- Before supplying fuel, let the fuel container rest for several hours so that water and dust in the fuel are deposited on the bottom. Pump up only the clean fuel.



(3) Fuel tank

OPTION

Be sure to attach a drain cock, precipitation trap and primary strainer to the fuel tank as shown illustration right.



3.1.2 Engine oil

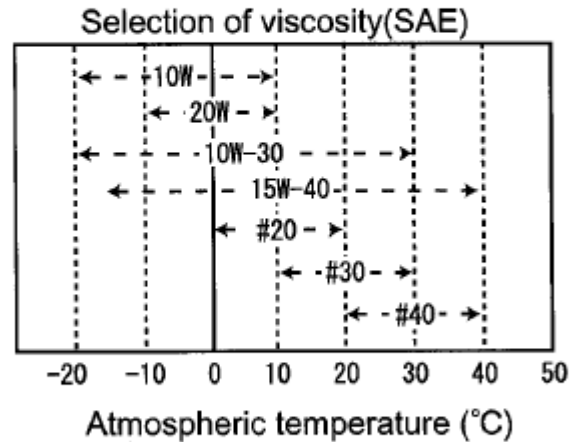
IMPORTANT:

Use of other than the specified engine oil may cause inner parts seizure or early wear, leading to shorten the engine service life.

(1) Selection of engine lube oil

use the following engine oil

- API classification CD or CF
(Standards of America Petroleum Institute)
 - SAE viscosity 10W-30 or 15W-40
(Standard of Society of Automotive Engineering)
- Engine oil with 10W-30 or 15W-40 can be used throughout the year.
(Refer to the shown right.)



(2) Handling of engine oil

- Carefully store and handle the oil so as to prevent dust or dirt entrance. When supplying the oil, pay attention and clean around the filler port.
- Do not mix different types of oil as it may adversely affect the lubricating performance.

3. BEFORE OPERATION — 32

⚠ CAUTION

Contact with engine oil may result in the roughened skin. Care should be taken so as not to contact with engine oil wearing protective gloves and clothing.

If contact, wash with soap and water thoroughly.

3.1.3 Cooling water

Use clean soft water and be sure to add the Long Life Coolant Antifreeze (LLC) in order to prevent rust built up and freezing. If there is any doubt over the water quality, distilled water or pre-mixed coolant should be used. The coolants / antifreezes, which are good performance for example, are shown below.

- TEXACO LONG LIFE COOLANT ANTIFREEZE, both standard and pre-mixed.
Product codes 7997 and 7998
- HAVOLINE EXTENDED LIFE ANTIFREEZE / COOLANT
Product code 7994

IMPORTANT:

- *Be sure to add Long Life Coolant Antifreeze(LLC) to soft water. In cold season, the LLC is especially important. Without LLC, cooling performance will decrease due to scale and rust in the cooling water line. Without LLC, cooling water will freeze and expand to break the cooling line.*
- *Be sure to use the mixing ratios specified by the LLC manufacturer for your temperature range.*
- *Do not mix different types (brand) of LLC, chemical reactions may make the LLC useless and engine trouble could result.*
- *Replace the cooling water every once a year.*

3. BEFORE OPERATION — 33

⚠ CAUTION

When handling Long Life Coolant Antifreeze, wear protective rubber gloves not to contact with it. If contact with the eyes or skin should occur, wash with clean water.

3.2 Supplying Fuel

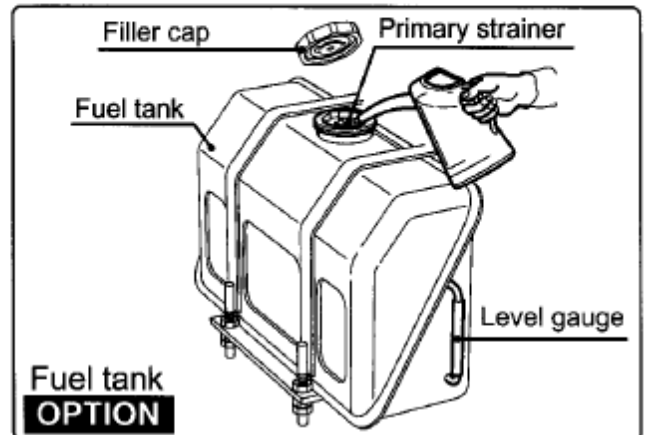


(Refer to 3.1.1.Fuel)

- Be sure to use the correct type of fuel when fueling / refueling. Mistakenly filling with gasoline or the like will result in ignition.
- Never refuel while the engine is running. If you spill fuel, wipe off such spillage completely.
- Never place oil or other flammable material close to the engine as this could result in ignition.
- Keep sparks, open flames or any other form of ignition (match, cigarette, etc.) away when fueling / refueling. Fire and or an explosion may result.

3.2.1 Filling the fuel tank

Fill the tank with clean fuel which has not been contained with water or dust. Do not remove the primary strainer from the filler port when fill the fuel tank. If remove, trash or dust could get into the fuel tank to cause fuel pipe line clogging. Overfilling is dangerous. Do not fill the tank beyond the full mark of the fuel gauge. Be sure to fill the fuel tank at well ventilated place.

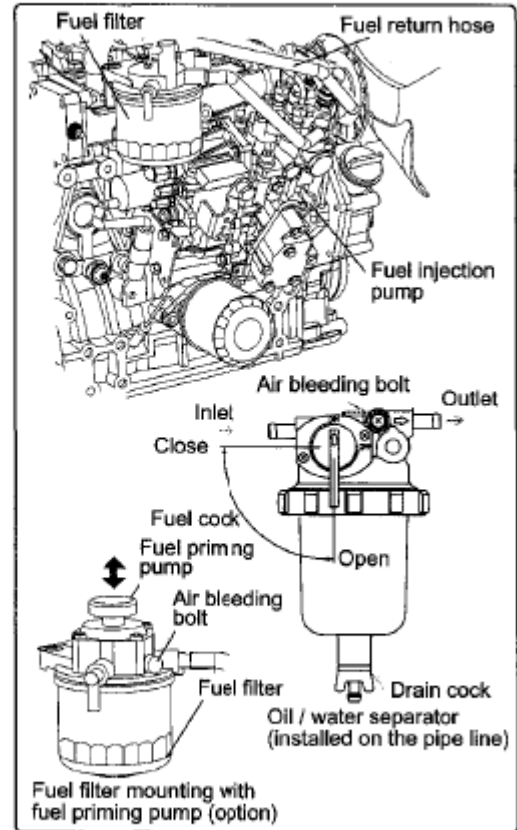


3. BEFORE OPERATION — 36

3.2.2 Bleeding the fuel system

Bleed the fuel system according to the following procedures. When there is air in the fuel system, the fuel injection pump will not be able to function.

- 1) Check the fuel oil level in the fuel tank. Refuel if insufficient.
- 2) Open the cock of the oil / water separator.
- 3) Loosen the air bleeding bolt on the oil /water separator by turning 2~3 times to the counter-clockwise using screw driver or spanner.
- 4) When the fuel coming out is clear and not mixed with any bubbles, tighten the air bleeding bolt.
- 5) Feed the fuel with the fuel priming pump or electromagnetic fuel feeding pump.
 - In case of the engine using the electromagnetic fuel feeding pump. **OPTION**
Turn the starter switch to the ON position and hold it in the position for 10~15 seconds to operate the fuel feeding pump.
 - In case of the engine installed the fuel filter mounting with the fuel priming pump. **OPTION**
Follow steps 1) to 4) of the above and then follow the steps below.
- 6) Loosen the air bleeding bolt on the fuel filter mounting by turning 2~3 times to the counter-clockwise using a screw driver or spanner.



3. BEFORE OPERATION — 37

- 7) Move the priming pump up and down to feed fuel until the fuel coming out is not mixed with any bubbles. And then tighten the air bleeding bolt.

3. BEFORE OPERATION — 38

3.3 Supplying Engine Oil

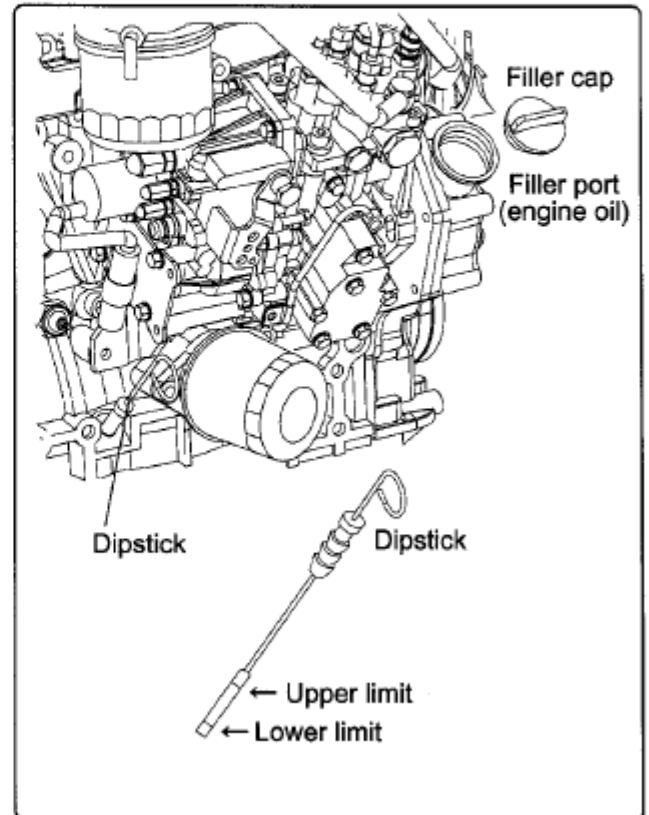
(Refer to 3.1.2 Engine oil)

Fill the oil pan with engine oil as specified level.

- 1) When checking or filling / refilling the engine oil, place the machine unit so that the engine is set on a level.
- 2) Remove the filler cap (yellow colored) on the rocker arm cover or on the side of the engine.
- 3) Fill with engine oil up to the upper limit on the dipstick. To check the oil level, insert the dipstick in fully. When checking the engine oil level with the dipstick, wait for about 3 minutes and then check the level as it takes a little while for the engine oil supplied from the filler port to fill the oil pan.
- 4) Manually tighten the filler cap. Do not use a tool such as pliers to tighten it. Excess tightening may cause to damage the filler cap.

IMPORTANT:

Do not overfill the oil pan with engine oil. Overfilling may result in white exhaust smoke, sudden over engine speed or engine internal damage, getting engine oil into the intake port. Be sure to keep the specified level between upper limit and lower limit on the dipstick.



Engine oil capacity (oil pan) (L)	
3CD1, 3CD1T, 3CE1	6.7
3CC1	5.5

NOTICE:

Engine oil capacity may differ from the above depending on the engine installed on the machine unit.

Refer to the instruction manual provided by the equipment manufacturer.

3.4 Supplying Cooling Water



(Refer to 3.1.3. Cooling water)

- Never open the radiator filler cap while the engine and radiator are still hot. Steam and hot water will spurt out and seriously burn you. Wait until the radiator is cooled down after the engine has stopped, wrap the filler cap with a rag piece and turn the cap slowly to gently release the pressure inside the radiator.
- Securely tighten the filler cap after checking the radiator. Steam can spurt out during operation, if the cap is tightened loosely.

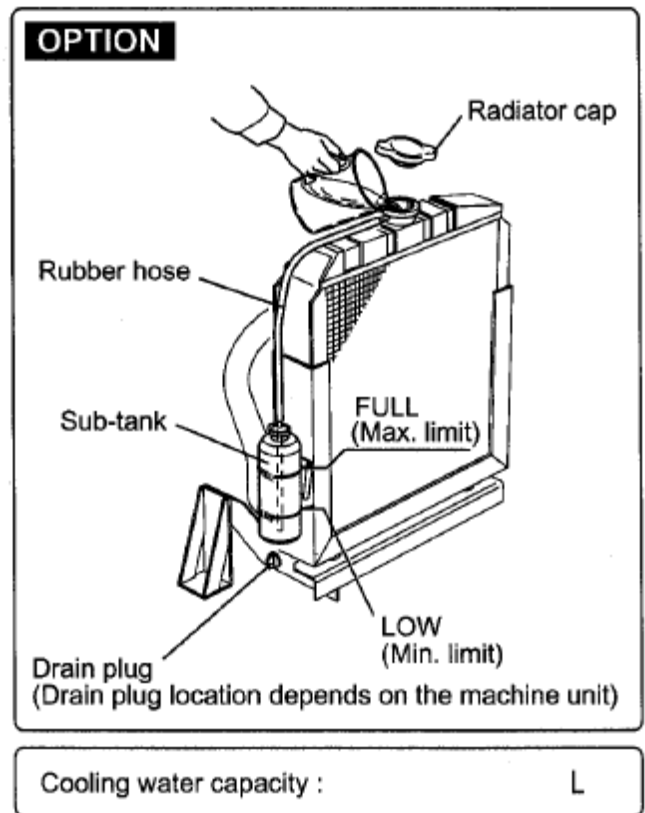
Isuzu Diesel Engine

MAC800G Air Heater

3. BEFORE OPERATION — 41

Fill the radiator and sub-tank with the cooling water as following procedures.

- 1) Before filling, check to be sure the drain plug is closed.
- 2) Remove the radiator cap of the radiator by turning the radiator cap counter-clockwise about 1/3 of a turn.
- 3) Pour the cooling water slowly into the radiator up to the lip of the filler port so that air bubbles do not develop.
- 4) After supplying the cooling water, surely tighten the radiator cap. To fasten the radiator cap, align the claws on the back face of the radiator cap with the notches of the filler port and press-turn the cap clockwise approx. 1/3 of a turn until contact with each other.
- 5) Remove the cap of the sub-tank, supply the cooling water to the FULL mark and fasten the cap.
- 6) Check the rubber hose connecting the sub-tank to the radiator. Be sure the rubber is securely connected and there is no looseness or damage. When the rubber hose is not water tight, an excessive amount of cooling water will be consumed.
- 7) When filling with the cooling water for the first time or replacing, the cooling water will enclose the air into the cooling water system. So, as the air in the cooling water system is made to bleed automatically during engine operation, the cooling water level in the radiator and sub-tank will be lowered. Replenish the cooling water into the radiator and sub-tank until it reaches the FULL mark of the sub-tank.



3. BEFORE OPERATION ——— 42

- Daily check of the cooling water level and refilling can be done by observing the sub-tank. **OPTION**
Refer to 4.1(4)
- The cooling water capacity of the radiator **OPTION** depends on the machine unit.
Refer to the instruction manual provided by the equipment manufacturer. And write down the cooling water capacity above right blank to remember.
- Check the cooling water level when the engine is cold. Radiator cooling water flows to the sub-tank when the radiator is still hot and makes accurate checks impossible.
- Check radiator and hoses for leakage.

3. BEFORE OPERATION ——— 43

3.5 Checking the Engine Oil and Cooling Water

When engine oil or cooling water is supplied for the first time or replaced, run the engine for a while and check the oil and water levels again.

The apparent levels go down because of being distributed to the engine oil passages and self-bleeding air in the cooling water system.

Refill with engine oil and cooling water until they reach the specified level.

(When checking the engine oil again after engine running, wait for about 10 minutes and then check the level as it takes a while for engine oil adhered to the engine internal parts to return to the oil pan.)

- For refilling with engine oil, refer to section 3.3.
- For refilling with cooling water, refer to section 3.4.

4. OPERATION INSTRUCTIONS

This section describes the procedures for starting, adjusting the speed and stopping the engine and the preparation before keeping the engine in storage for a long time.

⚠ WARNING

Never operate the engine while you are under the influence of alcohol

- Also, never operate the engine when you are ill or feel unwell as this results in unexpected accidents.

⚠ CAUTION



Safe work clothing

- Appropriate safety wear (gloves, special shoes / boots, eye / ear protection, head gear, harness' clothing, etc.) should be used / worn to match the task at hand. Avoid wearing jewelry, unbuttoned cuffs, ties or loose fitting clothes around moving machinery. A serious accident may occur if caught in moving / rotating machinery.
- Do not operate the engine and machine unit wearing earphone or headphone to listen to music or radio. A serious accident may occur because it is difficult to hear a warning from outside.

4. OPERATION INSTRUCTIONS — 46

⚠ WARNING



Preventing exhaust fumes inhalation

- Never block up windows, ventilation ports, or other ventilation equipment such as ventilators of the engine room. Ensure good ventilation during engine operation. Inhaling the exhaust fumes is harmful.
- Never operate the engine in a closed room, tunnel, underground room, manhole or ship's hold. It is dangerous since exhaust fumes cannot get out.

⚠ WARNING



Keep away from moving / rotating parts

- Pay sufficient attention so as not to touch moving rotating parts, or bring your hands or part of your body or clothes close to moving / rotating parts while the engine is running. Otherwise, you may get injured by being caught by the cooling fan, fly-wheel or PTO shaft. Never operate the engine without covers on the moving / rotating parts. Also, always keep kids and pets away from the engine (machine unit).
- Check before starting the engine to see that any tools or cloths used in the maintenance have been removed from the area.

4. OPERATION INSTRUCTIONS — 47

⚠ CAUTION



Preventing burn from contacting with hot surface

- Pay sufficient attention not to bring part of your hand and body or clothes in contact with the silencer, exhaust pipe, turbocharger and engine body during operation or shortly after stopping the engine. The whole engine is hot and scalding / serious burns may result.
- Carry out cooling down engine running for 5 minutes without load before the engine has been stopped. Sudden shutting the engine down without any cooling down running causes the engine and around temperature to rise rapidly. Scalding / serious burns or fires may result.

4. OPERATION INSTRUCTIONS ——— 48

4.1 Check before Daily Operation

Be sure to check the following points before starting the engine every day.

(1) Visual check around engine. If any problem is found, do not use before the engine repairs have been completed.

- Oil leak from the lubrication system
- Fuel leak from the fuel system
- Cooling water leak from the cooling water system
- Damaged parts
- Loosened or lost bolts
- Fuel, radiator rubber hoses cracked, loosened clamp

(2) Checking and refueling

Check the remaining fuel oil level in the fuel tank and refuel the recommended fuel if necessary.

(3) Checking and replenishing engine oil

- 1) Check the engine oil level with the dipstick.
- 2) If the remaining engine oil level is low, replenish the specified engine oil to the specified level through the filler port. Replenish the oil to the upper limit mark while checking the level with the dipstick gauge. See 3.3

(4) Checking and replenishing cooling water



Burns from scalding



- Never open the radiator filler cap while the engine and radiator are still hot. Steam and hot water will spurt out and seriously burn you. Wait until the radiator is cooled down after the engine has stopped, wrap the filler cap with a rag piece and turn the cap slowly to gently release the pressure inside the radiator.
- Securely tighten the filler cap after checking the radiator. Steam can spurt out during operation, if the cap is tightened loosely.

- 1) Check the cooling water level in the sub-tank. If the water level is close to the LOW mark, open the sub-tank cap and replenish clean soft water to the FULL mark.
- 2) If the sub-tank water level is lower than the LOW mark, open the radiator cap and check the cooling water level in the radiator. Replenish the cooling water into the radiator and sub-tank if the level is low. Refer to 3.4
 - Check the cooling water level while the engine is cool. Checking when the engine is hot is dangerous. And the water volume is expanded due to the heat.
 - Daily cooling water level check and replenishing shall be done only at the sub-tank. If the cooling water is close to the LOW mark, open the sub-tank cap and replenish only clean soft water to the FULL mark. Usually do not open the radiator cap to check or replenish.

4. OPERATION INSTRUCTIONS — 50

IMPORTANT:

If the cooling water runs short quickly or when the radiator runs short of water with the sub-tank level unchanged, water may be leaking or the air tightness may be lost. In such case, please contact your dealer.

Increase in the sub-tank water level during operation is not abnormal.

The increased water in the sub-tank returns to the radiator when the engine is cooled down.

(5) Checking accelerator operation

Make sure the accelerator of the machine unit can be operated smoothly before starting the engine. If it feels heavy to manipulate, lubricate the accelerator cable joints and pivots. Adjust the accelerator cable if there is a dislocation or excessive play between the accelerator and the governor lever. Refer to 5.3.3(3)

(6) Checking alarm operation

Before and after starting the engine, check to see the alarm function normally. Failure of alarm cannot warn the lack of the engine oil or the cooling water. Make it a rule to check the alarm operation before and after starting engine every day. Refer to 4.2

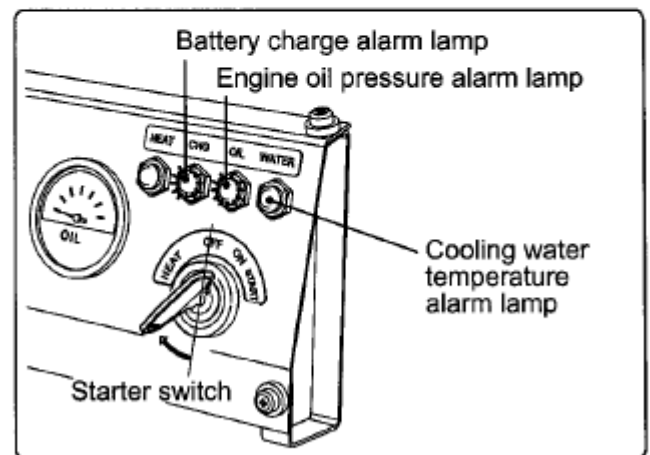
4.2 Checking the Control Panel and Alarm Devices

Be sure to check the alarm devices and other instruments on the panel before and after starting the engine. If the devices are not working properly, it is impossible to prevent any problems arising from insufficient oil and water in the engine. Make checking the alarm and other devices before and after starting a regular practice.

4.2.1 Checking alarm lamps

- 1) Insert the key into the starter switch.
- 2) Turning the key to the ON position, the alarm devices function as follows.
 - Battery charge alarm lamp comes on.
 - Engine oil press. alarm lamp comes on.
 - Cooling water temp. alarm lamp does not come on.When the lamps function as above, everything is normal.
- 3) When the key is turned to the START position to start the engine and then returned to the ON position after the engine starting up, the alarm devices function as follows.

All alarm lamps go off. After the engine starts up make it the rule to check alarm devices. If they do not work normally, contact your dealer.



4. OPERATION INSTRUCTIONS — 52

Function of alarm devices		
Alarm lamps	Key operation	
	OFF → ON	START → ON
Battery charge alarm lamp	ON	OFF
Engine oil pressure alarm lamp	ON	OFF
Cooling water temperature alarm lamp	OFF	OFF

4. OPERATION INSTRUCTIONS — 53

4.2.2 Checking the instruments (meters)

Before starting the engine, the needles of the meters are on the left side end. After starting the engine, the needles indicate the engine running conditions. Check the engine running conditions.

(A) Tachometer

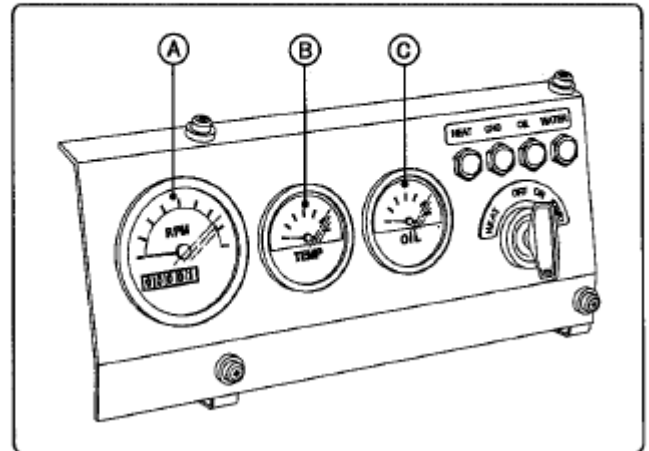
The needle indicates the engine speed in response to the running speed.

(B) Cooling water temperature meter

The needle indicates the cooling water temperature.

(C) Engine oil pressure meter

The needle indicates the engine oil pressure.



4.3 Starting

⚠ DANGER



Preventing fire

- Start the engine only from a starter switch without any load or in neutral position of the clutch of machine unit. Starting by means of connecting with the terminals of starter motor using a screwdriver or the like (jumping start) may cause fire due to spark at the terminals of starter motor. Also, the machine unit suddenly starts to move or generates power to cause serious personal injury.

⚠ WARNING



Keep away from moving / rotating parts

- Check before starting the engine to see that any tools or cloths used in the maintenance has been removed from the area.
- Pay sufficient attention so as not to touch moving / rotating parts, or bring your hands or part of your body or clothes close to moving / rotating parts while the engine is running.

Otherwise, you may get injured by being caught by the cooling fan, fly-wheel or PTO shaft. Never operate the engine without covers on the moving / rotating parts. Also, keep kids and pets away from the engine (machine unit).

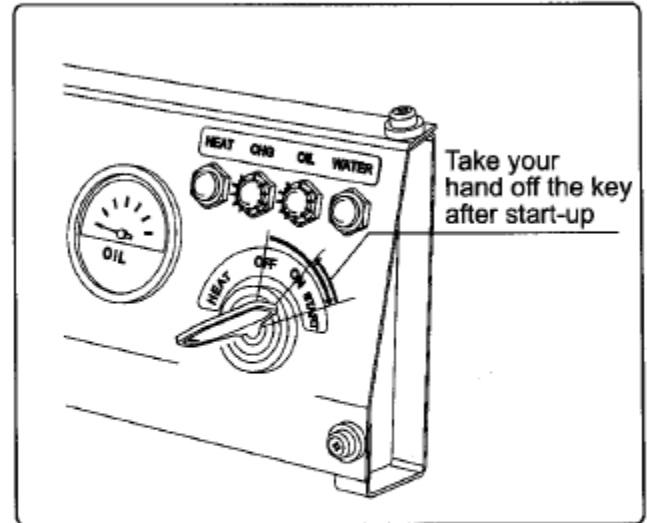
4.3.1 Daily starting the engine procedure

Start the engine as shown below.

- 1) Place in neutral position of the clutch or turn the main switch OFF to release the load on machine unit.
- 2) Open the cocks of the oil / water separator and fuel tank.
- 3) Insert the key into the starter switch.
- 4) Turn the key from the OFF to the ON position. Check all alarms are normal. Refer to 4.2.1
- 5) Set the accelerator (Governor lever) on the middle speed position.
- 6) Turn the key to the START position to start the engine. Release the key as soon as the engine starts. The key automatically returns to the ON position. If the engine does not start, turn the key to the OFF position first before trying to start again.

IMPORTANT:

Do not hold the key at the START position for more than 15 seconds at a time. Any longer attempt will overheat the starter motor.



Isuzu Diesel Engine

MAC800G Air Heater

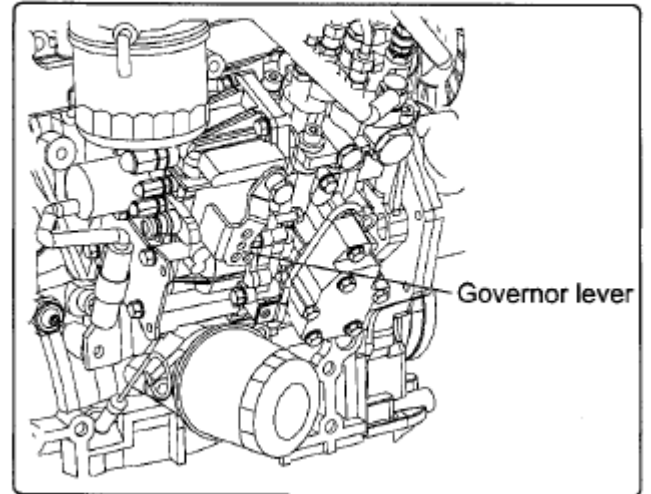
4. OPERATION INSTRUCTIONS — 56

4.3.2 Warming up running

After the engine has started, make sure to run for 5 minutes at an even low engine speed and without any load. On load running while the engine is cold causes to emit black exhaust smoke and shortens engine life as this engine has the device automatically adjusting the fuel injection quantity and timing by detecting the cooling water temperature. While warming up running, check the engine for any abnormal sound.

IMPORTANT:

Do not race the engine while it is cold.



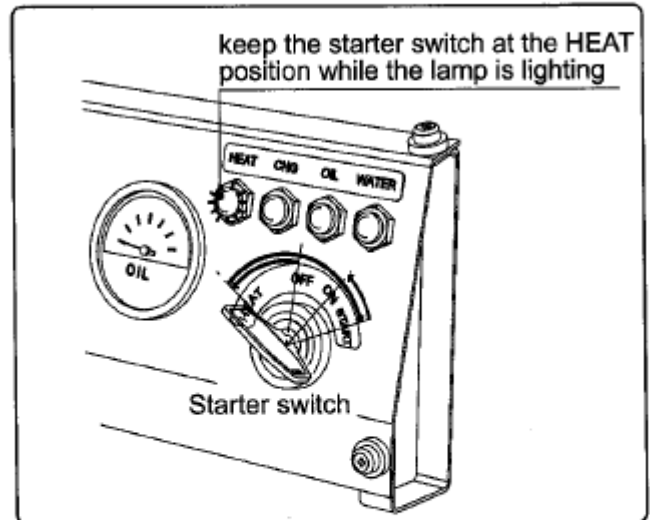
4.3.3 Starting up the engine at low ambient temperature

If the engine is hard to start in cold weather (approx. 0°C or below), use the air heater **OPTION** for easier starting. Follow steps 1) to 4) of the previous mentioned procedure and then follow the steps below.

- 7) Set the accelerator on the maximum speed position.
- 8) Turning the key from the OFF to the HEAT position, the HEAT lamp (blue colored) **OPTION** comes on. Keep the key in the HEAT position while the lamp is lighting.
- 9) When the air heater is heated up after about 15 seconds, the lamp goes off to turn the key to the START position. Remove your hand from the key as soon as the engine starts, and the key returns to the ON position by itself.

IMPORTANT:

- *Do not leave the air heater on for longer than 20 seconds at a time. Leaving the air heater on for longer periods of time will result in damage.*
- *Never use a engine start aiding liquid such as gasoline, ether. They will result in engine damage.*



Isuzu Diesel Engine

MAC800G Air Heater

4. OPERATION INSTRUCTIONS — 58

4.3.4 Restarting after starting failure

When attempting to restart the engine after starting failure, be sure that the engine is at a complete stop before turning the key.

IMPORTANT:

- Do not turn the key to the *START* position when the engine is not completely stopped or during operation. Otherwise, the starter motor pinion or ring gear will be damaged.
- Wait at least 30 seconds before the second attempt to allow for battery voltage recovery.

4.3.5 After the engine has started

After the engine has started, warm up the engine (refer to 4.3.2) and check the following points. If any abnormality, stop the engine and contact your dealer.

- Alarm lamps and instruments
- Water leak and oil leak from engine
- Color of exhaust gas
- Vibration or noise

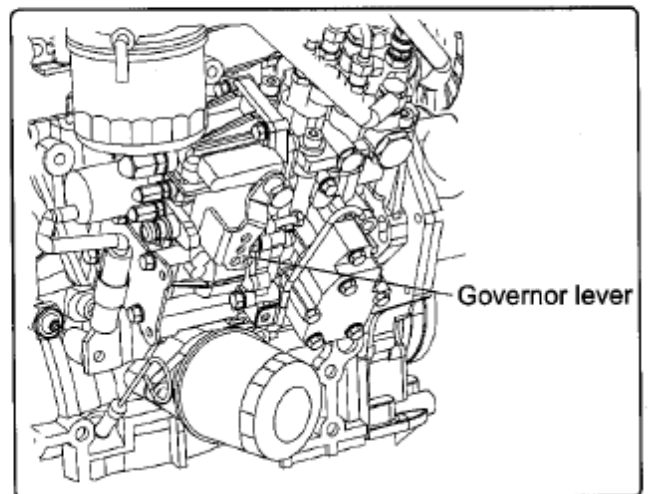
4. OPERATION INSTRUCTIONS — 59

4.4 Adjusting the Engine Speed

The engine speed is controlled by the governor lever. It is linked with the accelerator system on the machine unit side (accelerator handle and pedal to be procured by the equipment manufacturer) by means of an accelerator wire for remote control.

IMPORTANT:

For a new engine, be especially careful not to change engine speed abruptly or attach a heavy load for the first 50 hours of operation. Failure to do so may result in damage and shorten the life of the engine.



4. OPERATION INSTRUCTIONS — 60

4.5 Check during Operation

Watch the following points to check the engine conditions.

- Exhaust gas color

Avoid engine operation if black smoke continues to come out. Black smoke is generated when the engine is overloaded. This shortens the engine life.

- Abnormal noise or vibration

Depending on the machine unit structure, resonance may arise at a certain engine speed, resulting in sudden violent vibration. Avoid engine operation near that speed.

- Alarm lamps

If an alarm lamp comes on, do not be flurried but decrease the engine speed and remove the load on the engine. Then, stop the engine, check the cause and take the necessary action.

- Water, oil or gas leakage, or loosened bolts

Occasionally check the engine and its peripheral parts for any symptom of leakage or loosened bolt.

- Low fuel level in tank

Always replenish fuel before the level drops too low during operation.

IMPORTANT:

- *Allowable inclined engine operation : 25 deg. max. (both tossed and rolled side)*

Excess inclined engine operation may result in white exhaust smoke, sudden over engine speed or engine internal damage, getting engine oil into the intake port. Operate the engine on a place as level as possible.

4. OPERATION INSTRUCTIONS — 61

- *Avoid low load running as much as possible. When operating at low load, operate at 1/4 load or greater. If it continues for a long time, carbon will mix in with the unburned fuel depositing the piston head, injection nozzle and exhaust pipe to cause engine trouble.*
- *Do not turn the key to the START position while engine running. Otherwise, the starter motor pinion or ring gear will be damaged.*

4.6 Stopping the Engine

CAUTION



- Pay sufficient attention not to bring part of your hand and body or clothes in contact with the silencer, exhaust pipe, turbocharger and engine body during operation or shortly after stopping the engine. The whole engine is hot and may cause scalding / serious burns.
- Carry out the cool-down running for 5 minutes without load before the engine has been stopped. Suddenly shutting the engine down without any cool-down running causes the engine and around temperature to rise rapidly. Scalding / serious burns or fires may result.

Stop the engine in accordance with the following procedures.

- 1) Remove the load on the engine by disengaging the clutch or turning the main switch off.
- 2) Set the accelerator (governor lever) to the LOW speed position and carry out cool-down running for 5 minutes.
- 3) Turn the key to the OFF position to stop the engine. Remove the key from the starter switch and place it in a safe place.
- 4) Close the cock of the fuel tank.

IMPORTANT:

- *If the engine is stopped immediately after removing load, the temperature of engine parts will rise suddenly, and this could cause engine trouble. Always operate the engine without load at low speed for 5 minutes.*
- *When letting the engine (machine unit) leave in open air after operating, place on the level kept away from flammable material such as straws, withered grass as this could result in ignition. And after cooling the engine (machine unit) thoroughly, cover it with airtight plastic covers to protect the air cleaner, silencer and electrical parts (alternator, starter motor, switches, etc.) from water and dust.*

4. OPERATION INSTRUCTIONS — 64

4.7 Taking Care during Long-term Storage

When the engine is to be stored for a long time (3 months or more), take the following care for the next use.

4.7.1 Inspection and maintenance during long-term storage

(1) Periodic check

If the next periodic check is drawing near, carry out the inspection before storage.

(2) Cooling water

Be sure to be clean soft water added Long Life Coolant Antifreeze (LLC) in the cooling water system and do not drain the cooling water added LLC before long-term storage.

If drain the cooling water, it will cause to built up rust due to the residual water in the cooling water system.

(3) Exterior cleaning, fuel oil draining and greasing

- Clean the outside of the engine wiping off any dust or oil.
- To prevent condensation of moisture inside the fuel tank, either drain off the fuel oil or fill the tank with fuel oil.
- Grease the exposed area and joints of the accelerator system.

(4) Water - and dust - proofing

- Protect the air cleaner, silencer and electrical parts (alternator, starter motor, switches) from water and dust with airtight plastic covers.
- Store the engine at a well ventilated place not subject to high moisture or dust.

(5) To prevent the battery self-discharging

- Disconnect the negative terminal (-) of the battery during storage.
- To refill self-discharge from the battery, charge the battery at least once a month during storage.

4. OPERATION INSTRUCTIONS — 65

4.7.2 Checking the engine for reuse after long storage period

When using the engine after a long period of storage, prepare for operation in the same manner as for a new engine. And warm up the engine to distribute the engine oil to all of the parts in the same manner as for daily start the engine. Refer to 3. BEFORE OPERATION, 4. OPERATION INSTRUCTIONS.

⚠ WARNING



*Never run the engine in poorly ventilated room storing it.
Inhalation of exhaust fumes may be hazardous ones health and may cause a fire hazard.*

5. MAINTENANCE

5.1 Precaution for Inspection

Be sure to perform periodic checks.

The engine deterioration and degradation proceed in proportion to its service conditions and service hours. Leaving deterioration and degradation may cause an unexpected malfunction which interferes with your work an increase in consumption of the fuel and engine oil, or an increase in exhaust gas problems or noise, and result in shortening the life of the engine. Perform routine periodic checks and maintenance to prevent accidents from occurring. Also, perform the checks at a spacious and level place and free from traffic.

Never fail to start-up inspection.

Routine periodic checks are based on start-up inspections. Make a habit of performing the start-up inspections before initial start up for the day. Refer to the section 4.1 Check before Daily Operation.

Keep a record of daily operation to perform the periodic checks.

Keep a record of daily operation and the results of maintenance work. Periodic check intervals are established every 50, 250, 500, 1000 and 2000 service hours. Be sure to perform a periodic check after each set-up interval.

Always use genuine Isuzu parts.

Always use genuine Isuzu parts when replacing consumables. The use of replacement parts which are not genuine may degrade the engine performance or shorten its life.

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5. MAINTENANCE — 68

Have a set of maintenance tool always ready.

Have a set of maintenance tool always ready for checking the machinery.

Ask for our help with periodic checks and maintenance work.

Our professional engineers with good expertise and skills will help you with maintenance, inspection and servicing. Consult your dealer.

Tightening torque for bolts and nuts

Applying excessive tightening torque to a bolt or nut may loosen or damage a tightened part, and too small tightening torque may cause a oil leak from the mounting surface or a loose bolt, which leads to component failure. On essential parts, bolts and nuts should be tightened with an accurate tightening torque using a torque wrench in a correct way and correct order.

When removing parts is required for maintenance, consult your dealer.

The followings are the standard tightening torque for standard bolts and nuts.

IMPORTANT:

The tightening torque described below should be applied only to the bolts with "7" on their head. (JIS strength classification: 7T)

- Apply 60% tightening torque for the bolts which do not appear here.
- Apply 80% tightening torque when tightened to aluminum alloy.



Thread size × Pitch mm	M6×1.0	M8×1.25	M10×1.5	M12×1.75	M14×1.5	M16×1.5
Tightening torque N·m (kgf·m)	10.8±1.0 (1.1±0.1)	25.5±2.9 (2.6±0.3)	49.0±4.9 (5.0±0.5)	88.3±9.8 (9.0±1.0)	137±9.8 (14.0±1.5)	226±9.8 (23.0±2.0)

5.2 List of Periodic Inspections

Daily and periodic inspections are important to keep the engine in its best condition. The following is a summary of inspection and servicing items by inspection interval. Periodic inspection intervals vary depending on the use, loads, fuels and engine oils used and handling conditions, and are hard to establish definitively. The following should be treated only as a general standard.

IMPORTANT:

Establish a periodic check plan according to the operating conditions and make sure to conduct checks at specified intervals. Otherwise, malfunctioning may occur to shorten the engine life.

As special knowledge and skill are required for items marked with ●, consult your dealer or Isuzu distributor.

○: Check ◇: Replace ●: Contact your dealer

System	Check item	Daily	Periodic inspection interval				
			Every 50 hours	Every 250 hours	Every 500 hours	Every 1000 hours	Every 2000 hours
Fuel oil	Fuel tank oil level check and refill	○					
	Draining from fuel tank		○				
	Draining from oil / water separator		○				
	Cleaning oil / water separator				○		
	Fuel filter replacement				◇		

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MAC800G Air Heater

5. MAINTENANCE — 70

System	Check item	Daily	Periodic inspection interval				
			Every 50 hours	Every 250 hours	Every 500 hours	Every 1000 hours	Every 2000 hours
Engine oil	Engine oil level	○					
	Engine oil replacement		◇	◇			
	Engine oil filter replacement		1st time	2nd & after			
Cooling water	Check & addition cooling water	○					
	Radiator fin checking & cleaning			○			
	Cooling fan V-belt checking & adjusting		○ 1st time	○ 2nd & after			
	Cooling water replacement				◇ or every 1 yr.		
	Cooling water path flushing & maintenance						●
Rubber hoses	Fuel & cooling water pipe replacement						● or every 2 yrs.
Operating system	Governor lever & accelerator check & adjust	○		○			
Intake & exhaust	Air cleaner element cleaning & replacement			○	◇		
	Turbocharger blower washing *					●	
Electrical equipment	Alarm operation check	○					
	Battery electrolyte check & recharging		○				
Cylinder head	Adjust intake / exhaust valve clearance					●	
	Lapping intake / exhaust valve seats						●

5. MAINTENANCE — 71

System	Check item	Daily	Periodic inspection interval				
			Every 50 hours	Every 250 hours	Every 500 hours	Every 1000 hours	Every 2000 hours
Fuel valve, pump *	Check fuel injection valve pressure & adjust					●	
	Check & adjust fuel injection pump						●

*The specific emissions related parts for the EPA/ARB regulations.

EPA allows to apply Maintenance schedule for Emission related parts as follows.

—	Check Fuel Valve Nozzle and clean	Adjust, cleaning and repair of Fuel injection Pump and Fuel Valve Nozzle
kW ≤ 130	1500 hours of use and at 1500-hour intervals thereafter	3000 hours of use and at 3000-hour intervals thereafter

5.3 Periodic Inspection Items

5.3.1 Inspection after initial 50 hours operation

(1) Replacing the engine oil and engine oil filter (1st time)



When the engine oil is still hot, be careful with a splash of engine oil which may cause burns. Cool the engine to replace engine oil until the engine oil becomes warm. It is most effective to drain the engine oil while the engine is still warm.

In early period of use, the engine oil gets dirty rapidly because of the initial wear of internal parts. Replace the engine oil earlier.

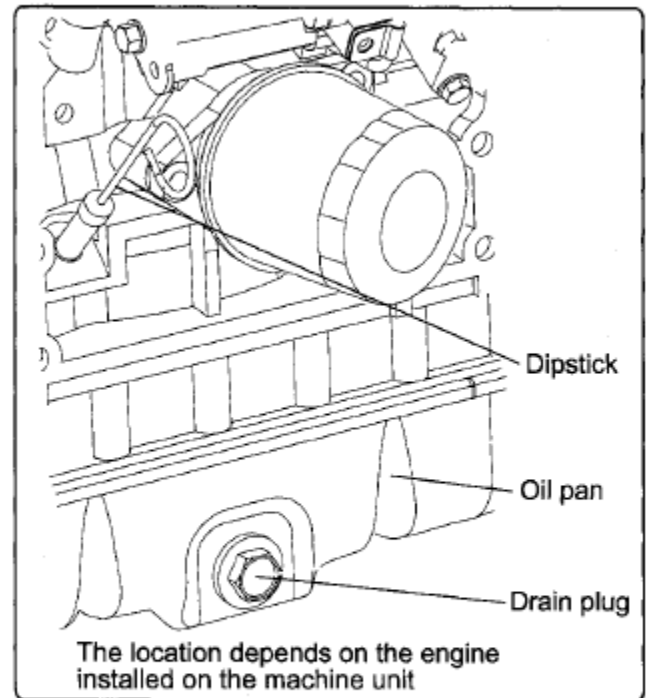
Engine oil filter should also be replaced when the engine oil is replaced.

Engine oil and engine oil filter replacing procedures are as follows.

Remove the oil filler cap to drain easily while draining the engine oil.

- 1) Prepare a waste oil container collecting waste oil.
- 2) Loosen the drain plug using a wrench (customer procured) to drain the engine oil.
- 3) Securely tighten the drain plug after draining the engine oil.
- 4) Turn the engine oil filter counter-clockwise using a filter wrench (customer procured) to remove it.
- 5) Clean the engine oil filter mounting face.
- 6) Moisten the new engine oil filter gasket with the engine oil and install the new engine oil filter manually turning it clockwise until it comes into contact with the mounting surface, and tighten it further to 3/4 of a turn with the filter wrench.

Tightening torque: 20~24N•m (2.0~2.4kgf•m)



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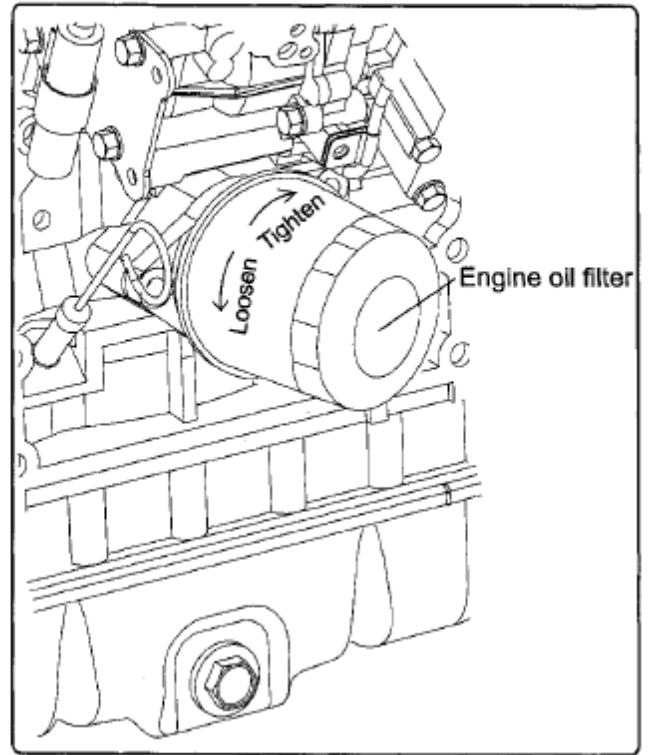
- 7) Fill with the new engine oil until it reaches the specified level as explained in section 3.3.

IMPORTANT:

Do not overfill the oil pan with engine oil.

Be sure to keep the specified level between upper and lower limit on the dipstick.

- 8) Warm up the engine by running for 5 minutes while checking any oil leakage. (Refer to 4.3.2 Warming up running)
- 9) Stop the engine after warming up and leave it stopping for about 10 minute to recheck the engine oil level with dipstick and replenish the engine oil. If any oil is spilled, wipe it away with a clean cloth.



(2) Checking and adjusting cooling fan V-belt

When there is not enough tension in the V-belt, the V-belt will slip making it impossible for the alternator to generate power and cooling water pump and cooling fan will not work causing the engine to overheat.

Check and adjust the V-belt tension (deflection) in the following manner.

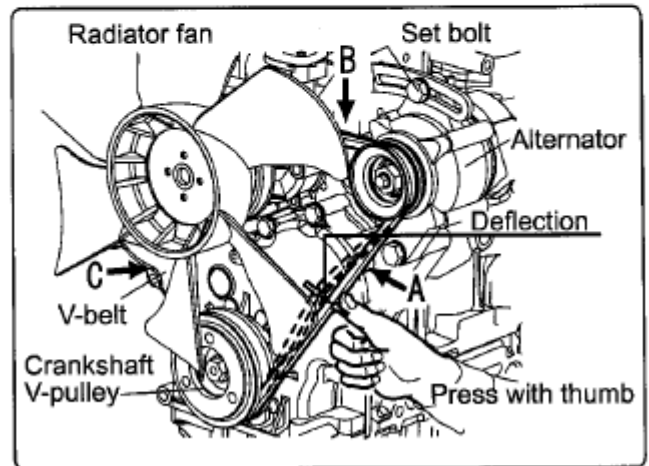
- 1) Press the V-belt down with your thumb [approx. 98N(10kgf)] at the middle of the V-belt span to check the tension (deflection).

Available positions to check and adjust the V-belt tension (deflection) are at the A, B and C showing with the arrow direction as shown illustration right.

You may choose a position whichever you can most easily carry out the check and adjustment on the machine unit.

The specified deflection to be measured at each position should be as follows.

A	B	C
10~14 mm	7~10 mm	9~13 mm



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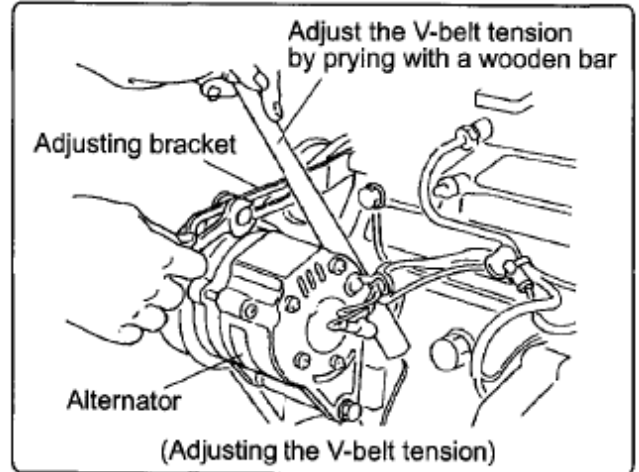
MAC800G Air Heater

5. MAINTENANCE — 76

- 2) If necessary, adjust the V-belt tension (deflection). To adjust the V-belt tension, loosen the set bolt and move the alternator to tighten the V-belt.
- 3) Visually check the V-belt for cracks, oiliness or wear. If any, replace the V-belt with new one.
 - "New V-belt" refers to a V-belt which has been used less than 5 minutes on a running engine.
 - "Used V-belt" refers to a V-belt which has been used on a running engine for 5 minutes or more.

Install the new V-belt adjusting the deflection to the value in the table below according to the above manner. After adjusting, run the engine for 5 minutes and readjust the deflection to the value in the table above.

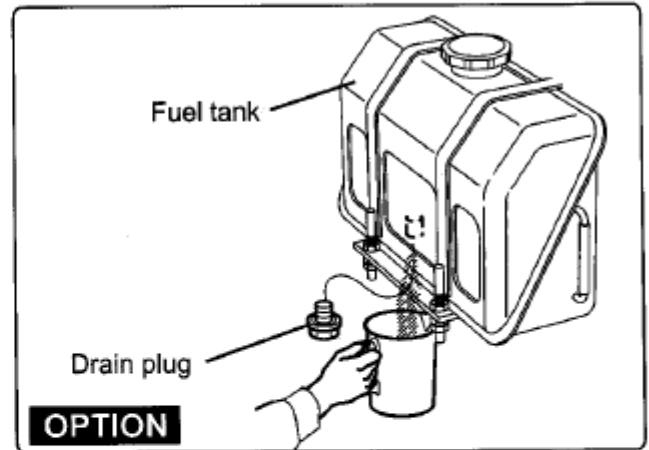
A	B	C
8~12 mm	5~8 mm	7~11 mm



5.3.2 Inspection every 50 hours operation

(1) Draining of the fuel tank

- 1) Prepare a waste oil container.
- 2) Loosen the drain plug of the fuel tank to drain (water, dust, etc.) from the fuel tank bottom.
- 3) Drain until fuel with no water and dust flow out. Then tighten the drain plug firmly.



(2) Draining of the oil/water separator

Drain off the oil/water separator whenever there is a lot of drain collected in the oil/water separator at the bottom of the cup even if not the time for periodic inspection hour. The cup of the oil/water separator is made from semi-transparency material and in the cup, the red colored float ring which rises on the surface of the drain is installed to visualize the amount of drain. Also, the oil/water separator with sensor to detect the drain for warning device on a control panel is provided as the optional.

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5. MAINTENANCE — 78

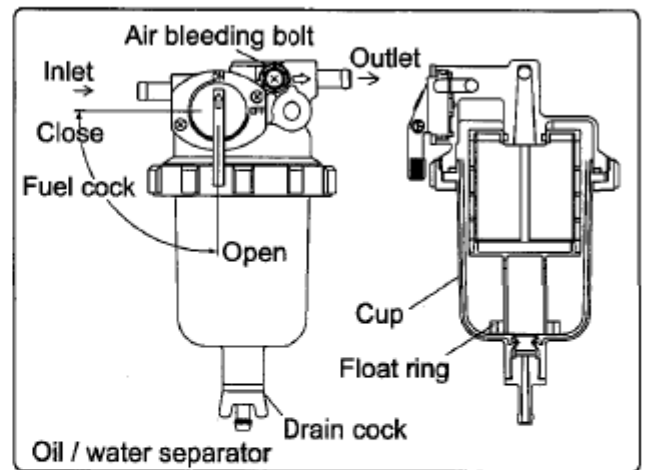
Drain off the oil/water separator in the following manner.

- 1) Prepare a waste oil container.
- 2) Close the fuel cock.
- 3) Loosen the drain cock at the bottom of the oil/water separator, and drain off any water collected inside.
- 4) Tighten the drain cock with hand.
- 5) Be sure to bleed air in the fuel system.
Refer to 3.2.2

NOTE:

If no drain drips when the drain cock is opened, loosen the air bleeding bolt on the top of the oil/water separator by turning counter-clockwise 2~3 times using screw driver.

(This may occur in case of the oil/water separator position is higher than the fuel oil level in the fuel tank). After draining, be sure to tighten the air bleeding bolt.



(3) Inspection of battery

⚠ WARNING



Fire due to electric short-circuit

- Make sure to turn off the battery switch or disconnect the negative cable (-) before inspecting the electrical system. Failure to do so could cause short-circuiting and fires.
- Always disconnect the (-) Negative battery cable first before disconnecting the battery cables from battery. An accidental "Short circuit" may cause damage, fire and or personnel injury.
And remember to connect the (-) Negative battery cable (back onto the battery) LAST.



Proper ventilation of the battery area

Keep the area around the battery well ventilated, paying attention to keep away any fire source. During operation or charging, hydrogen gas is generated from the battery and can be easily ignited.

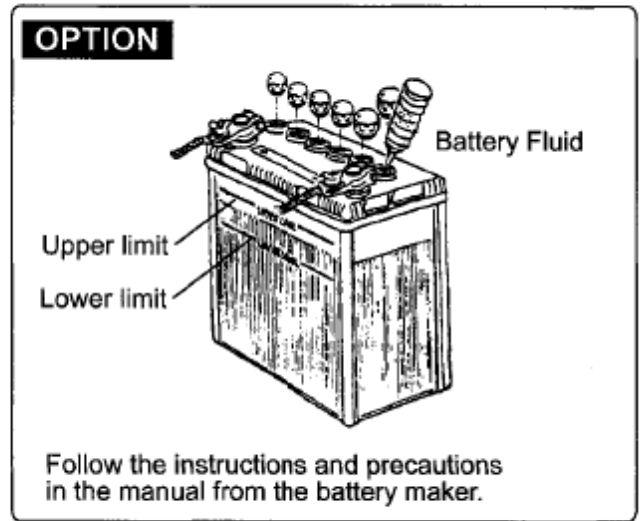


Do not come in contact with battery electrolyte

Pay sufficient attention to avoid your eyes or skin from being in contact with the fluid. The battery electrolyte is dilute sulfuric acid and causes burns. Wash it off immediately with a large amount of fresh water if you get any on you.

5. MAINTENANCE — 80

- Check the level of fluid in the battery.
When the amount of fluid nears the lower limit, fill with battery fluid (available in the market) to the upper limit. If operation continues with insufficient battery fluid, the battery life is shortened, and the battery may overheat and explode.
- Battery fluid tends to evaporate more quickly in the summer, and the fluid level should be checked earlier than the specified times.
- If the engine cranking speed is so slow that the engine does not start up, recharge the battery.
- If the engine still will not start after charging, replace the battery.
- Remove the battery from the battery mounting of the machine unit after daily use if letting the machine unit leave in the place that the ambient temperature could drop at -15°C or less. And store the battery in a warm place until the next use the unit to start the engine easily at low ambient temperature.



5. MAINTENANCE — 81

5.3.3 Inspection every 250 hours operation

(1) Replacing the engine oil and engine oil filter (2nd time and after)

Replace the engine oil every 250 hours operation from 2nd time and on. Replace the engine oil filter at the same time. Refer to 5.3.1(1).

(2) Checking and cleaning radiator fins.

CAUTION



Beware of dirt from air blowing

Wear protective equipment such as goggles to protect your eyes when blowing compressed air. Dust or flying debris can hurt eyes.

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MAC800G Air Heater

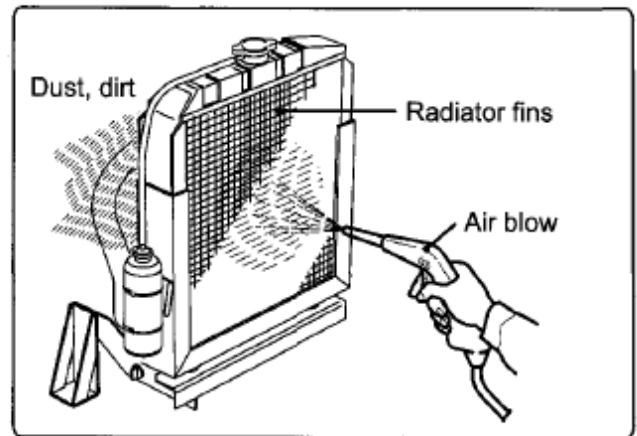
5. MAINTENANCE — 82

Dirt and dust adhering on the radiator fins reduce the cooling performance, causing overheating. Make it a rule to check the radiator fins daily and clean as needed.

- Blow off dirt and dust from fins and periphery with compressed air [0.19MPa (2kgf/cm²) or less] not to damage the fins with compressed air.
- If contaminated heavily, apply detergent, thoroughly clean and rinse with tap water shower.

IMPORTANT:

Never use high pressure water or air from close by fins or never attempt to clean using a wire brush. Radiator fins can be damaged.

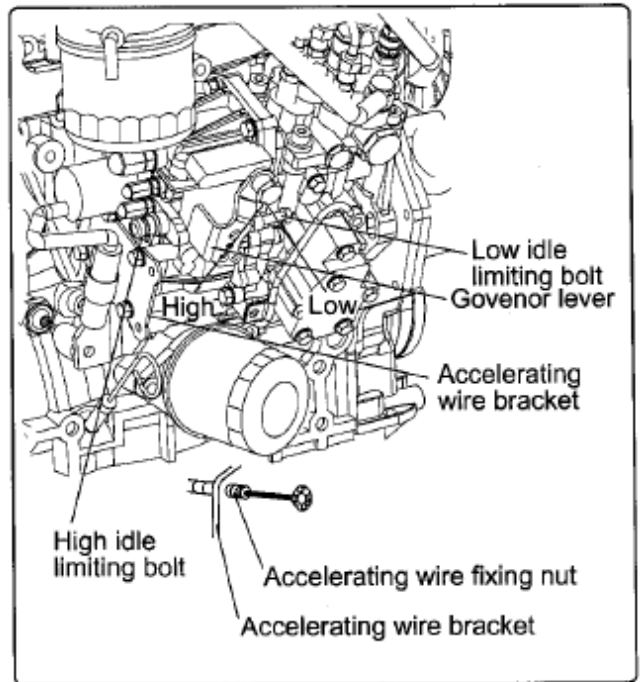


(3) Checking and adjusting the governor lever and accelerating device

The governor lever and accelerating devices (accelerating lever, pedal, etc.) of the machine unit are connected by an accelerating wire or rod. If the wire becomes stretched or the connections loosen, the deviation in the position may result and make operation unsafe. Check the wire periodically and adjust if necessary. Consult your dealer for the adjustment. Do not strongly move the accelerating wire or accelerating pedal. It may deform the governor lever or stretch the wire to cause irregular engine speed control.

Checking and adjusting procedures are as follows.

- 1) Check that the governor lever of the engine makes uniform contact with the high idling and low idling limiting bolt when the accelerating devices is in the high idling speed or low idling speed position.
- 2) If either the high or the low idling speed side does not make contact with the limiting bolt, adjust the accelerating wire.
Loosen the accelerating wire fixing nut and adjust the wire to contact with the limiting bolt.



IMPORTANT:

Never release the limiting bolts. It will impair the safety and performance of the product and functions and result in shorter engine life.

5. MAINTENANCE — 84

(4) Air cleaner element cleaning

CAUTION

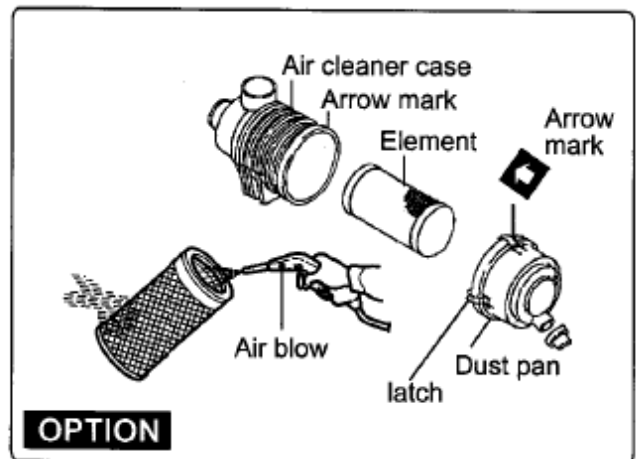
Beware of dirt from air blowing

Wear protective equipment such as goggles to protect your eyes when blowing compressed air. Dust or flying debris can hurt eyes.



The engine performance is adversely affected when the air cleaner element is clogged by dust. So periodical cleaning after disassembly is needed.

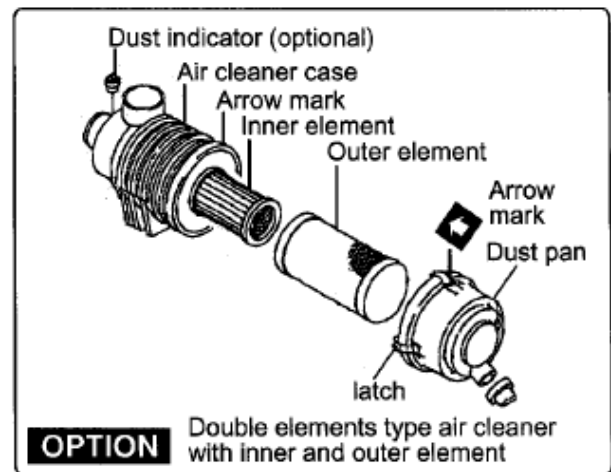
- 1) Undo the latches on the dust pan and remove the dust pan.
- 2) And then pull out the element.



- 3) Blow air [0.29~0.49MPa (3.0~5.0kgf/cm²)] from inside the element to blow dust off as shown the illustration right. Apply the air blowing pressure as low as possible so as not to damage the element. If having the air cleaner with double elements, never remove and clean the inner element. The aim of installing the inner element is for back up protecting from intaking dust during engine running when leaving the outer element to reinstall after removing to clean it or when damaging the outer element unexpectedly during engine running.
- 4) Replace the element with new one if the element is damaged, excessively dirty or oily.
- 5) Clean inside of the dust pan.
- 6) Reinstall the element inserting into the air cleaner case. And install the dust pan to the air cleaner case matching the arrow marks on the dust pan and air cleaner case, then fasten the dust pan with the latches.

IMPORTANT:

- When the engine is operated in dusty conditions, clean the element more frequently.
- Do not run the engine with removed air cleaner or element, as this may cause foreign material to enter and damage the engine.



(5) Checking and adjusting cooling fan V-belt (2nd time and after)

Check and adjust the cooling fan V-belt tension every 250 hours operation from 2nd time and on.
Refer 5.3.1(2)

5.3.4 Inspection every 500 hours operation

(1) Replacing the air cleaner element

Replace the air cleaner element periodically even if it is not damaged or dirty.

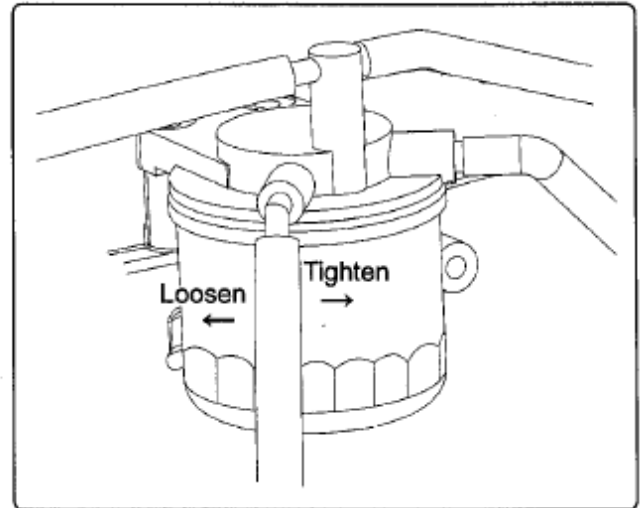
When replacing the element, clean the inside air cleaner case at the time.

If having the air cleaner with double elements, do not remove the inner element. If the engine output is still not recover (or the dust indicator still actuates if having the air cleaner with a dust indicator) even though the outer element has replaced with new one, replace the inner element with new one.

(2) Replacing fuel filter

Replace the fuel filter at specified intervals before it is clogged with dust to adversely affect the fuel flow. Also, replace the fuel filter after the engine has fully been cooled.

- 1) Close the fuel cock of the oil/water separator.
- 2) Remove the fuel filter using a filter wrench(customer procured). When removing the fuel filter, hold the bottom of the fuel filter with a piece of rag to prevent the fuel oil from dropping. If you spill fuel, wipe such spillage carefully.
- 3) Clean the filter mounting surface and slightly apply fuel oil to the gasket of the new fuel filter.
- 4) Install the new fuel filter manually turning it clockwise until it comes into contact with the mounting surface, and tighten it further to one turn using a filter wrench. Tightening torque: 20~24N·m(2.0~2.4kgf·m)
- 5) Bleed the fuel system. Refer to 3.2.2



IMPORTANT:

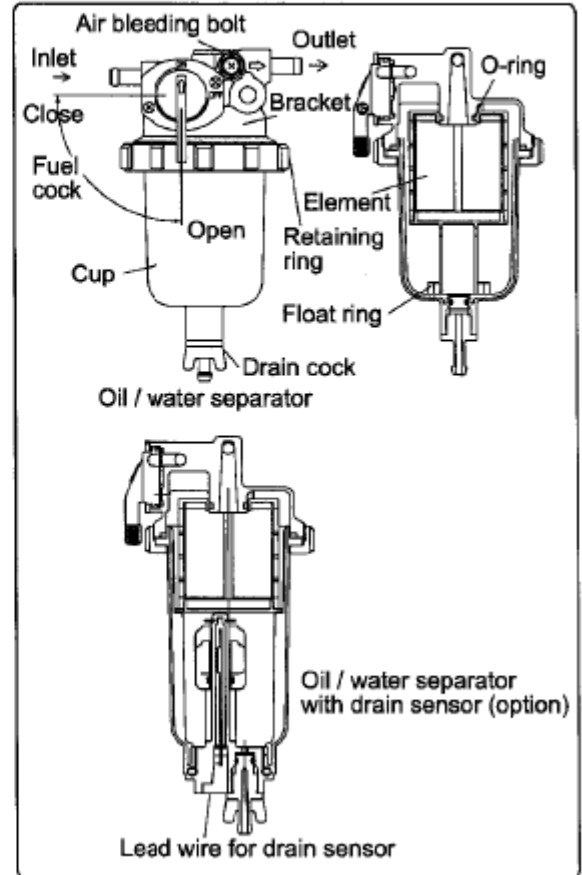
Be sure to use genuine Isuzu part (super fine mesh filter). Otherwise, it results in engine damage, uneven engine performance and shorten engine life.

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(3) Cleaning oil/water separator

Periodically wash the oil/water separator element and inside cup with clean fuel oil.

- 1) Prepare a waste oil container.
- 2) Close the fuel cock.
- 3) Loosen the drain cock and drain.
Refer to 5.3.2(2)
- 4) Turn the retaining ring counter-clockwise and remove the cup. (Keep the float ring at hand.)
(Disconnect the coupler of the lead wire for drain sensor before removing the cup if it is with drain sensor).
- 5) Wash the element and inside cup with clean fuel oil. Replace the element with new one if any damaged.
- 6) Insert the element to the bracket (O-ring) and after putting the float ring in the cup, install it to the bracket by tightening the retaining ring clockwise.
Tightening torque: 15~20N•m(1.5~2.0kgf•m)
- 7) Close the drain cock (connect the coupler if with drain sensor).
- 8) Bleed the fuel system. Refer to 3.2.2

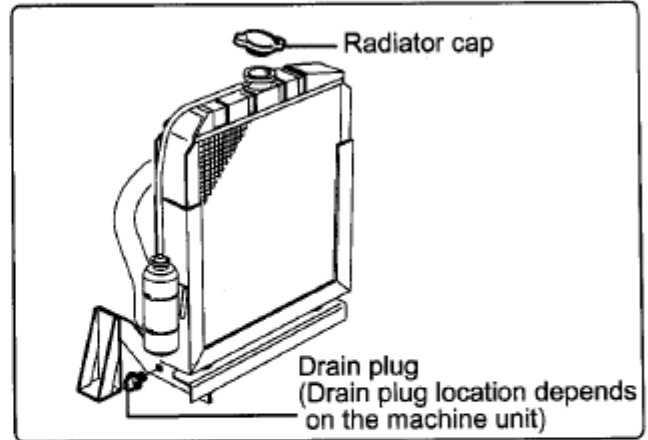


5.3.5 Inspection every 1000 hours operation

(1) Replacing cooling water

Cooling water contaminated with rust or water scale reduces the cooling effect. Even when antifreeze agent (LLC) is mixed, the cooling water gets contaminated due to deteriorated ingredients. Replace the cooling water at least once a year.

- 1) Remove the radiator cap.
- 2) Loosen the drain plug at the lower portion of the radiator and drain the cooling water.
- 3) After draining the cooling water, tighten the drain plug.
- 4) Fill radiator and engine with cooling water. Refer to 3.4



CAUTION



Beware of scalding by hot water

Wait until the temperature goes down before draining the cooling water. Otherwise, hot water may splash to cause scalding.

(2) Washing the turbocharger blower **3CD1T**

As this washing the turbocharger blower requires specialized knowledge. Consult your dealer. When engine speed seems sluggish or the exhaust color poor, the blades of the turbocharger blower may be dirty. Wash the blower.

(3) Checking and adjusting the fuel injection valve

As the adjustment requires specialized knowledge and skill, consult your dealer. This adjustment is needed to obtain the optimum injection pattern for full engine performance.

(4) Adjusting intake / exhaust valve clearance

As this adjustment requires specialized knowledge and skill, consult your dealer. The adjustment is necessary to maintain the correct timing for the opening and closing of valves. Neglecting the adjustment will cause the engine to run noisily and result in poor engine performance and other damage.

5.3.6 Inspection every 2000 hours operation

(1) Flushing the cooling system and checking the cooling system parts

As this maintenance requires specialized knowledge and skill, consult your dealer. Rust and water scale will accumulate in the cooling system through many hours of operation. This lowers the engine cooling effect. And for the engine oil cooler (3CD1T), they quickly deteriorate the engine oil.
Cooling system parts: radiator, cooling water pump, thermostat, cylinder block, cylinder head, oil cooler (3CD1T).

(2) Checking and replacing fuel hoses and cooling water hoses

As this maintenance requires specialized knowledge and skill, consult your dealer. Regularly check the rubber hoses of the fuel system and cooling water system. If cracked or degraded, replace them with new one. Replace the rubber hoses at least every 2 years.

(3) Lapping the intake and exhaust valves

As this maintenance requires specialized knowledge and skill, consult your dealer. The adjustment is necessary to maintain proper contact of the valves and seats.

(4) Checking and adjusting the fuel injection timing

As this maintenance requires specialized knowledge and skill, consult your dealer.

5.3.7 Checking and adjusting the EPA emission related parts

The inspection and servicing require specialized knowledge and techniques. Consult your dealer or Isuzu distributor.

EPA allows to apply maintenance schedule for emission related parts as follows.

—	Check Fuel Valve Nozzle and clean	Adjust, cleaning and repair of Fuel injection Pump and Fuel Valve Nozzle
kW ≤ 130	1500 hours of use and at 1500-hour intervals thereafter	3000 hours of use and at 3000-hour intervals thereafter

6. TROUBLESHOOTING

In case of an abnormality, stop the engine immediately and locate a problem by referring to the following table.

SYMPTOM	PROBABLE CAUSE	ACTION	Ref. Section
Alarm lamps lighting during operation	IMPORTANT: When a alarm lamp lights, immediately stop the engine and check and remove the cause.		
• Engine oil pressure alarm lamp	Insufficient level of engine oil. Clogged engine oil filter	Replenish engine oil. Replace the filter element.	3.3 5.3.1(1)
• Cooling water Temp. alarm lamp	Low radiator cooling water level Contaminated radiator fins Leak of cooling water V-belt is loose or damaged Contaminated cooling water system Faulty cooling water pump	Replenish cooling water Clean the radiator fins Ask for repair Adjust V-belt or replace Ask for service Ask for repair	4.1(4) 5.3.3(2) — 5.3.1(2) — —
• Charge lamp	V-belt is loose or damage Battery failure Faulty alternator	Adjust V-belt or replace Check electrolyte recharge Ask for repair	5.3.1(2) 5.3.2(3) —
Faulty alarm lamp	IMPORTANT: If a alarm lamp is faulty, do not continue operation. Otherwise, faults will not be noticed, developing a serious accident.		
• Charge lamp, engine oil pressure lamp not coming on when starter switch is turned ON (OFF → ON)	Faulty electrical wiring or faulty lamp	Ask for repair	—

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MAC800G Air Heater

6. TROUBLESHOOTING — 94

SYMPTOM	PROBABLE CAUSE	ACTION	Ref. Section
• Charge lamp, engine oil pressure lamp not going off when starter switch is turned from START to ON (START → ON)	Faulty alternator or faulty engine oil pressure	Ask for repair	—
Failure to start			
• Starter motor works but engine does not start	No fuel Air in fuel system Improper fuel Clogged fuel filter Poor fuel injection Compressed air leakage from intake / exhaust valves	Replenish fuel, bleed Bleed Replace with recommended fuel Replace fuel filter Ask for repair Ask for repair	3.2 3.2.2 3.1.1 5.3.4(2) — —
• Starter motor does not turn or turns too slowly (engine can be turned manually)	In sufficient battery charge Faulty cable connection at battery terminals Faulty starter switch Faulty starter motor	Check electrolyte, recharge Clean terminals, retighten Ask for repair Ask for repair	5.3.2(3) — — —
• Cannot be turned manually	Inner parts seized or damaged	Ask for repair	—
Poor exhaust gas color			
• Black smoke	Overloaded Clogged air cleaner element Improper fuel Faulty spraying of fuel injection Excessive intake / exhaust valve clearance	Reduce load Clean element or replace Replace with recommended fuel Ask for repair Ask for repair	— 5.3.3(4) 5.3.4(1) 3.1.1 — —

SYMPTOM	PROBABLE CAUSE	ACTION	Ref. Section
• White smoke	Improper fuel	Replace with recommended fuel	3.1.1
	Faulty spraying of fuel injection	Ask for repair	—
	Fuel injection timing delay	Ask for repair	—
	Engine oil burning	Ask for repair	—

TROUBLESHOOTING INFORMATION

If your engine is not working normally, check it referring to the troubleshooting section.

You can of course consult your dealer.

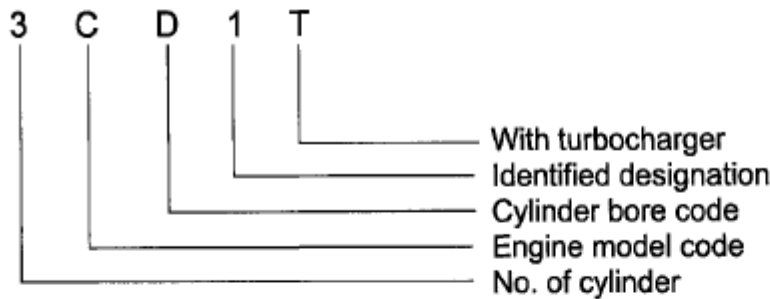
When asking the service, please give the following information to your dealer:

- Model name and serial number of your engine
- The machine unit type, manufacturers name, model and serial number.
- Operating conditions. Which speed or work has brought a problem.
- How long have you used your engine? (Approximate area worked or hours of operation)
- Situation when a trouble is developed
Engine revolution, color of exhaust gas, fuel in use, engine oil type, engine sound, etc.
- History of troubles
- Any other information when a trouble has occurred.

7. ENGINE SPECIFICATIONS

7.1 General

• Description of model name



• Engine speed specifications

Notation	Available engine speed min ⁻¹	Intended uses
VM	2000 ~ 3000	Agricultural, constructive, industrial machines, etc.
CL	1500 or 1800	4-pole generator sets; irrigation pumps, etc.

VM: Variable, Medium speed

CL: Constant Low speed

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7. ENGINE SPECIFICATIONS ——— 98

• Engine general specifications

Type	Vertical inline water cooled 4-cycle diesel engine
Combustion system	Direct injection
Starting system	Electric starting
Cooling system	Radiator
Lubricating system	Forced lubrication with trochoid pump
P.T.O position	Flywheel end
Direction of rotation	Counter-clockwise (viewed from flywheel side)

NOTE:

- 1) *The information described in the principal engine specifications (the next page and after) is for "standard" engine. To obtain the information for the engine installed in your machine unit, please refer to the manual provided by the equipment manufacturer.*
- 2) *Engine rating conditions are as follows (SAE J1349, ISO 3046/1)*
 - *Atmospheric condition: Room temperature 25°C, Atmospheric pressure 100 kPa (750mm Hg), Relative humidity 30%*
 - *Fuel temperature: 25°C (Fuel injection pump inlet)*
 - *With cooling fan, air cleaner, exhaust silencer (Isuzu standard)*
 - *After running-in hours. Output allowable deviation: ±3%*
 - *1PS = 0.7355 kW*

7.2 Principal Engine Specifications

• 3CC1

Engine model	—	3CC1							
Version	—	CL			VM				
Type	—	Vertical inline water cooled diesel engine							
Combustion system	—	Direct injection							
Aspiration	—	Natural							
No. of cylinder	—	3							
Bore × Stroke	mm	82×84							
Displacement	L	1.331							
Continuous rated output / Engine speed	kW/min ⁻¹ (PS)	9.9/1500 (13.5)	12.0/1800 (16.3)	—					
Max. rated output(net) / Engine speed	kW/min ⁻¹ (PS)	11.0/1500 (14.9)	13.2/1800 (17.9)	14.6/2000 (19.9)	16.0/2200 (21.8)	17.5/2400 (23.8)	19.0/2600 (25.8)	20.4/2800 (27.8)	21.9/3000 (29.8)
High idling	min ⁻¹	1600±25	1895±25	2205±25	2420±25	2615±25	2810±25	2995±25	3210±25
Engine mass(dry)** with flywheel housing	kg	138			128				
P.T.O position	—	Flywheel side							
Direction of rotation	—	Counter-clockwise (viewed from flywheel side)							
Cooling system	—	Water cooled (radiator)							
Lubricating system	—	Forced lubrication with trochoid pump							
Starting system	—	Electric starting (Starter motor: DC12V1.2kW, Alternator: DC12V40A) (Recommended battery capacity:12V52Ah (5h rating) for 12V1.2kW S.motor)							
Dimensions (L×W×H)**	mm	553×489×565			528×489×565				
Engine oil capacity (Oil pan)	L	5.5/3.6 (Dipstick upper limit / lower limit)							

Isuzu Diesel Engine

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7. ENGINE SPECIFICATIONS ——— 100

Engine model	—	3CC1
Cooling water capacity(engine)	L	1.8
Cooling fan(std.)	—	335mm O/D, 6 blades pusher type

• 3CD1

Engine model	—	3CD1							
Version	—	CL			VM				
Type	—	Vertical inline water cooled diesel engine							
Combustion system	—	Direct injection							
Aspiration	—	Natural							
No. of cylinder	—	3							
Bore × Stroke	mm	84×90							
Displacement	L	1.496							
Continuous rated output / Engine speed	kW/min ⁻¹ (PS)	11.3/1500 (15.3)	13.5/1800 (18.3)	—					
Max. rated output(net) / Engine speed	kW/min ⁻¹ (PS)	12.4/1500 (16.8)	14.8/1800 (20.1)	16.4/2000 (22.3)	18.1/2200 (24.6)	19.7/2400 (26.8)	21.3/2600 (29.0)	23.0/2800 (31.3)	24.6/3000 (33.5)
High idling	min ⁻¹	1600±25	1895±25	2205±25	2420±25	2615±25	2810±25	2995±25	3210±25
Engine mass(dry)** with flywheel housing	kg	161			155				
P.T.O position	—	Flywheel side							
Direction of rotation	—	Counter-clockwise (viewed from flywheel side)							
Cooling system	—	Water cooled (radiator)							
Lubricating system	—	Forced lubrication with trochoid pump							
Starting system	—	Electric starting (Starter motor: DC12V1.2kW, Alternator: DC12V40A) (Recommended battery capacity:12V60Ah (5h rating) for 12V1.2kW S.motor)							
Dimensions (L×W×H)**	mm	589×486×622			564×486×622				

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7. ENGINE SPECIFICATIONS — 101

Engine model	—	3CD1
Engine oil capacity (Oil pan)	L	6.7/3.9 (Dipstick upper limit / lower limit)
Cooling water capacity(engine)	L	2.0
Cooling fan(std.)	—	335mm O/D, 6 blades pusher type

** Engine mass and dimensions without radiator

• 3CD1T

Engine model	—	3CD1T						
Version	—	CL			VM			
Type	—	Vertical inline water cooled diesel engine						
Combustion system	—	Direct injection						
Aspiration	—	Turbocharged						
No. of cylinder	—	3						
Bore × Stroke	mm	84×90						
Displacement	L	1.496						
Continuous rated output / Engine speed	kW/min ⁻¹ (PS)	14.0/1500 (19.0)	16.5/1800 (22.5)	—				
Max. rated output(net) / Engine speed	kW/min ⁻¹ (PS)	15.8/1500 (21.5)	18.8/1800 (25.5)	21.0/2000 (28.5)	22.8/2200 (31.0)	25.0/2400 (34.0)	26.8/2600 (36.5)	29.1/2800 (39.5)
High idling	min ⁻¹	1600±25	1895±25	2205±25	2420±25	2615±25	2810±25	2995±25
Engine mass(dry)** with flywheel housing	kg	161			155			
P.T.O position	—	Flywheel side						
Direction of rotation	—	Counter-clockwise (viewed from flywheel side)						
Cooling system	—	Water cooled (radiator)						
Lubricating system	—	Forced lubrication with trochoid pump						

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7. ENGINE SPECIFICATIONS — 102

Engine model	—	3CD1T			
Starting system	—	Electric starting (Starter motor: DC12V1.2kW, Alternator: DC12V40A) (Recommended battery capacity:12V60Ah (5h rating) for 12V1.2kW S.motor)			
Dimensions (L×W×H)**	mm	589×486×622		564×486×622	
Engine oil capacity (Oil pan)	L	6.7/3.9 (Dipstick upper limit / lower limit)			
Cooling water capacity(engine)	L	2.0			
Cooling fan(std.)	—	350mm O/D, 6 blades pusher type			

• 3CE1

Engine model	—	3CE1							
Version	—	CL				VM			
Type	—	Vertical inline water cooled diesel engine							
Combustion system	—	Direct injection							
Aspiration	—	Natural							
No. of cylinder	—	3							
Bore × Stroke	mm	88×90							
Displacement	L	1.642							
Continuous rated output / Engine speed	kW/min ⁻¹ (PS)	12.3/1500 (16.7)	14.8/1800 (20.1)	—					
Max. rated output(net) / Engine speed	kW/min ⁻¹ (PS)	13.5/1500 (18.4)	16.3/1800 (22.1)	18.0/2000 (24.5)	19.9/2200 (27.0)	21.6/2400 (29.4)	23.5/2600 (31.9)	25.2/2800 (34.2)	27.1/3000 (36.8)
High idling	min ⁻¹	1600±25	1895±25	2205±25	2420±25	2615±25	2810±25	2995±25	3210±25
Engine mass(dry)** with flywheel housing	kg	161			155				
P.T.O position	—	Flywheel side							

7. ENGINE SPECIFICATIONS — 103

Engine model	—	3CE1			
Direction of rotation	—	Counter-clockwise (viewed from flywheel side)			
Cooling system	—	Water cooled (radiator)			
Lubricating system	—	Forced lubrication with trochoid pump			
Starting system	—	Electric starting (Starter motor: DC12V1.2kW, Alternator: DC12V40A) (Recommended battery capacity:12V60Ah (5h rating) for 12V1.2kW S.motor)			
Dimensions (L×W×H)**	mm	589×486×622		564×486×622	
Engine oil capacity (Oil pan)	L	6.7/3.9 (Dipstick upper limit / lower limit)			
Cooling water capacity(engine)	L	2.0			
Cooling fan(std.)	—	335mm O/D, 6 blades pusher type			

** Engine mass and dimensions without radiator

7. ENGINE SPECIFICATIONS — 104

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. The right is reserved to make changes at any time without notice.

INSTRUCTION MANUAL (INDUSTRIAL)

3CC1, 3CD1, 3CD1T, 3CE1

IDE-6143

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309-01K

Isuzu Diesel Engine

MAC800G Air Heater

ISUZU

IDE-6143

Notes

MAC800G Air Heater

Notes

MAC800G Air Heater

Replacement Parts and Filters

MAC800G Air Heater

Fan Motor	Part No. MAC0966
Fan	Part No. MAC1961 (fan) Part No. MAC1969 (funnel)
Thermostat	Part No. MAC1516
High limit safety switch	Part No. MAC1488
Air flow switch	Part No. MAC1399
Battery	Part No. MAC2013
Burner filter	Part No. MAC0576
Isuzu engine oil filter	Part No. MAC3020826
Isuzu engine fuel filter	Part No. MAC3020827
Isuzu fuel filter sediment	Part No. MAC3020828
Isuzu engine air filter	Part No. MAC3020836
Isuzu engine fan belt	Part No. MAC3020829
Isuzu engine glow plug	Part No. MAC3020830
Isuzu engine injector	Part No. MAC3020831
Isuzu engine starter	Part No. MAC3020832
Isuzu engine alternator	Part No. MAC3020833
Isuzu engine water pump	Part No. MAC3020834
Isuzu engine thermostat assembly	Part No. MAC3020835
Isuzu engine overheat switch	Part No. MAC3020808
Isuzu engine oil pressure switch	Part No. MAC3020807

Service Record

MAC800G Air Heater

DATE	HOURS	SERVICE PERFORMED	PERFORMED BY	NOTES

Service Record

MAC800G Air Heater

DATE	HOURS	SERVICE PERFORMED	PERFORMED BY	NOTES



AIR HEATERS

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