INGERSOLL-RAND®

OPERATING, MAINTENANCE, PARTS MANUAL

COMPRESSOR MODELS

XHP650WCAT **XHP825WCAT**
XHP750WCAT **XHP900WCAT**

Code: A **Code: A**

This manual contains important safety information.
Do not destroy this manual.
This manual must be available to the personnel who operate and maintain this machine.

INGERSOLL-RAND®
AIR COMPRESSORS
Portable Air Compressor Division
P.O. Box 868 - 501 Sanford Ave
Mocksville, N.C. 27028

Book 35393925 (05/03) **Revised (09-12)**

QUALITY POLICY

We will supply products and services that consistently meet the requirements of our customers and each other.

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.

Foreword

Machine models represented in this manual may be used in various locations worldwide. Machines sold and shipped into European common market countries requires that the machine display the EC Mark and conform to various directives. In such cases, the design specification of this machine has been certified as complying with EC directives. Any modification to any part is absolutely prohibited and would result in the CE certification and marking being rendered invalid. A declaration of that conformity follows:

Declaration of Conformity

WITH EC DIRECTIVE

98/37/EC

We

Ingersoll-Rand Company
P.O. Box 868
501 Sanford Avenue
Mocksville, North Carolina 27028

Represented In EC By:

Ingersoll-Rand Company Limited
Swan Lane, Hindley Green
NR Wigan WN2 4EZ
United Kingdom

Declare that, under our sole responsibility for manufacture and supply, the product(s)

HP1300WCU	VHP825WCU	XHP900WCAT	VHP750WCAT	XHP1070CAT
XP1400WCU	HP935WCU	XHP650WCAT	VHP850WCAT	NXP1300WCU
P1600WCU	XP1050WCU	XHP750WCAT	HP900WCAT	
XP900WCU	HP825WCU	XHP825WCAT	XP1000WCAT	

To which this declaration relates, is (are) in conformity with the provisions of the above directives using the following principal standards

EN1012-1, EN29001, EN202, EN60204-1
PN8NTC2, EN 50081, EN50082

Issued at Mocksville on 1-1-95

Ric Lunsford
Manager of Quality Control

Issued at Hindley Green on 1-1-95

H. Seddon, Q.A. Manager

Nothing contained in this document is intended to extend any promise, warranty or representation, expressed or implied, regarding the Ingersoll-Rand products described herein. Any such warranties or other terms and conditions of sale of products shall be in accordance with the standard terms and conditions of sale for such products, which are available upon request.

This manual contains instructions and technical data to cover all routine operation and scheduled maintenance tasks by operation and maintenance staff. Major overhauls are outside the scope of this manual and should be referred to an authorized Ingersoll-Rand service department.
All components, accessories, pipes and connectors added to the compressed air system should be:

- of good quality, procured from a reputable manufacturer and, wherever possible, be of a type approved by Ingersoll-Rand.
- clearly rated for a pressure at least equal to the machine maximum allowable working pressure.
- compatible with the compressor lubricant/coolant.
- accompanied with instructions for safe installation, operation and maintenance.

Details of approved equipment are available from Ingersoll-Rand Service departments.
The use of repair parts other than those included within the Ingersoll-Rand approved parts list may create hazardous conditions over which Ingersoll-Rand has no control. Therefore, Ingersoll-Rand cannot be held responsible for equipment in which non-approved repair parts are installed.

Ingersoll-Rand reserves the right to make changes and improvements to products without notice and without incurring any obligation to make such changes or add such improvements to products sold previously.

The intended uses of this machine are outlined below and examples of unapproved usage are also given. However, Ingersoll-Rand cannot anticipate every application or work situation that may arise. **If in doubt, consult supervision.**

This machine has been designed and supplied for above ground operation to be used for compression of normal ambient air containing no additional gases, vapors or particles within the ambient temperature range specified in the general data section of this manual.

This machine should not be used:

A. For direct or indirect human consumption of the compressed air.

B. Outside the ambient temperature range specified in the general data section of this manual.

C. When an actual or foreseeable risk of hazardous levels of flammable gases or vapors exists.

D. With other than Ingersoll-Rand approved components.

E. With guards, or controls or switches missing or disabled.

F. For storage or transportation of materials inside or on the enclosure.

This company accepts no responsibility for errors in translation of this manual from the original English version.

TABLE OF CONTENTS

SECTION 1- SAFETY

SAFETY PRECAUTIONS

General Information

Ensure that the operator reads and understands the decals and consults the manuals before maintenance or operation.

Ensure that the Operation and Maintenance manual, and the manual holder if equipped, are not removed permanently from the machine.

Ensure that maintenance personnel are adequately trained, competent and have read the manuals.

Make sure that all protective covers are in place and that the canopy/doors are closed during operation.

The specification of this machine is such that the machine is not suitable for use in flammable gas risk areas. If such an application is required then all local regulations, codes of practice and site rules must be observed. To ensure that the machine can operate in a safe and reliable manner, additional equipment such as gas detection, exhaust spark arrestors, and intake (shut-off) valves may be required, dependent on local regulations or the degree of risk involved.

Air discharged from this machine may contain carbon monoxide or other contaminants which will cause serious injury or death. Do not breathe this air.

Compressed air can be dangerous if incorrectly handled. Before doing any work on the unit, ensure that all pressure is vented from the system and that the machine cannot be started accidentally.

Ensure that the machine is operating at the rated pressure and that the rated pressure is known to all relevant personnel.

All air pressure equipment installed in or connected to the machine must have safe working pressure ratings of at least the machine safety valve rating.

If more than one compressor is connected to one common downstream plant, effective check valves and isolation valves must be fitted and controlled by work procedures, so that one machine cannot accidentally be pressurized or over pressurized by another.

Compressed air must not be used for a feed to any form of breathing apparatus or mask.

The discharged air contains a very small percentage of compressor lubricating oil and care should be taken to ensure that downstream equipment is compatible.

If the discharged air is to be ultimately released into a confined space, adequate ventilation must be provided.

When using compressed air, always use appropriate personal protective equipment.

All pressure containing parts, especially flexible hoses and their couplings, must be regularly inspected, be free from defects and be replaced according to the Manual instructions.

Avoid bodily contact with compressed air.

The safety valve located in the separator tank must be checked periodically for correct operation.

Never operate unit without first observing all safety warnings and carefully reading the operation and maintenance manual shipped from the factory with this machine.

Never operate the engine of this machine inside a building without adequate ventilation. Avoid breathing exhaust fumes when working on or near the machine. Do not alter or modify this machine.

A battery contains sulfuric acid and can give off gases which are corrosive and potentially explosive. Avoid contact with skin, eyes and clothing. In case of contact, flush area immediately with water.

Exercise extreme caution when using booster battery. To jump battery, connect ends of one booster cable to the positive (+) terminal of each battery. Connect one end of other cable to the negative (-) terminal of the booster battery and other end to a ground connection away from dead battery (to avoid a spark occurring near any explosive gases that may be present). After starting unit, always disconnect cables in reverse order.

Never operate unit without first observing all safety warnings and carefully reading the operation and maintenance manual shipped from the factory with this machine.

This machine may include such materials as oil, diesel fuel, antifreeze, brake fluid, oil/air filters and batteries which may require proper disposal when performing maintenance and service tasks. Contact local authorities for proper disposal of these materials.

Air discharged from this machine may contain carbon monoxide or other contaminants which will cause serious injury or death. Do not breathe this air.

Never operate the engine of this machine inside a building without adequate ventilation. Avoid breathing exhaust fumes when working on or near the machine.

A battery contains sulfuric acid and can give off gases which are corrosive and potentially explosive. Avoid contact with skin, eyes and clothing. In case of contact, flush area immediately with water.

High Pressure Air can cause serious injury or death. Relieve pressure before removing filler plugs/caps, fittings or covers.

Air pressure can remain trapped in air supply line which can result in serious injury or death. Always carefully vent air supply line at tool or vent valve before performing any service.

This machine produces loud noise with the doors open or service valve vented. Extended exposure to loud noise can cause hearing loss. Always wear hearing protection when doors are open or service valve is vented.

Never inspect or service unit without first disconnecting battery cable(s) to prevent accidental starting.

Do not remove the pressure cap from a HOT radiator. Allow radiator to cool down before removing pressure cap.

Do not use petroleum products (solvents or fuels) under high pressure as this can penetrate the skin and result in serious illness. wear eye protection while cleaning unit with compressed air to prevent debris from injuring eye(s).

Disconnect air hoses whip and can cause serious injury or death. Always attach a safety flow restrictor to each hose at the source of supply or branch line in accordance with OSHA Regulation 29CFR Section 1926.302(b).

Hot pressurized fluid can cause serious burns. Do not open radiator while hot.

Rotating fan blade can cause serious injury. Do not operate without guard in place.

Use care to avoid contacting hot surfaces (engine exhaust manifold and piping, air receiver and air discharge piping, etc.).

Ether is an extremely volatile, highly flammable gas. USE SPARINGLY! If too much is injected, it may result in costly damage to the engine.

Never allow the unit to sit stopped with pressure in the receiver-separator system. As a precaution, open the manual blowdown valve.

Never operate unit with guards, covers or screens removed. Keep hands, hair, clothing, tools, blow gun tips, etc. well away from moving parts.

Make sure wheels, tires and tow bar connectors are in safe operating condition and tow bar is properly connected before towing.

Whenever the machine is stopped, air will flow back into the compressor system from devices or systems downstream of the machine unless the service valve is closed. Install a check valve at the machine service valve to prevent reverse flow in the event of an unexpected shutdown when the service valve is open.

Hazardous Substance Precaution

The following substances are used in the manufacture of this machine and may be hazardous to health if used incorrectly.

Precaution: Avoid ingestion, skin contact and breathing fumes for the following substances: Antifreeze, Compressor Oil, Engine Lubricating Oil, Preservative Grease, Rust Preventative, Diesel Fuel and Battery Electrolyte.

The following substances may be produced during the operation of this machine and may be hazardous to health:

Avoid build-up of Engine Exhaust Fumes in confined spaces.

Avoid breathing Exhaust Fumes.

Avoid breathing Brake Lining Dust during maintenance.

SAFETY LABELS

Look for these signs on machines shipped to international markets outside North America, which point out potential hazards to the safety of you and others. Read and understand thoroughly. Heed warnings and follow instructions. If you do not understand, inform you supervisor.

Corrosion risk

Hot Surface

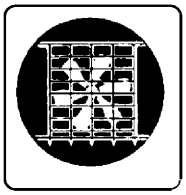
Lifting point

WARNING: Electrical shock risk.

Parking Brake

No open flame

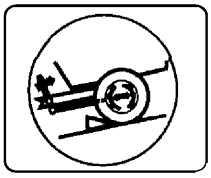
Diesel Fuel.
No open flame.



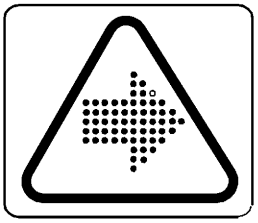
Do not operate the machine without guard being fitted.

Lifting point

WARNING – Flammable liquid.



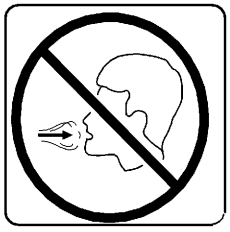
When parking use prop stand, handbrake and wheel chocks.



Air/gas flow or Air discharge.

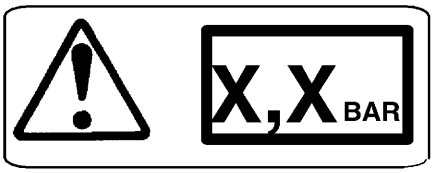
WARNING – Hot and harmful exhaust gas.

Tie down point

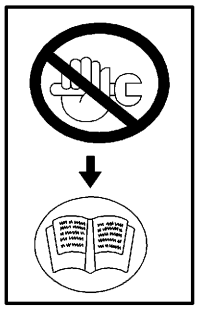


Do not breathe the compressed air from this machine.

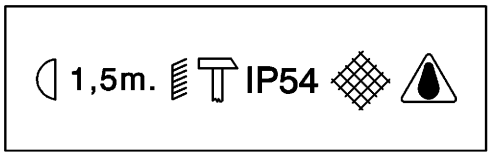
Read the Operation and Maintenance manual before operation or maintenance of this machine is undertaken.



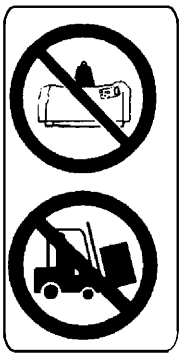
WARNING - Maintain correct tire pressure. (Refer to the *GENERAL INFORMATION* section of this manual).



WARNING: Consult the operation and maintenance manual before performing any maintenance.

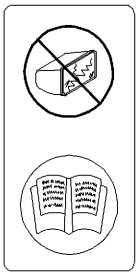


Rough Service Designation
Wet Location Operation

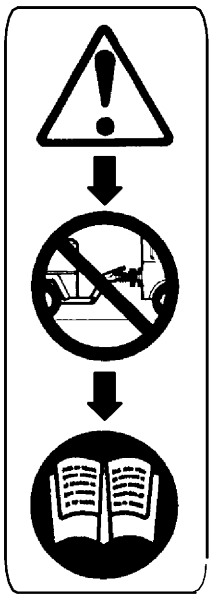


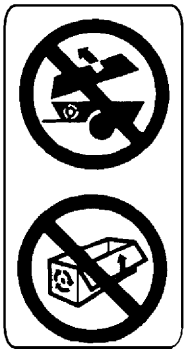
Do not stack

Do not use fork lift truck from this side

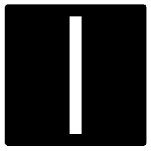


Replace any cracked protective shield.



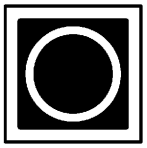


Do not operate with the doors or enclosure open.



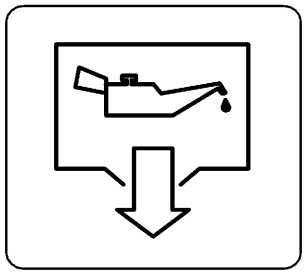
On (power).

Off (power).

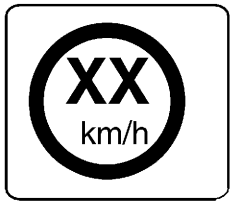


Emergency stop.

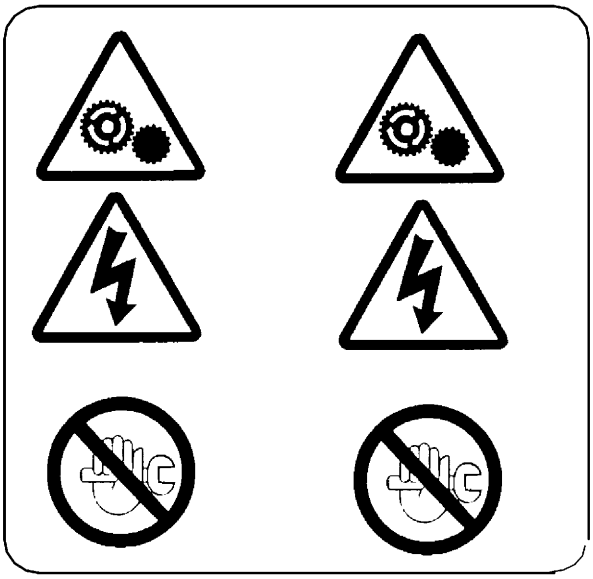
WARNING - Before connecting the tow bar or when preparing to tow, consult the operation and maintenance manual.



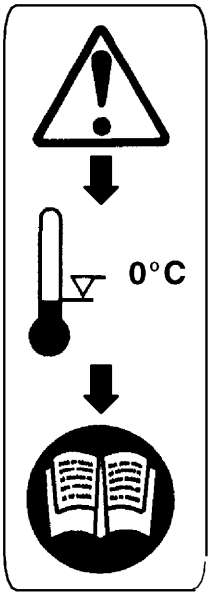
Oil Drain



Do not exceed the speed limit.



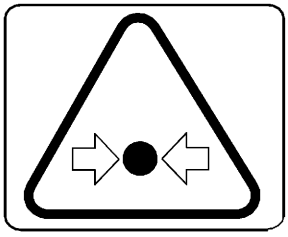
WARNING - Do not undertake any maintenance on this machine until the electrical supply is disconnected and the air pressure is totally relieved.



WARNING - For operating temperature below 0°C, consult the operation and maintenance manual.

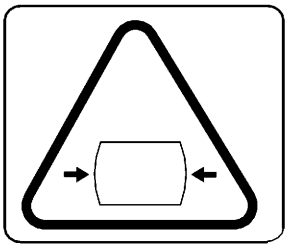
Read the Operation and Maintenance manual before operation or maintenance of this machine is undertaken

Do not remove the Operating and Maintenance manual and manual holder from this machine.



Pressurized vessel.

Use fork lift truck from this side only.



Pressurized component or system.

Look for these signs on machines shipped to markets in North America, which point out potential hazards to the safety of you and others. Read and understand thoroughly. Heed warnings and follow instructions. If you do not understand, inform you supervisor.

DANGER

(Red Background)

Indicates the presence of a hazard which WILL cause serious injury, death or property damage, if ignored.

WARNING

(Orange Background)

Indicates the presence of a hazard which CAN cause serious injury, death or property damage, if ignored.

CAUTION

(Yellow Background)

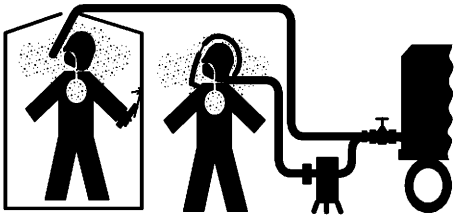
Indicates the presence of a hazard which WILL or can cause injury or property damage, if ignored.

NOTICE

(Blue Background)

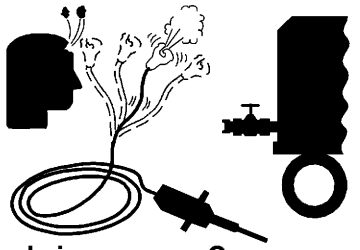
Indicates important set-up, operating or maintenance information.

DANGER



Air discharged from this machine can contain carbon monoxide or other contaminants which will cause serious injury or death. Do not breathe this air.

WARNING



Trapped air pressure. Can cause serious injury or death.

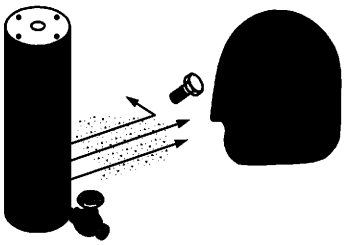
Close service valve and operate tool to vent trapped air before performing any service.

WARNING

Hot pressurized fluid.
Can cause serious burns.

Do not open radiator while hot.

WARNING



High pressure air. Can cause serious injury or death.

Relieve pressure before removing filler plugs/ caps, fittings or covers.

WARNING

Improper operation of this equipment. CAN cause serious injury or death.

Read Operator's Manual supplied with this machine before operation or servicing.

WARNING

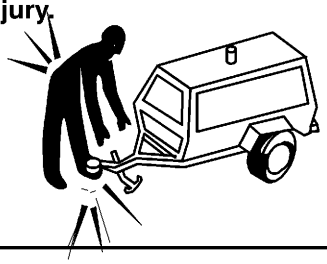
Modification or alteration of this machine. CAN cause serious injury or death.

Do NOT alter or modify this machine without the express written consent of the manufacturer.

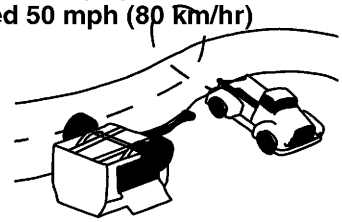
WARNING

Collapsing jack stand. Will cause serious injury.

Insert locking pin completely.

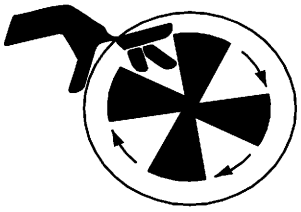


Excessive towing speed. Can cause serious injury or death. Do NOT exceed 50 mph (80 km/hr)



For Highway Towable Units

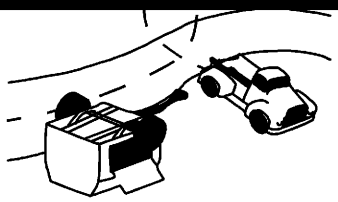
WARNING



Rotating Fan Blade. CAN cause serious injury.

Do NOT operate with guard removed.

WARNING

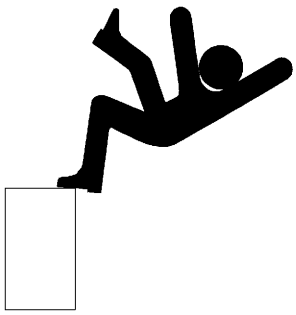


Excessive Towing Speed. CAN cause serious injury or death.

Do NOT Tow on Highway.
Do NOT exceed 20 mph (32 km/h)

For Non-Highway Towable Machines

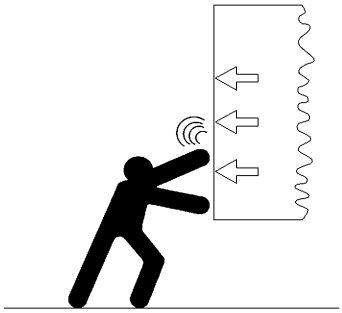
WARNING



Falling off machine. CAN cause serious injury or death.

Access Lifting Bail from inside machine.

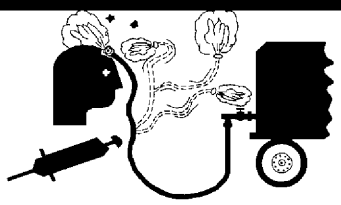
WARNING



Door under pressure CAN cause serious injury.

Use both hands to open door when machine is running.

WARNING



Disconnected Air Hoses Whip. CAN cause serious injury or death.

When using air tools attach safety device (OSHA Valve) at source of air supply for each tool.

WARNING

Combustible Gas. CAN cause serious burns, blindness or death.

Keep sparks and open flames away from batteries.

FREE SAFETY DECALS!

To promote communication of Safety Warnings on products manufactured by the Portable Compressor Division in Mocksville, N.C., Safety Decals are available **free** of charge. Safety decals are identified by the decal heading: **DANGER, WARNING or CAUTION.**

Decal part numbers are on the bottom of each decal and are also listed in the compressor's parts manual. Submit orders for Safety Decals to the Mocksville Parts Service Department. The no charge order should contain only Safety Decals. Help promote product safety! Assure that decals are present on the machines. Replace decals that are not readable.

SECTION 2 - Warranty

Ingersoll-Rand, through its distributor, warrants that each item of equipment manufactured by it and delivered hereunder to the initial user will be free of defects in material and workmanship for a period of three (3) months from initial operation or six (6) months from the date of shipment to the initial user, whichever occurs first.

With respect to the following types of equipment, the warranty period enumerated below will apply in lieu of the foregoing warranty period.

A. **Aftercoolers -** The earlier of nine (9) months from date of shipment to or six (6) months from start up by initial user.

B. **Portable Compressors, Portable Generator Sets (GENSET), Portable Light Towers and Air Dyers -** The earlier of twelve (12) months from shipment to or the accumulation of 2,000 hours of service by the initial user.

C. **Portable Compressor Air Ends -** The earlier of twenty-four (24) months from shipment to or the accumulation of 4,000 hours of service by the initial user. For Air Ends, the warranty against defects will include replacement of the complete Air End, provided the original Air End is returned assembled and unopened.

C.1 **Portable Compressor Airend Limited Optional Warranty -** The earlier of sixty (60) months from shipment to or the accumulation of 10,000 hours of service. The optional warranty is limited to defects in rotors, housings, bearings and gears and provided all the following conditions are met:

The original airend is returned assembled and unopened.

Continued use of genuine Ingersoll-Rand parts, fluids, oils and filters.

Maintenance is performed at prescribed intervals.

D. **Genset Generators -** The earlier of twenty-four (24) months from shipment to or the accumulation of 4,000 hours of service by the initial user.

E. **Portable Light Tower Generators -** The earlier of twelve (12) months from shipment to or the accumulation of 2,000 hours of service by the initial user. Light Source model only, the earlier of twenty-four (24) months from shipment to or the accumulation of 4,000 hours of service.

F. **Ingersoll-Rand Engines -** The earlier of twenty-four (24) months from shipment to or the accumulation of 4,000 hours of service.

G. **Ingersoll-Rand Platinum Drive Train Warranty (Optional)** - Platinum drive train pertains to the Ingersoll-Rand Engine and Airend combination. The earlier of sixty (60) months from shipment to, or the accumulation of 10,000 hours of service. The starter, alternator, fuel injection system and all electrical components are excluded from the extended warranty. The airend seal and drive coupling are included in the warranty (airend drive belts are not included). The optional warranty is automatically available when meeting the following conditions:

The original airend is returned assembled and unopened.

Continued use of genuine Ingersoll-Rand parts, fluids, oil and filters.

Maintenance is performed at prescribed intervals.

It is the obligation of the user to provide verification that these conditions have been satisfied when submitting warranty claims.

H. **Spare Parts** – Six (6) months from date of shipment.

Ingersoll-Rand will provide a new part or repaired part, at its election, in place of any part which is found upon its inspection to be defective in material and workmanship during the period prescribed above. Such part will be repaired or replaced without charge to the initial user during normal working hours at the place of business of an Ingersoll-Rand distributor authorized to sell the type of equipment involved or other establishment authorized by Ingersoll-Rand. User must present proof of purchase at the time of exercising warranty.

The above warrantees do not apply to failures occurring as a result of abuse; misuse, negligent repairs, corrosion, erosion and normal wear and tear, alterations or modifications made to the product without express written consent of Ingersoll-Rand; or failure to follow the recommended operating practices and maintenance procedures as provided in the product's operating and maintenance publications.

Accessories or equipment furnished by Ingersoll-Rand, but manufactured by others, including, but not limited to, engines, tires, batteries, engine electrical equipment, hydraulic transmissions, carriers, shall carry whatever warranty the manufacturers have conveyed to Ingersoll-Rand and which can be passed on to the initial user.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED, (EXCEPT THAT OF TITLE),AND THERE ARE NO WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE.

GENERAL WARRANTY INFORMATION

GENERAL WARRANTY			Extended Coverage
Portable Compressor	Package	1 year/2000 hrs	
	Airend	2 yrs/4000 hrs	5 yrs/10,000 hrs Limited warranty, major components (refer to operator's manual).

Portable Genset 8kW, 11KW, 20KVA thru 575KVA	Package	1 yr/2000 hrs	None
	Generator	2 yrs/4000 hrs	None

Portable Genset 3.5KW thru 7.0KW and 10KW	Package	1 yr/2000 hrs (parts only)	None
	Generator	1 yrs/2000 hrs (parts only)	None

Light Tower	Package	1 yr/2000 hrs	
	Generator	1 yr/2000 hrs	2 years/4000 hours, for Lightsource introduced 8/16/99.

ENGINES			
CATERPILLAR	**Months**	**Hours**	**Extended Coverage**
	12	unlimited	Available at dealer
CUMMINS	24	2000	Major components 3 yrs/10,000 hrs Available at dealer
JOHN DEERE (in compressors)	24	2000	5 yrs/5000 hrs using OEM fluids and filters with $250 deductible
(in generators as of 1/1/01)	24	2000	2 yrs/4000 hrs using IR fluids and filters
DEUTZ	24	2000	Available at dealer
INGERSOLL-RAND	24	4000	5 yrs/10,000 hrs when using genuine Ingersoll-Rand fluids and parts. Refer to operator's manual.
KUBOTA (North America only)	24	2000	Major components 36 mo/3000 hrs (parts only)
(Western Europe & Oceania)	24	2000	None
(Central & South America, Asia, Middle East & Africa)	12	1000	None
MITSUBISHI	24	2000	2 yrs/4000 hrs using IR fluids & filters
VOLVO	24	2000	2 yrs/4000 hrs using ir fluids & filters
HONDA	12	unlimited	None
VANGUARD	24	unlimited	None

PARTS			
	Months	**Hours**	**Coverage**
Ingersoll-Rand	6	No Limit	Parts Only

AIREND EXCHANGE			
	Months	**Hours**	**Extended Coverage**
Airend	12	2000 hours	2 yrs/4000 hrs - available from IR.

Note: Actual warranty times may change. Consult the manufacturer's warranty policy as shipped with each new product.

Extended Limited Airend Warranty

Ingersoll-Rand Portable Compressor Division is pleased to announce the availability of extended limited airend warranty. Announcement of the extended warranty coincides with the introduction of PRO•TEC™ Compressor Fluid. PRO•TEC™ Compressor Fluid is an amber colored fluid specially formulated for Portable Compressors and is being provided as the factory filled fluid for all machines except [1] XHP650/900/1070 models.

All machines have the standard airend warranty - *The earlier of 24 months from shipment to, or the accumulation of 4000 hours of service.*

The warranty against defects will include replacement of the complete airend, provided the original airend is returned assembled and unopened.

The optional limited warranty is the earlier of 60 months from shipment to, or the accumulation of 10,000 hours of service. The optional warranty is limited to defects in major components (rotors, housings, gears, bearings), and is automatically available when the following three conditions are met:

1. The original airend is returned assembled and unopened.
2. Submissions of proof that Ingersoll-Rand fluid, filters and separators have been used. Refer to the Operation and Parts manual for the correct fluids, filters and separator elements required.
3. Submission of proof that maintenance intervals have been followed.

WARRANTY	TIME	*BARE AIREND	* * AIREND COMPONENTS
STANDARD	**2 yrs/4000 hrs**	**100% parts and labor**	**100% parts and labor**
OPTIONAL	**5 yrs/10,000 hrs**	**100% parts and labor**	**0%**

* Bare Airend - pertains to major airend parts (rotors, housings, gears and bearings).

** Airend Components - pertains to auxiliary attachments to the bare airend (drive coupling, seals, pumps, valves, tubes, hoses, fittings and filter housing).

PRO•TEC™ and XHP605 Compressor Fluids are available from the Mocksville Product Support department by calling 1-800-633-5206.

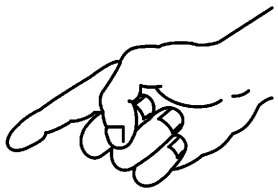
[1] XHP650/900/1070 will continue to use XHP605 and will have the extended warranty when above conditions are met.

WARRANTY REGISTRATION

Complete Machine Registration

Machines shipped to locations within the United States do not require a warranty registration unless the machine status changes (i.e. change of ownership).

Machines shipped outside the United States require notification be made to initiate the machine warranty.



Fill out the Warranty Registration Form in this section, keep a copy for your records and mail form to:

Ingersoll-Rand Company
Portable Compressor Division
P.O. Box 868
Mocksville, North Carolina 27028

Attn: Warranty Department

Note: Completion of this form validates the warranty.

Selling Distributor	Servicing Distributor	WARRANTY REGISTRATION
Name _____	Name _____	Owner/User Name _____
Address _____	Address _____	Address _____
City _____	City _____	City _____
County _____	County _____	County _____
State _____	State _____	State _____
Zip Code _____	Zip Code _____	Zip Code _____
Telephone _____	Telephone _____	Telephone _____

Complete the Applicable Blocks

Owner/User Type of Business (check one only)

☐ Construction–Heavy (highway, excavation, etc.)	☐ Asphalt Contractor	☐ Coal Mining	☐ Other Mining
☐ Construction–Light (carpentry, plumbing, pools, mason, etc.)	☐ Government (municipal, state, county, etc.)	☐ Quarry	☐ Shallow Oil & Gas
☐ Rental (rental center, rental fleet, etc.)	☐ Building Contractor	☐ Waterwell	☐ Utility Company (gas, electric, water, etc.)
☐ Industrial (plant use)	☐ Other specify _____	☐ Exploration	☐ Utility Contractor

Model	Unit S/N	Engine S/N	Date Delivered

Unit–Hours	Airend S/N	Truck S/N	Truck Engine S/N

SERVICING DISTRIBUTOR/USER ACKNOWLEDGEMENT

1. The Purchaser has been instructed and/or has read the manual and understands proper preventative maintenance, general operation and safety precautions.
2. The warranty and limitation of liability has been reviewed and understood by the owner/user.
3. In the event that this unit is to be used within a nuclear facility, the owner/user shall notify Ingersoll–Rand of such use so that Ingersoll–Rand may arrange for appropriate nuclear liability protection from the owner–licensee of the facility.
4. Ingersoll–Rand reserves the right to make design changes or modifications of Ingersoll–Rand products at anytime without incurring any obligation to make similar changes or modifications on previously sold units.

fold

Ingersoll-Rand Company
Portable Compressor Division
P.O. Box 868
Mocksville, North Carolina 27028

Attention: Warranty Department

SECTION 3 - NOISE EMISSION

This section pertains only to machines distributed within the United States.

WARNING

TAMPERING WITH NOISE CONTROL SYSTEM PROHIBITED

Federal law prohibits the following acts or the causing thereof:

(1) The removal or rendering inoperative by any persons, other than for purposes of maintenance, repair, or replacement, of any device or element of design incorporated into any new compressor for the purpose of noise control prior to its sale or delivery to the ultimate purchaser or while it is in use; or (2) the use of the compressor after such device or element of design has been removed or rendered inoperative by any person.

Among those acts included in the prohibition against tampering are these:

4. Removal or rendering inoperative any of the following:
   a. the engine exhaust system or parts thereof
   b. the air intake system or parts thereof
   c. enclosure or parts thereof

5. Removal of any of the following:
   a. fan shroud
   b. vibration mounts
   c. sound absorption material

6. Operation of the compressor with any of the enclosure doors open.

Compressor Noise Emission Control Information

A. The removal or rendering inoperative, other than for the purpose of maintenance, repair, or replacement of any noise control device or element of design incorporated into this compressor in compliance with the noise control act;

B. The use of this compressor after such device or element of design has been removed or rendered inoperative.

Note: the above information applies only to units that are built in compliance with the U.S. Environmental Protection Agency.

Ingersoll-Rand Company reserves the right to make changes or add improvements without notice and without incurring any obligation to make such changes or add such improvements to products sold previously.

The Purchaser is urged to include the above provisions in any agreement for any resale of this compressor.

NOISE EMISSION CONTROL MAINTENANCE LOG

COMPRESSOR MODEL _____
SERIAL NO. _____
USER UNIT NO. _____

UNIT IDENTIFICATION	**DEALER OR DISTRIBUTOR FROM WHOM PURCHASED:**
Engine Make & Model: _____	
Serial No.: _____	_____
Purchaser or Owner: _____	_____
Address: _____	Date Purchased: _____

The Noise Control Act of 1972 (86 Stat. 1234) prohibits tampering with the noise control system of any compressor manufactured and sold under the above regulations, specifically the following acts or the causing thereof:

(1) the removal or rendering inoperative by any persons, other than for purposes of maintenance, repair, or replacement, of any device or element of design incorporated into new compressor for the purpose of noise control prior to its sale or delivery to the ultimate purchaser or while it is in use; or (2) the use of the compressor after such device or element of design has been removed or rendered inoperative by any person.

NOISE EMISSION WARRANTY

The manufacturer warrants to the ultimate purchaser and each subsequent purchaser that this air compressor was designed, built and equipped to conform at the time of sale to the first retail purchaser, with all applicable U.S. EPA Noise Control Regulations.

This warranty is not limited to any particular part, component, or system of the air compressor. Defects in the design, assembly or in any part, component, or system of the compressor which, at the time of sale to the first retail purchaser, caused noise emissions to exceed Federal Standards are covered by this warranty for the life of the air compressor.

INTRODUCTION

The unit for which this Maintenance Log is provided conforms to U.S. E.P.A. Regulations for Noise Emissions, applicable to Portable Air Compressors.

The purpose of this book is to provide (1) the Maintenance Performance Schedule for all required noise emission controls and (2) space so that the purchaser or owner can record what maintenance was done, by whom, where and when. The Maintenance Schedule and detailed instructions on the maintenance items are given on following page.

MAINTENANCE SCHEDULE

ITEM	AREA	PERIOD
A.	Compressed Air Leaks	As Detected
B.	Safety and Control Systems	As Detected
C.	Acoustic Materials	Daily
D.	Fasteners	100 hours
E.	Enclosure Panels	100 hours
F.	Air Intake & Engine Exhaust	100 hours
G.	Cooling Systems	250 hours
H.	Isolation Mounts	250 hours
I.	Engine Operation	See Operator's Manual
J.	Fuels & Lubricants	See Operator's Manual

A. Compressed Air Leaks

Correct all compressed air leaks during the first shutdown period after discovery. If severe enough to cause serious noise problems and efficiency loss, shut down immediately and correct the leak(s).

B. Safety and Control Systems

Repair or replace all safety and control systems or circuits as malfunction occurs. No compressor should be operated with either system bypassed, disabled, or nonfunctional.

C. Acoustic Materials

In daily inspections, observe these materials. Maintain all acoustic material as nearly as possible in its original condition. Repair or replace all sections that have: 1) sustained damage, 2) have partially separated from panels to which they were attached, 3) are missing, or have otherwise deteriorated due to severe operating or storage conditions.

D. Fasteners

All fasteners such as hinges, nuts, bolts, clamps, screws, rivets, and latches should be inspected for looseness after each 100 hours of operation. They should be retightened, repaired, or if missing, replaced immediately to prevent subsequent damage and noise emission increase.

E. Enclosure Panels

Enclosure panels should also be inspected at 100 hour operational intervals. All panels that are warped, punctured, torn, or otherwise deformed, such that their noise containment function is reduced, should be repaired or replaced before the next operation interval. Doors, access panels, and hatch closures especially, should be checked and adjusted at this time to insure continuous seating between gasket or acoustic material and the mating frame.

F. Air Intake and Engine Exhaust

Engine and compressor air intake and engine exhaust systems should be inspected after each 100 hours of operation for loose, damaged, or deteriorated components. Repairs or replacements should be made before the next period of use.

G. Cooling Systems

All components of the cooling system for engine water and compressor oil should be inspected every 250 hours of use. Any discrepancies found should be corrected before placing the unit back in operation. Unrestricted airflow over the radiator and oil cooler must be maintained at all times during operation.

H. Isolation Mounts

Engine/airend isolation mounts should be inspected after each 250 hours of operation. Those mounts with cracks or splits in the molded rubber, or with bent or broken bolts due to operation or storage in severe environments, all should be replaced with equivalent parts.

I. Engine Operation

Inspect and maintain engine condition and operation as recommended in the manuals supplied by the engine manufacturer.

J. Fuels and Lubricants

Use only the types and grades of fuels and lubricants recommended in the Ingersoll-Rand Company and Engine Manufacturer's Operator and Maintenance Manuals.

MAINTENANCE RECORD FOR NOISE EMISSION CONTROL AND EXTENDED WARRANTY

ITEM NO.	DESCRIPTION OF WORK	HOURMETER READING	MAINT/ INSPECT DATE	LOCATION CITY/ STATE	WORK DONE BY (NAME)

SECTION 4 - General Data

Models	650	750	825	900
Rated Delivery:				
-cfm (-litres/sec)	650(310)	750(355)	825(390)	900(425)
Rated Pressure:				
-psi (-kPa)	350(2400)	300(2100)	250(1725)	350(2400)
Engine Caterpillar (Diesel)	3306TA	3306TA	3306TA	3406TA
Full Load Speed - rpm	1850	1850	1850	1800
No Load Speed - rpm	1200	1200	1200	1200
Electrical System - volt	24	24	24	24
Weights - pounds(kilograms)	13600(6174)	13600(6174)	13600(6174)	14900(6765)

Fluid Capacities - U.S. Gallons (litres)

Compressor Lubricant, Initial (dry) Fill	47(178)	47(178)	47(178)	55(208)
Service Refill	44(167)	44(167)	44(167)	44(167)
Fuel Tank (Use clean DIESEL fuel)	180(680)	180(680)	180(680)	180(680)
Engine Crankcase Lubricant	7.2 (27.3)	7.2 (27.3)	7.2 (27.3)	9.0 (34.1)
Engine Coolant (Radiator)	12.5(47)	12.5(47)	12.5(47)	17.0(64)

Unit Measurements - Feet (Meters)

Overall Length with Drawbar up 15.9 (4.84)
Overall Height 8.46 (2.58)
Overall Width 7.38 (2.25)

Running Gear

Tire Size ..... 8.25 x 15TR
Load Range ..... "F"
Inflation Pressure (Cold) - PSI (kPa) ..... 105(720)
Towing Speed (Maximum) -MPH (km/hr) 20 (32)

NOTICE: Any departure from these specifications may make this equipment unsafe and out of factory warranty. Do not mix different types of lubricants.

Service Parts

Compressor Oil Filter Element		36758613	36758613	36758613	36758613
Compressor Oil Separator Element		36762250	36762250	36762250	36762250
Air Cleaner Element,	Inner	35123520	35123520	35123520	36864379
	Outer	35123512	35123512	35123512	36864361
Engine Cleaner Element	Inner	35355353	35355353	35355353	36864379
	Outer	35355395	35355395	35355395	36864361

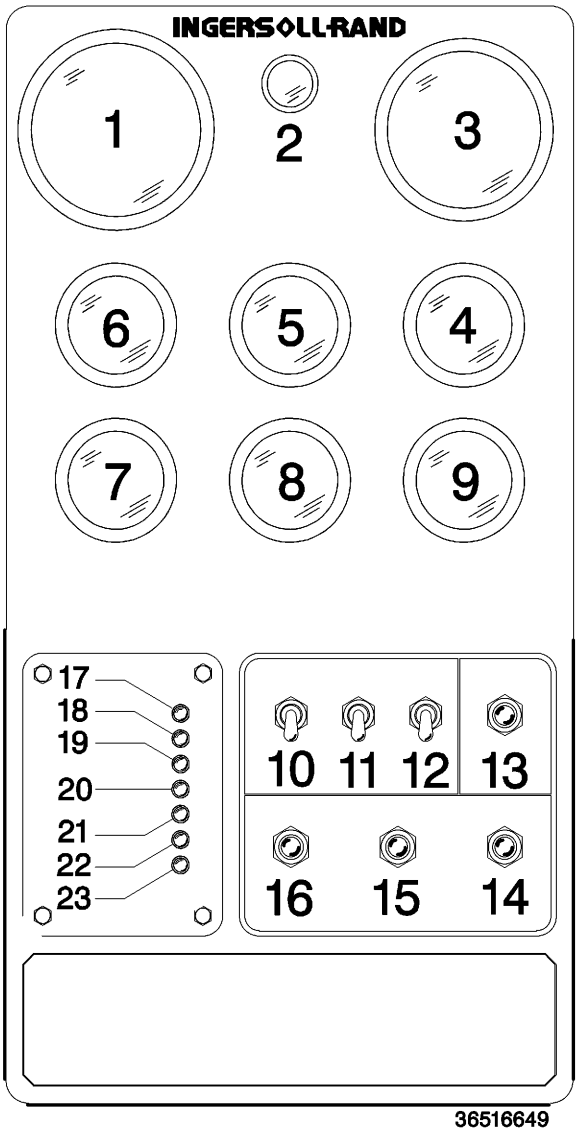
Models 650/750/825 (1) 14" for AE
(1) 14" for Engine

Model 900 (1) 18" for AE
(1) 18" for Engine

SECTION 5 - OPERATING INSTRUCTIONS

Instrument Control Panel

OPERATING CONTROLS & INSTRUMENTS



1. Compressor Disch. Pressure Gauge - Indicates pressure in receiver tank, normally from 0 psi (kPa) to the rated pressure of the machine.

2. Lamp - Controlled by Switch 11.

3. Engine Tachometer - Indicates engine speed in RPM from 0 when stopped to full speed.

4. Discharge Air Temperature Gauge - Indicates in °F and °C. Normal operating range:185°F/85°C to 230 °F/110 °C.

5. Fuel Level Gauge - Indicates amount of fuel in tanks.

6. Engine Oil Pressure Gauge - See Engine Operation Manual for normal range.

7. Hourmeter - Records running time for maintenance purposes.

8. Voltmeter - Indicates battery condition.

9. Engine Water Temperature Gauge - Indicates coolant temperature, with normal operating range from 180°F(82°C) to 210°F(99°C).

CONTROLS

10. Power Switch - Flip "On" to operate, "Off" to stop.

11. Lights Switch - Operates Lamp 2 and those within gauges.

12. Heaters Switch - Activates control system heaters for operation below 32°F(°C).

13. Service Air Button - After warm up, provides full air pressure at the service outlet.

14. Bypass Button - Bypasses automatic shutdown circuit.

15. Start Button - Activates the engine starter.

16. Ether Inject Button - Injects a measured shot. USE SPARINGLY.

DIAGNOSTICS / AUTOMATIC SHUTDOWN

17. High Compressor Temperature - 248°F(120°C) or more.

18. Low Engine Oil Pressure - 12 psi or less.

19. High Engine Temperature - Coolant above 215°F (102°C).

20. Low Fuel Level - Comes on first as a warning and eventually triggers a shutdown.

21. Alternator Not Charging - Needs attention.

22. Low Coolant Level - Dangerously low; needs attention.

23. Air Filters Restricted - Need servicing.

WARNING

Do not climb on top of unit. The lifting eye can be reached through the roof door ONLY from INSIDE of the unit.

BEFORE TOWING

When lifting or lowering drawbar, always grasp drawbar firmly and stand to one side.

Ensure that the tires, wheels and running gear are in good condition and secure.

Units equipped with hydraulic brakes:

- Check brake fluid level. Top off as required with DOT 3 brake fluid.
- Check condition of brake lines, hoses and cables. Repair or replace damaged parts.
- Attach brake actuator breakaway chain above hitch on towing vehicle.

Units equipped with electric brakes:

Start by making sure the trailer brakes are properly adjusted (see adjustment procedure). Vehicles towing units with electric brakes should be equipped with the Ingersoll-Rand Electric Brake Kit P/N 36088799. If tow vehicle is already equipped with an electric brake controller, check operation of the brakes before towing. Attach brake breakaway cable to hitch on towing vehicle.

TOWING

Steerable Axle Units - Do not tow this unit in excess of 20mph (32km/hr).

Use a tow vehicle whose towing capacity is greater than the gross weight of this unit.

Tandem Axle Units - These units are designed to be highway towable. Do NOT exceed 65 mph towing speed.

SET - UP

Place the unit in an open, well-ventilated area. Position as level as possible. The design of these units permits a 15 degree sidewise limit on out-of-level operation.

When the unit is to be operated out-of-level it is important:

(1) To keep the engine crankcase oil level near the high level mark (with the unit level),

(2) To have the compressor oil level gauge show no more than mid-scale.

Do not overfill the engine crankcase or the compressor.

Compressor Mounting

Portable compressors, which are modified to remove the running gear and mount the machine direct to trailers, truck beds or frames, etc. may experience failure of the enclosure, frame, and/or other components. It is necessary to isolate the compressor package from the carrier base with a flexible mounting system. Such a system must also prevent detachment of the package from the carrier base in the event the isolators fail. Contact Ingersoll-Rand representative for flexible mounting kits.

Warranty does not cover failures attributable to mounting of the compressor package to the carrier base unless it is an Ingersoll-Rand provided system.

DISCONNECT

Engage parking brakes and chock wheels of both tow vehicle and compressor.

Stand aside while:

- Withdraw pin, swing jack down and fully insert pin to lock in down position.
- Disconnect safety chains from tow vehicle.
- Disconnect brake actuator chain from tow vehicle.
- If so equipped, disconnect running light plug from the tow vehicle.
- Operate drawbar jack to raise pintle eye from hitch of tow vehicle.

CAUTION

Whenever the machine is stopped, air will flow back into the compressor system from devices or systems downstream of the machine unless the service valve is closed. Install a check valve at the machine service valve to prevent reverse flow in the event of an unexpected shutdown when the service valve is open.

WARNING

Unrestricted air flow from a hose will result in a whipping motion of the hose which can cause serious injury or death. A safety device must be attached to the hose at the source of supply to reduce pressure in case of hose failure or other sudden pressure release. Reference: OSHA regulation 29 CFR Section 1926.302 (b).

BEFORE STARTING -

All checks should be made while unit is level.

• Open service valve (s) to ensure pressure is relieved in receiver-separator system.

• Close valve (s) in order to build up full air pressure and ensure proper oil circulation.

• Check battery for proper connections and condition.

WARNING

COMBUSTIBLE GAS CAN CAUSE SEVERE BURNS, BLINDNESS OR DEATH. KEEP SPARKS AND OPEN FLAME AWAY FROM BATTERY.

Check the compressor and engine lubricating oil levels.

The oil level should be checked before the unit is started. Always check the oil level while the unit is level, the engine off, and there is zero pressure in the separator tank. the proper oil level is midway on the sigh gauge. Add oil if the level falls to the bottom of the sight gauge when the unit is running at full load. Do not overfill.

WARNING

Hot pressurized fluid can cause serious burns. Do not open radiator while hot.

• Check engine coolant level by removing the radiator top cap and looking for coolant in the filler neck of the radiator. Add coolant as required. Insure that radiator cap is installed properly and tightened.

NOTICE: If the appropriate mixture of antifreeze is not used during freezing temperatures, failure to drain the engine may cause costly engine damage. Never use water only as corrosion inhibitors are required in engine coolant fluid.

CAUTION

No smoking, sparks, or open flame near fuel.

• Check the fuel level. Add only CLEAN DIESEL fuel for maximum service from the engine. Refer to the Engine Section for fuel specifications.

A fuel level gauge reading can be obtained by turning the power switch to "ON".

NOTICE

To minimize condensation (water) in the fuel tank, fill the tank at the end of each day.

WARNING

This machine produces loud noise with doors open. Extended exposure to loud noise can cause hearing loss. Wear hearing protection when doors or valve (s) are open.

• Close the side doors to maintain a cooling air path and to avoid recirculation of hot air. This will maximize the life of the engine and compressor and protect the hearing of surrounding personnel.

• Make sure no one is IN or ON the compressor unit.

STARTING -

CAUTION

Exercise caution when using a booster battery charger to start.

To jump-start, connect the positive booster/charger cable to the 24VDC positive (+) terminal of the battery. Then connect the negative booster/charger cable to the engine block...Not to the negative (-) terminal of the weak battery. After starting, disconnect the negative (-) cable from engine block; then from the booster battery/charger. Disconnect positive (+) cable from both batteries.

• Flip the POWER switch to "ON". All diagnostics lamps will light (glow) for two (2) seconds. Then all lamps should go off except for ALTERNATOR NOT CHARGING and LOW ENGINE OIL PRESSURE.

• In freezing weather, flip HEATERS switch "ON" and wait sixty (60) seconds. This applies heat to the control system components for easier starting. Leave this switch "ON" while operating at these temperatures.

If equipped with 24 volt compressor (Cold Start Option)

• Press and hold the BYPASS button for ten (10) to fifteen (15) seconds. This operates the 24 volt compressor which pressurizes the inlet valve and holds it closed for easier starting.

• Press both the START and the BYPASS buttons to crank the engine. DO NOT OPERATE THE STARTER MOTOR FOR MORE THAN TEN (10) SECONDS WITHOUT ALLOWING AT LEAST ONE MINUTE COOLING TIME BETWEEN START ATTEMPTS.

CAUTION

Ether is an extremely volatile, high flammable gas. Use Sparingly! If too much is injected, the uncontrolled explosion may result in costly damage to the engine.

In cold weather:

In cold weather, as required, press the ETHER INJECT button once or twice only while the engine is cranking. This injects a measured amount of ETHER to the engine.

Release the START button when the engine starts and sustains running. If the engine does not start after a couple of attempts, Refer to Trouble Shooting Section.

Release BYPASS button when the engine speed reaches 1000 rpm. The engine oil pressure should be above 20 psi. If the engine oil pressure does not rise within five (5) seconds, stop the unit and refer to Engine Operator's Manual.

Once running, All DIAGNOSTIC lamps should be off. If not, stop the machine and investigate.

Observe the gauges while the unit warms up for five (5) to ten (10) minutes or until the coolant temperature reaches 140° F (60° C).

Push the SERVICE AIR button. The engine should go to full speed and the discharge pressure rise to slightly over rated pressure. If there is no air being consumed, the compressor will unload (intake should be throttled or closed) and the engine speed drop to the no load speed.

• Compressor is now ready to furnish air when the service valve is opened.

STOPPING

• Close air service valve (s).
• Allow the unit to run at "no load" for 3 to 5 minutes to reduce the engine temperatures
• Flip all toggle switches to "Off".

Note: Once the engine stops, the automatic blowdown valve will begin to relieve all pressure from the receiver-separator system.

CAUTION

Never allow the unit to sit stopped with pressure in the receiver-separator system. As a precaution, open the service valve.

WARNING

Even after pressure is relieved from the receiver-separator system, any air supply line from the compressor to a tool or machine could remain under pressure and cause very serious personal injury or death.

After the compressor stops, carefully open a valve at any tool or machine to exhaust the pressure in any line prior to removal or servicing.

CAUTION

When the machine is connected for operation, its system will become pressurized and/or contaminated if it is stopped with the service valve open. Any volume of air downstream of the compressor will flow back into the compressor through the open service valve. A check valve is required as close to the service valve as possible to prevent reverse flow.

EQUIPMENT PROTECTION

NOTICE

Do NOT wire around or bypass a shutdown sensor or switch.

All units in this family of machines are protected by five (5) sensors or switches at the following locations:

(1) High engine COOLANT temperature in the engine.

(2) Low engine oil pressure, in the engine.

(3) Low Fuel Level. (First, the light on the control panel will come on as a warning).

High Discharge AIR Temperature

(4) At the airend outlet.

(5) In the safety valve connection on the side of the separator tank.

All sensors will automatically reset when the problem condition is corrected.

Automatic Shutdown/Diagnostics

Should any of these problem situations occur, the unit will automatically shutdown and stop. BEFORE restarting the unit or flipping the POWER switch to "Off", check the DIAGNOSTICS area on the instrument panel.

In a shutdown situation, the function of the panel lamps is to indicate what specific failure caused the unit to shut down. These lamps will remain illuminated until the Power Switch is turned "OFF".

Note: None of the panel lamps should be glowing when machine is operating. If they are, shut unit down and investigate.

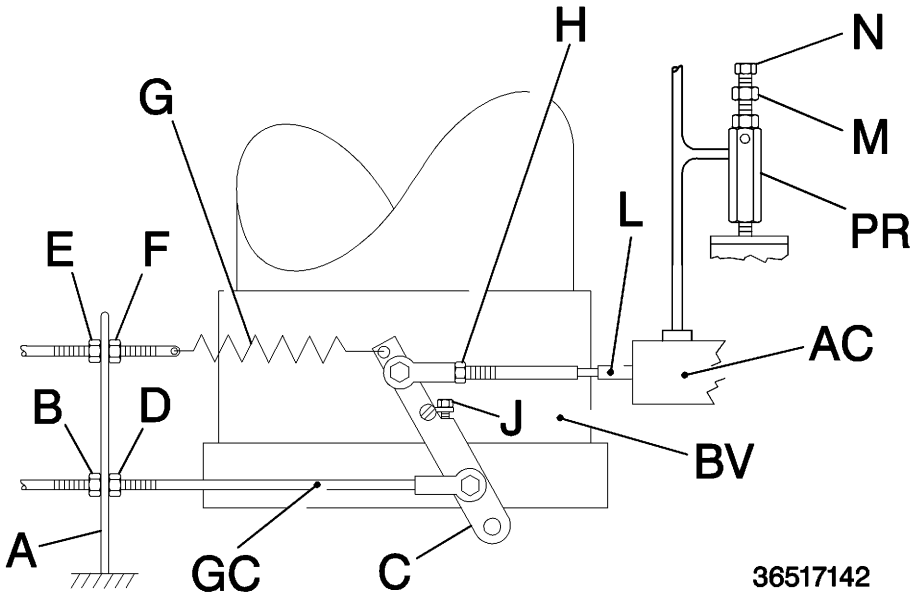
The upper four (4) lamps are electronically "latched" to only respond to the first or primary signal for a shutdown. In other words, if the automatic shutdown is the result of one of these four problems, only that particular problem lamp will be lit. And the lamp will remain lit as long as the batteries provide power.

Refer to OPERATING CONTROLS AND INSTRUMENTS for the various problem signal criteria (°F, psi, etc.). The indicated problem area should be inspected for a physical cause (low fluid, broken fan belt, evidence of excessive heat, etc.) and corrections made.

Sensors (1) through (5) will automatically reset when the problem condition is corrected.

Other possible causes for an unexpected shutdown are listed on the Trouble Shooting Chart.

SPEED AND PRESSURE REGULATION



Adjustment Instructions

The operating pressure of this unit was set at the factory to the maximum rating (at full speed). See General Data. However, this pressure may be reset down to 150 psi (1050 kPa).

Normally, regulation requires no adjusting; but if proper adjustment is lost, proceed as follows:

1. **WITH UNIT STOPPED**, disconnect rod end bearing on governor cable (GC) at engine governor lever.

2. At bracket (A) near butterfly valve (BV) run nut (B) back on governor cable housing. Push governor cable housing toward lever (C). Tighten nut (D).

3. Loosen nut (E) to relax spring (G).

4. Loosen nut (H). Turn rod (L) in Air Cylinder (AC) until approximately 3/4 inch (20 mm) between nut (H) and flats on rod (L).

5. Turn rod (L) One round into rod end bearing. Tighten nut (H). Rotate butterfly shaft/lever (C), open and close, several times to assure that linkage is not binding.

6. With engine governor lever in full speed position, reconnect rod end bearing.

7. Take slack out of spring (G) by moving nuts (E) and (F). Tighten nuts.

XHP 900 Units ONLY: *Adjust spring so it is full stretched, and nut (F) is at far end of rod, closest to spring (G). Tighten nuts.*

8. Start unit and allow to warm up for 3 to 5 minutes.

9. Push "Service Air" button on control panel.

10. With service air valve closed, adjust pressure regulator (PR) to rated pressure (*) plus 10 psi (70 kPa) as follows:

11. Loosen locknut (M) counterclockwise;. Turn adjustment cap (N) clockwise to increase pressure, counterclockwise to decrease pressure.

12. Set no load speed (*) by adjusting position of rod end bearing on governor cable at engine. Tighten lock nut.

13. Open service air valve and observe full load engine speed (*). Adjust regulator to give rated operating pressure (*). Tighten locknut (M).

14. Close and slowly open service air valve. If engine speed surges, increase tension on spring (G) by moving nuts (E) and (F). ***XHP900 Units ONLY:*** *Should not be adjusted by moving nuts (E) and (F). See Step 7.* If set speeds are not correct, repeat steps 12, 13 and 14 as required.

15. To regulate to any pressure between 150 psi (1050 kPa) and maximum rating (*), make adjustments at the pressure regulator.

SECTION 6 - MAINTENANCE

GENERAL

In addition to periodic inspections, many of the components in these units require periodic servicing to provide maximum output and performance. Servicing may consist of pre-operation and post-operation procedures to be performed by the operating or maintenance personnel. The primary function of preventive maintenance is to prevent failure, and consequently, the need for repair. Preventive maintenance is the easiest and the least expensive type of maintenance. Maintaining your unit and keeping it clean at all times will facilitate servicing. Refer to the engine Operator's Manual furnished in this manual for the specific requirements on preventive maintenance for the engine.

SCHEDULED MAINTENANCE

The maintenance schedule is based on normal operation of the unit. This page can be reproduced and used as a checklist by the service personnel. In the event unusual environmental operating conditions exist, the schedule should be adjusted accordingly.

COMPRESSOR OIL LEVEL

The oil level is most consistent when the unit is RUNNING AT FULL LOAD and should be checked at this time. The optimum operating level is midway of the sight tube on the side of the receiver tank. See the decal beside the sight tube. If the oil level is not in the "OK" range, make appropriate corrections (Add or Drain). A totally filled sight tube in which the level is not visible indicates an over-full condition and requires that oil be drained.

If necessary, Refer to Lubrication Section for recommended lubricant.

AIR CLEANER

This unit is equipped with an AIR FILTERS RESTRICTED lamp on the instrument panel, covering both the engine and the compressor.

This should be checked daily during operation. If the lamp glows (red) with the unit operating at full speed, servicing of the cleaner element is necessary.

Also weekly squeeze the rubber valve (precleaner dirt dump) on each air cleaner housing to ensure that they are not clogged.

NOTICE: Holes or cracks downstream of the air cleaner housing will cause the restriction indicators to be ineffective.

The air filters restricted sensor will automatically reset after the main power switch is flipped to "OFF."

1. Loosen outer wing nut and remove with outer element. Remove loose inner wing nut and inner (safety) element.

2. Inspect air cleaner housing for any condition that might cause a leak and correct as necessary.

3. Wipe inside of air cleaner housing with a clean, damp cloth to remove any dirt accumulation, especially in the area where the element seals against the housing.

4. Inspect the primary element by placing a bright light inside and rotating slowly. If any holes or tears are found in the paper, discard this element. If no ruptures are found, the element can be cleaned by one of the following procedures.

   Do not clean the safety element. Replace it with a new element.

5. Check new air filter elements for any shipping damage.

6. Install cleaned or new elements in the reverse order to the above. Tighten wing nuts firmly.

7. Inspect to ensure that the end cap seals tightly 360 degrees around the air cleaner body.

In the event that the filter element must be reused immediately, compressed air cleaning (as follows) is recommended since the element must be thoroughly dry. Direct compressed air through the element in the direction opposite to the normal air flow through the element.

Move the nozzle up and down while rotating the element. Be sure to keep the nozzle at least one inch (25.4 mm) from the pleated paper.

NOTICE

To prevent damage to the element, never exceed a maximum air pressure of 100 psi (700 kPa).

The air cleaner system (housing and piping) should be inspected every month for any leakage paths or inlet obstructions. Make sure the air cleaner mounting bolts and clamps are tight. Check the air cleaner housing for dents or damage which could lead to a leak. Inspect the air transfer tubing from the air cleaner to the compressor and the engine for holes.

Make sure that all clamps and flange joints are tight.

GAUGES

The instruments or gauges are essential for safety, maximum productivity and long service life of the machine. Inspect the gauges and test any diagnostic lamps prior to start-up. During operation observe the gauges and any lamps for proper functioning. Refer to Operating Controls & Instruments for the normal readings.

FUEL TANK

This unit is equipped with tank that can be filled from front of unit. Using clean fuel in the fuel tank is vitally important and every precaution should be taken to ensure that only clean fuel is either poured or pumped into the tank.

Every six months the drain valve should be opened so that any sediment or accumulated condensate may be drained. When closing the valve, make sure it is fully closed and does not leak.

BATTERY

Keep the battery posts-to-cable connections clean, tight and lightly coated with a grease. Also the electrolyte level in each cell should cover the top of the plates. If necessary, top-up with clean distilled water.

TIRES

A weekly inspection is recommended. Tires that have cuts or cracks or little tread should be repaired or replaced. Monthly check the wheel lug nuts for tightness.

AUTOMATIC SHUTDOWN SYSTEM

The discharge air temperature switches will require approximately 248°F (120°C) to actuate. The engine coolant temperature switch will require approximately 215°F (102°C) to actuate. Replace any defective switch before continuing to operate the unit.

A low oil pressure switch may be tested by removing it and connecting it to a source of controlled pressure while monitoring an ohmmeter connected to the switch terminals. As pressure is applied slowly from the controlled source, the switch should close at 12 psi (.84 kgf per cm 2) and show continuity through the contacts. As the pressure is slowly decreased to 8 psi (0.56 kgf per cm2) the contacts should open and the ohmmeter should show lack of continuity (infinite ohms) through the contacts. Replace a defective switch before continuing to operate the unit.

COMPRESSOR OIL COOLER

The compressor lubricating and cooling oil is cooled by means of the fin and tube-type oil cooler, located beside the radiator. The lubricating and cooling oil, flowing internally through the core section, is cooled by the air stream from the cooling fan flowing past the core section. When grease, oil and dirt accumulate on the exterior surfaces of the oil cooler, its efficiency is impaired.

Each month it is recommended that the oil cooler be cleaned by directing compressed air which contains a nonflammable safety solvent through the core of the oil cooler. This should remove the accumulation of grease, oil and dirt from the exterior surfaces of the oil cooler core so that the entire cooling area can transmit the heat of the lubricating and cooling oil to the air stream.

In the event foreign deposits, such as sludge and lacquer, accumulate in the oil cooler to the extent that its cooling efficiency is impaired, a resulting high discharge air temperature is likely to occur, causing shut down of the unit. To correct this situation it will be necessary to clean it using a cleaning compound in accordance with the manufacturer's recommendations. After completing the cleaning procedure, the oil cooler must be flushed before returning to service.

RADIATOR

WARNING

Do not remove the cap from a HOT engine radiator. The sudden release of pressure from a heated cooling system can result in serious personal injury.

The engine cooling system is filled at the factory with a 50/50 mixture of water and ethylene glycol. This permanent type antifreeze contains rust inhibitors and provides protection to -35° F (-37°C). The use of such a mixture is recommended for both summer and winter operation. When using water alone, be sure to add a reputable brand of rust inhibitor to prevent internal corrosion.

It is recommended to test the freezing protection of the coolant every six months or prior to freezing temperatures. Replenish with a fresh mixture every twelve months. A drain for the system is located in the bottom radiator tank. An alternate method would be to disconnect a bottom radiator hose.

Each month, inspect the radiator exterior for obstructions (dirt, bugs, etc.). If present, blow water or compressed air containing a nonflammable solvent between the fins in a direction opposite the normal air flow. Should the radiator be clogged internally, standard automotive practices should be followed.

HOSES

Each month it is recommended that all of the intake lines to and from the air cleaners, the engine cooling system hoses and all of the flexible hoses used for air, oil, and fuel be inspected.

To ensure freedom from air leaks, all rubber hose joints and the screw-type hose clamps must be absolutely tight. Regular inspection of these connections for wear or deterioration is a definite "must" if regulator servicing of the air cleaners is not to prove futile. Premature wear of both the engine and compressor is ASSURED whenever dust-laden air is permitted to enter the engine's combustion chamber or the compressor intake practically unfiltered.

The flexible hoses used in the fuel, oil and air lines on these units are primarily used for their ability to accommodate relative movement between components. It is extremely important they be periodically inspected for wear and deterioration. Clamps are used to prevent hose cover abrasion through vibration. This abrasion may occur when two hose lines cross, or when a hose line rubs against a fixed point; therefore, it is necessary that all clamps be replaced if missing. It is also important the operator does not use the hoses as convenient hand hold or steps. Such use can cause early cover wear and hose failure.

NOTICE

Piping systems operating at less than 150 psi (1050 kPa) may use a special nylon tubing. The associated fittings are also of a special "push-in" design. If so, features are as follows:

Pulling on the tubing will cause the inner sleeve to withdraw and compress, thus tightening the connection. The tubing can be withdrawn only while holding the sleeve against the fitting. The tubing can be removed and replaced numerous times without losing its sealing ability.

To install the nylon tubing, make a mark (with tape or grease pencil) approximately 7/8 inch from the end of the tubing. Insert the tubing into the sleeve and "push-in" past the first resistance to the bottom. The mark should be approximately 1/16 inch from the sleeve, for the 3/8 inch O.D. tubing; 1/8 inch for the 0.25 inch O.D. tubing. This will ensure that the tubing is fully engaged in the sealing mechanism.

FASTENERS

Visually check entire unit in regard to bolts, nuts and screws being properly secured. Spot check several capscrews and nuts for proper torque. If any are found loose, a more thorough inspection must be made. Take corrective action.

Note: For Nyloc Nuts, IF REMOVED, replace with new ones.

COMPRESSOR OIL

The lubricating and cooling oil must be replaced every 1000 hours of operation or six (6) months, whichever comes first.

RUNNING GEAR

Every month or 500 miles, tighten the wheel lug nuts to 85 - 95 lbs.-ft. Every six months the wheel bearings, grease seals and axle spindles should be inspected for damage (corrosion, etc.) or excessive wear. Replace any damaged or worn parts. Repack wheel bearings. Use a wheel bearing grease conforming to specification MIL-G-10924 and suitable for all ambient temperatures.

Grease can be replaced in a wheel bearing using a special fixture or by hand as follows.

Before installing bearing, place a light coat of grease on the bearing cups which are pressed in the hub.

Place a spoonful of grease in the palm of one hand and take the bearing in the other hand. Push a segment of the wider end of the bearing down into the outer edge of the grease pile closest to the thumb. Keep lifting and pushing the bearing down into the edge of the grease pile until grease oozes out both from the top and from between the rollers. Then rotate the bearing to repeat this operation on the next segment. Keep doing this until you have the entire bearing completely filled with grease.

NOTICE

Excessive grease in the hub or grease cap serves no purpose due to the fact that there is no way to force the grease into the bearing. The manufacturer's standard procedure is to thoroughly pack the inner and outer bearing with grease and then to apply only a very small amount of grease into the grease cap.

If bearing adjustment is required or the hub has been removed for any reason, the following procedure must be followed to ensure a correct bearing adjustment of 0.001 to .012 free play.

1. While rotating hub slowly to seat the bearings, tighten spindle nut to approximately 15 lbs.-ft. Grasp the tire at the top and bottom and rock, in and out. There should be no evidence of looseness (free play) at the bearing.

2. Loosen nut to remove preload torque. Do not rotate hub.

3. Finger tighten nut until just snug. Loosen nut until the first nut castellation lines up with cotter pin hole in spindle. Insert cotter pin.

4. Ensure a definite but minimal amount of free play by rocking the tire.

5. Bend over cotter pin legs to secure nut and clear grease cap.

6. Nut should be free to move with only restraint being the cotter pin.

WARNING

High pressure air can cause serious injury or death from hot oil and flying parts. Always relieve pressure before removing caps, plugs, covers or other parts from pressurized air system.

*** Open service valve and manual blowdown valve at end of machine.**
*** Ensure pressure is relieved, with BOTH:**
- Discharge air pressure gauge reads zero (0).
- No air discharging from service valve or manual blowdown valve.

When draining oil, use valve at bottom of separator tank.

When adding oil, remove and replace (make tight) plug on side of separator tank.

In the compressor lubricating and cooling system, separation of the oil from the compressed air takes place in the receiver-separator tank. As the compressed air enters the tank, the change in velocity and direction drop out most of the oil from the air.

Additional separation takes place in the oil separator element which is located in the top of the tank.

Any oil accumulation in this separator element is continuously drained off by means of a scavenge tube which returns the accumulated oil to the system.

The life of the oil separator element is dependent upon the operating environment (soot, dust, etc.) and should be replaced every twelve months or 2000 hours. To replace the element proceed as follows:

* Ensure the tank pressure is zero.

* Disconnect the hose from the scavenge tube.

* Remove scavenge tube from tank cover.

* Disconnect service line from cover.

* Remove cover, element and inner shell.

* Remove any gasket material left on cover or tank.

* Install new gasket, inner shell and new element.

NOTICE

Do not remove staples from the elementgasket. The staples provides continuity between the mating components.

*Place a straightedge across top of element and measure from bottom of straightedge to bottom of element (See Fig. 4.1).

*Replace scavenge tube in cover (cover is still off of tank).

*Measure from bottom of cover to end of scavenge tube (See Fig. 4.2). Measurement should be from 1/8" to 1/4" less than the element measurement. If not, cut to size, being sure to cut in an approximate 45° angle.

*Remove scavenge tube.

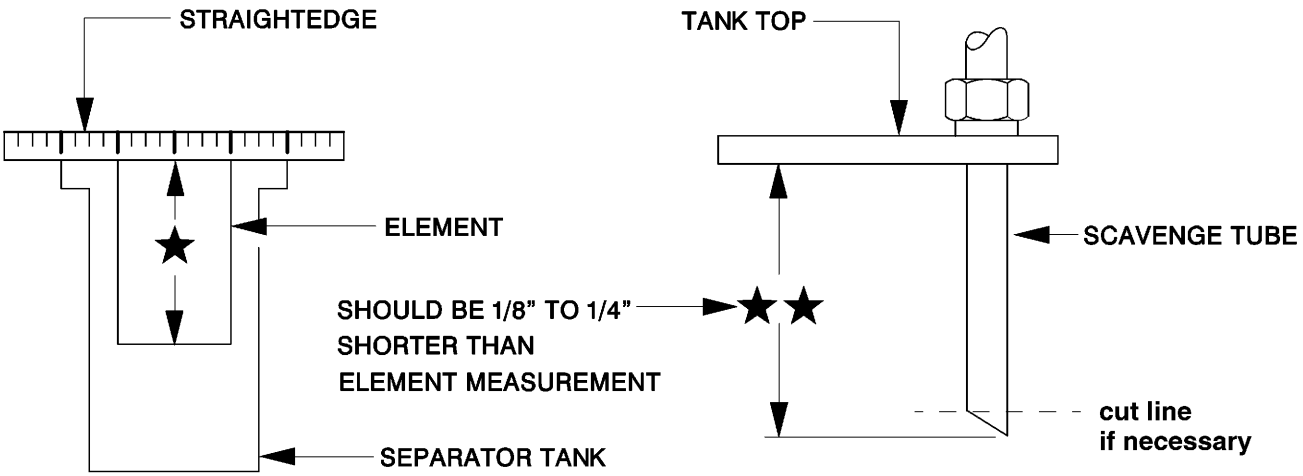
*Reposition cover (use care not to damage gaskets).

*Replace cover mounting screws: tighten in a crisscross pattern to recommended torque value.

*Reconnect service line. Replace scavenge tube. Re-connect hose.

*Close service valve. Start unit and look for leaks.

When replacing the element, the scavenge lines, orifice, filter, and check valve should be thoroughly cleaned and the oil changed.



SCAVENGE LINE

WARNING

High pressure air can cause serious injury or death from hot oil and flying parts. Always relieve pressure before removing caps, plugs, covers or other parts from pressurized air system.

The scavenge line originates at the receiver-separator tank cover and terminates at the compressor airend through an orifice.

Once a year or every 2000 hours of operation, whichever comes first, remove this line and any orifice, thoroughly clean, then reassemble.

NOTICE

Excessive oil carry-over may be caused by an oil-logged separator element. Do not replace element without first performing the following maintenance procedure:

1. Check oil level. Maintain as indicated earlier in this section.
2. Thoroughly clean scavenge line, any orifice and check valve.
3. Assure minimum pressure valve is holding 65-70 psi.
4. Run unit at rated operating pressure for 30 to 40 minutes to permit element to clear itself.

EXTERIOR FINISH CARE

This unit was painted and heat cured at the factory with a high quality, thermoset polyester powder coating. The following care will ensure the longest possible life from this finish.

1. If necessary to remove dust, pollen, etc. from housing, wash with water and soap or dish washing liquid detergent. Do not scrub with a rough cloth, pad, etc.

2. If grease removal is needed, a fast evaporating alcohol or chlorinated solvent can be used. Note: This may cause some dulling of the paint finish.

3. If the paint has faded or chalked, the use of a commercial grade, non-abrasive car wax may partially restore the color and gloss.

Field Repair of Texture Paint

1. The sheet metal should be washed and clean of foreign material and then thoroughly dried.

2. Clean and remove all grease and wax from the area to be painted using Duponts 3900S Cleaner prior to sanding.

3. Use 320 grit sanding paper to repair any scratches or defects necessary.

4. Scuff sand the entire area to be painted with a red scotch brite pad.

5. Wipe the area clean using Duponts 3900S.

6. Blow and tack the area to be painted.

7. Apply a smooth coat of Duponts 1854S Tuffcoat Primer to all bare metal areas and allow to dry.

8. Apply 2 medium - wet coats of Duponts 222S Adhesion Promoter over the entire area to be painted, with a 5 minute flash in between coats.

9. To apply the texture coat, use Duponts 1854S Tuffcoat Primer. The proper technique to do this is to spray the Tuffcoat Primer using a pressure pot and use about 2-5 pounds of air pressure. This will allow the primer to splatter causing the textured look. Note: You must be careful not to put too much primer on at one time, this will effect the amount of texture that you are trying to achieve. Allow the texture coat to flash for 20 minutes or until dry to touch.

10. Apply any of Duponts Topcoat Finishes such as Imron™ or Centari™ according to the label instructions.

Note: To re-topcoat the textured surfaces when sheet metal repairs are not necessary, follow steps 1, 2, 4, 5, 6, 8 and 10.

COOLING FAN DRIVE

The heat exchanger or cooling fan is driven by a belt arrangement directly from the engine. Inspect the engine fan belt weekly or at 50 hour intervals. Refer to engine section for proper belt adjustment procedures.

BRAKE SYSTEMS (Hydraulic Only)

This compressor is equipped with mechanical parking brakes and hydraulic surge brakes. The maintenance of these brake systems is required to ensure safe operation of this compressor.

Every six months visually check the brake shoes for proper operation and deterioration. The common automotive standards and procedures would apply in replacing the brake shoes.

When replacing brake cables it is necessary to adjust the brake shoes before adjusting the parking brake system. To adjust the shoes, remove the rubber hole plug in the brake backing plate and rotate the star adjusting nut until you cannot rotate the wheel by hand. Then back off the adjustment ten to twelve (10-12) notches.

Note: Always rotate wheel in direction of forward travel only. Replace hole plug and proceed to next wheel and repeat procedure.

Adjust parking brakes after all brake shoes have been adjusted by:

1. Turning knob on brake lever until lever is perpendicular to bracket when in "OFF" position. Wheels should turn freely.

2. With lever in "OFF" position, adjust brake cables until each has approximately the same tension. Wheels should turn freely.

3. Move lever to "ON" position. Check each wheel to see that it will not rotate. If all wheels will rotate, adjust knob on lever until brakes are fully applied. If one or two wheels will still rotate, adjust the cables for those wheels and recheck.

4. After brakes are adjusted, move lever to "ON" position and apply grease to cable strands from conduit six inches toward lever. This is to prevent dirt from getting into the conduit.

NOTE: New cables will stretch and therefore should be readjusted after the first week of use.

Every six months, apply a multi-purpose grease to the fittings on the brake actuator.

Before servicing the hydraulic surge brake system, the actuator, reservoir, wheels and underside of frame should be cleaned to prevent dirt and other contaminants from entering the hydraulic system.

Whenever a brake line hose, tube or fitting is removed/replaced, the hydraulic brake system must be bled of air to ensure proper brake operation. Bleed the brakes, at each wheel cylinder, in the following order: RH rear; LH rear; RH front; LH front (front is the hitch end; instrument panel is on LH side), while maintaining brake fluid level in reservoir. Use brake fluid conforming to DOT 3 or DOT 4 specifications.

BRAKE SYSTEMS - (Non Hydraulic)

This compressor may be equipped with mechanical parking brakes or electric brakes. The maintenance of these brake systems is required to ensure safe operation of this compressor.

Parking Brakes:

Every six months visually check the brake shoes for proper operation and deterioration. The common automotive standards and procedures would apply in replacing the brake shoes.

When replacing brake cables it is necessary to adjust the brake shoes before adjusting the parking brake system. To adjust the shoes, remove the rubber hole plug in the brake backing plate and rotate the star adjusting nut until you cannot rotate the wheel by hand. Then back off the adjustment ten to twelve (10-12) notches. Note: always rotate wheel in direction of forward travel only. Replace hole plug and proceed to next wheel and repeat procedure.

Adjust parking brakes after all brake shoes have been adjusted by:

1. Turning knob on brake lever until lever is perpendicular to bracket when in "OFF" position. Wheels should turn freely.

2. With lever in "OFF" position, adjust brake cables until each has approximately the same tension. Wheels should turn freely.

3. Move lever to "ON" position. Check each wheel to see that it will not rotate. If all wheels will rotate, adjust knob on lever until brakes are fully applied. If one or two wheels will still rotate, adjust the cables for those wheels and recheck.

4. After brakes are adjusted, move lever to "ON" position and apply grease to cable strands from conduit six inches toward lever. This is to prevent dirt from getting into the conduit.

NOTE: New cables will stretch and therefore should be readjusted after the first week of use.

Every six months, apply a multi-purpose grease to the fittings on the brake actuator.

Electric Brake Adjustment:

Brakes should be adjusted (1) after the first 200 miles of operation when the brake shoes and drums have "seated", (2) at 3000 mile intervals, (3) or as use and performance requires. The brakes should be adjusted in the following manner:

1. Jack up trailer and secure on adequate capacity jack stands. Check that the wheel and drum rotate freely.

2. Remove the adjusting hole cover from the adjusting slot on the bottom of the brake backing plate.

3. With a screwdriver or standard adjusting tool, rotate the starwheel of the adjuster assembly to expand the brake shoes. Adjust the brake shoes out until the pressure of the linings against the drum makes the wheel very difficult to turn.

4. Then rotate the starwheel in the opposite direction until the wheel turns freely with a slight lining drag.

5. Replace the adjusting hole cover and lower the wheel to the ground.

6. Repeat above procedures on all brakes.

CAUTION

Any unauthorized modification or failure to maintain this equipment may make it unsafe and out of factory warranty.

If performing more than visual inspections, disconnect battery cables and open manual blowdown valve.

Use care to avoid contacting hot surfaces (engine exhaust manifold and piping, air receiver and air discharge piping, etc.).

Never operate this machine with any guards removed.

Inch and metric hardware was used in the design and assembly of this unit. Consult the parts manual for clarification of usage.

Notice: Disregard any maintenance pertaining to components not provided on your machine.

MAINTENANCE SCHEDULE

These time periods should be reduced if operating in extreme conditions (very hot, cold, dusty or wet).

	Daily	Weekly	Monthly	3 MOS .	6 MOS.	12 MOS.
LARGE UNITS				500 hours	1000 hours	2000 hours
**Hydraulic Oil Level		C			R	
Compressor Oil Level	C					
Engine Oil Level	C					
**Radiator Coolant Level	C					
Gauges/Lamps	C					
Air Cleaner Service Indicators	C					
Fuel Tank (fill at end of day)	C				DRAIN	
**Fuel/Water Separator DRAIN	C					
Air Cleaner Precleaner Dumps		C				
Fan/Alternator Belts		C				
Battery Connections/Electrolyte		C				
**Tire Pressure and Surface		C				
**Wheel Lug Nuts			C			
Hoses (oil, air, intake, etc.)			C			
Automatic Shutdown System Test			C			
Air Cleaner System Visual			C			
Compressor Oil Cooler Exterior			C	CLEAN		
**Engine Radiator Exterior			C	CLEAN		
Fasteners, Guards				C		
Air Cleaner Elements				WI		
** Fuel/Water Separator Element					R	
*Compressor Oil Filter Element					R	
*Compressor Oil					R	
**Wheels (bearings, seals, etc)					C	C
Engine Coolant Test					C	R
Shutdown Switch Settings Test						C
Scavenge Orifice & related parts						CLEAN
Oil Separator Element						R
**Lights (running, brake, & turn)	CBT					
**Pintle Eye Bolts	CBT					
Engine (oil changes, oil & fuel filters, etc)				R		

**Disregard if not appropriate for this particular machine.

R=replace, **C**=check (adjust if necessary), **WI**=OR when indicated, **CBT** = check before towing.

Refer to specific sections of the operator's manual for more information.

SECTION 7 - LUBRICATION

GENERAL INFORMATION

Lubrication is an essential part of preventive maintenance, affecting to a great extent the useful life of the unit. Different lubricants are needed and some components in the unit require more frequent lubrication than others. Therefore, it is important that the instructions regarding types of lubricants and the frequency of their application be explicitly followed. Periodic lubrication of the moving parts reduces to a minimum the possibility of mechanical failures.

The Preventive Maintenance Schedule shows those items requiring regular service and the interval in which they should be performed. A regular service program should be developed to include all items and fluids. These intervals are based on average operating conditions. In the event of extremely severe (hot, cold, dusty or wet) operating conditions, more frequent lubrication than specified may be necessary. Details concerning lubrication of the running gear are in Maintenance Section.

All filters and filter elements for air and compressor lubricant must be obtained through Ingersoll-Rand to assure the proper size and filtration for the compressor.

COMPRESSOR OIL CHANGE

These units are normally furnished with an initial supply of oil sufficient to allow operation of the unit for approximately 6 months or 1000 hours, whichever comes first. If a unit has been completely drained of all oil, it must be refilled with new oil before it is placed in operation. Refer to specifications in Lubrication Table.

NOTICE

Some oil types are incompatible when mixed and result in the formation of varnishes, shellacs, or lacquers which may be insoluble. Such deposits can cause serious troubles including clogging of the filters. Where possible, do NOT mix oils of different types and avoid mixing different brands. A type or brand change is best made at the time of a complete oil drain and refill.

If the unit has been operated for the time/ hours mentioned above, it should be completely drained of oil. If the unit has been operated under adverse conditions, or after long periods in storage, an earlier change period may be necessary as oil deteriorates with time as well as by operating conditions.

WARNING

High pressure air can cause severe injury or death from hot oil and flying parts. Always relieve pressure before removing caps, plugs, covers or other parts from pressurized air system. Ensure the following conditions are met:

- Discharge air pressure gauge reads zero (0).
- No air discharging from an "open" manual blowdown valve.

An oil change is good insurance against the accumulation of dirt, sludge, or oxidized oil products.

Completely drain the receiver- separator, piping, and oil cooler. If the oil is drained immediately after the unit has been run for some time, most of the sediment will be in suspension and, therefore, will drain more readily. However, the fluid will be hot and care must be taken to avoid contact with the skin or eyes.

After the unit has been completely drained of all old oil, close the drain valve. Add oil in the specified quantity at the filler plug. Tighten the filler plug and run the machine to circulate the oil. Check the oil level WHEN RUNNING AT FULL LOAD. If not near the middle of the sight tube, stop the unit and make corrections. DO NOT OVERFILL.

NOTICE

Ingersoll-Rand provides compressor oil specifically formulated for Portable Compressors and requires the use of these fluids in order to obtain extended limited airend warranty.

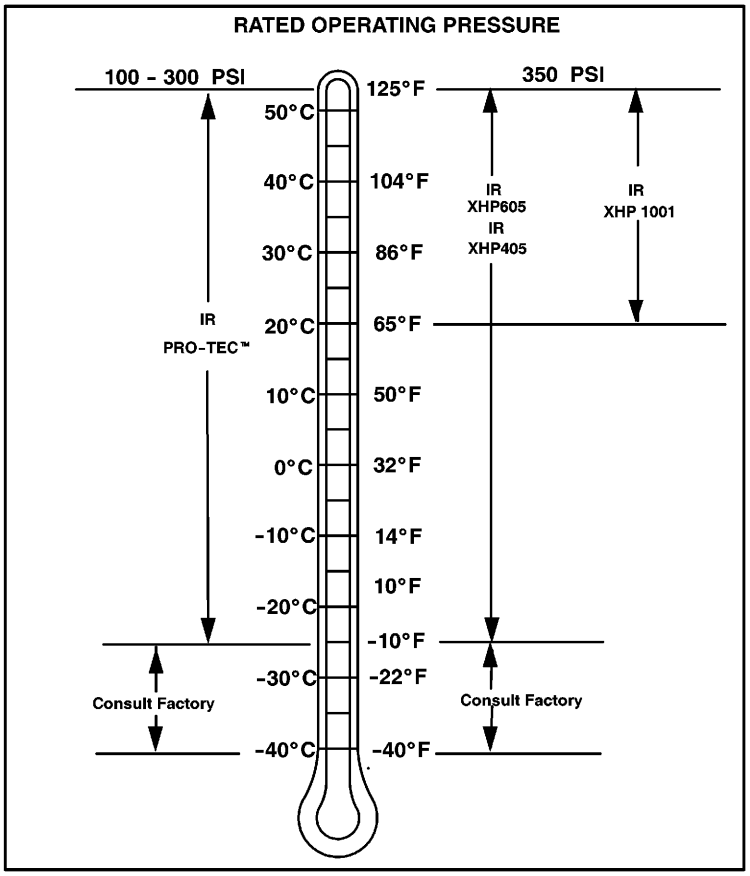
Portable Compressor Fluid Chart

Refer to these charts for correct compressor fluid required. Note that the selection of fluid is dependent on the design operating pressure of the machine and the ambient temperature expected to be encountered before the next oil change.

Note: Fluids listed as "preferred" are required for extended warranty.

Compressor oil carryover (oil consumption) may be greater with the use of alternative fluids.

Design Operating Pressure	Ambient Temperature	Specification
100 psi to 300 psi	-10°F to 125°F (-23°C to 52°C)	Preferred: **IR Pro-Tec™** Alternate: ISO Viscosity Grade 46 with rust and oxidation inhibitors, designed for air compressor service.
350 psi	(-23°C to 52°C) -10°F to 125°F	Preferred: **IR XHP 605** Alternate: IR XHP405 ISO Viscosity Grade 68 Group 3 or 5 with rust and oxidation inhibitors designed for air compressor service.
	65°F to 125°F (-18°C to 52°C)	Preferred: **XHP605** **IR XHP1001**



Preferred Ingersoll-Rand Fluids - Use of these fluids with original I-R filters can extend airend warranty. Refer to operator's manual warranty section for details or contact your I-R representative.

Ingersoll-Rand Preferred Fluids	1 gal. (3.8 Litre)	5 gal. (19.0 Litre)	55 gal. (208.2Litre)	220 gal. (836 litre)
Preferred:				
IR Pro-Tec™	36899698	36899706	36899714	36899722
IR XHP605	-	22252076	22252050	22252068
IR XHP1001	-	35612738	35300516	-
XHP405	-	22252126	22252100	22252118

SECTION 8 - Trouble Shooting

INTRODUCTION

Trouble shooting for a portable air compressor is an organized study of a particular problem or series of problems and a planned method of procedure for investigation and correction. The trouble shooting chart that follows includes some of the problems that an operator may encounter during the operation of a portable compressor.

The chart does not attempt to list all of the troubles that may occur, nor does it attempt to give all of the answers for correction of the problems. The chart does give those problems that are most apt to occur. To use the trouble shooting chart:

A. Find the "complaint" depicted as a bold heading.

B. Follow down that column to find the potential cause or causes. The causes are listed in order (1,2,3 etc.) to suggest an order to follow in trouble shooting.

ACTION PLAN

A. Think Before Acting

Study the problem thoroughly and ask yourself these questions:

(1) What were the warning signals that preceded the trouble?
(2) Has a similar trouble occurred before?
(3) What previous maintenance work has been done?
(4) If the compressor will still operate, is it safe to continue operating it to make further checks?

B. Do The Simplest Things First

Most troubles are simple and easily corrected. For example, most complaints are "low capacity" which may be caused by too low an engine speed or "compressor over- heats" which may be caused by low oil level.

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

Note: For trouble shooting electrical problems, refer to the Wiring Diagram Schematic found in Parts List Section.

C. Double Check Before Disassembly

The source of most compressor troubles can be traced not to one component alone, but to the relationship of one component with another. Too often, a compressor can be partially disassembled in search of the cause of a certain trouble and all evidence is destroyed during disassembly. Check again to be sure an easy solution to the problem has not been overlooked.

D. Find And Correct Basic Cause

After a mechanical failure has been corrected, be sure to locate and correct the cause of the trouble so the same failure will not be repeated. A complaint of "premature breakdown" may be corrected by repairing any improper wiring connections, but something caused the defective wiring. The cause may be excessive vibration.

TROUBLE SHOOTING CHART

Bold Headings depict the COMPLAINT – Subheadings suggest the CAUSE

Note: Subheadings suggest sequence to follow troubleshooting.

1. Unit Shutdown:

	Corrective Action
Out of Fuel	Add CLEAN diesel Fuel
Compressor Oil Temp. Too High	See Complaint 10
Engine Water Temp. Too High	Check coolant level. If necessary, Add.
Engine Oil Pressure Too Low	See Complaint 3 and Complaint 4.
Broken Engine Fan Belt	Replace fan belt.
Loose Wire Connection	Wiggle wires at switches & connector blocks. Make repairs.
Low Fuel Level Shutdown Switch	Replace switch.
Defective Discharge Air Temp. Switch	Replace switch.
Defective Engine Oil Pressure Switch	Replace switch.
Defective Shutdown Solenoid	Replace solenoid.
Malfunctioning Relay	Replace relay.
* < 16 Volts at Shutdown Solenoid	Check battery and alternator. Make repairs.
Blown Fuse	Replace fuse.
Engine Malfunctioning	See Trouble Shooting in Engine Manual.
Airend Malfunctioning	See Complaint 10.

2. Won't Start/Run:

Low Battery Voltage	Check electrolyte level. Check connections.
* <16 Volts at Shutdown Solenoid	Charge battery and alternator. Make repairs.
Blown Fuse	Replace fuse.
Malfunctioning Start Switch	Replace switch.
Defective Safety Bypass Switch	Replace switch.
Clogged Fuel Filters	Service filters. See Engine Operator's Manual.
Out of Fuel	Add CLEAN fuel.
Compressor Oil Temp. Too High	See Complaint 10.
Engine Water Temp. Too High	Check fluid level. If necessary, Add.
Engine Oil Pressure Too Low	See Complaint 3 and Complaint 4.
Loose Wire Connection	Repair or replace connection.
Defective Discharge Air Temp. Switch	Replace switch.
Defective Engine Oil Pressure Switch	Replace switch.
Defective Shutdown Solenoid	Replace solenoid.
Malfunctioning Relay	Replace relay.
Engine Malfunctioning	See Trouble Shooting in Engine Manual.
Airend Malfunctioning	See Complaint 10.

3. Engine Temperature Lamps Stays On:

Broken Engine Fan Belt	Replace fan belt set.
Malfunctioning Circuit Board	Replace circuit board.
* Ambient Temp. >125°F (52°C)	Above spec limit.
Dirty Operating Conditions	Move unit to cleaner environment.
Dirty Cooler	Clean exterior of cooler.
* Out of Level >15 degrees	Relocate or reposition unit.
Operating Pressure Too High	Reduce pressure to spec.
Recirculation of Cooling Air	Close side doors.
Loose Wire Connection	Repair or replace.
Malfunctioning circuit board.	Replace circuit board.

* : > = greater than, < = less than

4. Engine Oil Pressure Lamp Stays On:

	Corrective Action
Low Oil Level	Add oil.
Out of Level >15 degrees	Relocate or reposition.
Wrong Lube Oil	See Engine Oil Spec. Change oil.
Clogged Oil Filter Element(s)	Replace element(s).
Engine Malfunctioning	See Trouble Shooting in Engine Manual.
Loose Wire Connection.	Repair or replace.
Malfunctioning circuit board	Replace circuit.

5. Engine Temperature Lamps Stays Off:

Bulb Burned Out	Replace circuit board.
Malfunctioning circuit board	Replace circuit board.

6. Engine Oil Pressure Lamp Stays Off:

Bulb Burned Out	Replace circuit board.
Malfunctioning circuit board	Replace circuit board.

7. Alternator Lamp Stays On:

Loose or Broken Belts	Tighten or replace belt set.
Loose Wire Connection	Repair or replace connection.
Low Battery Voltage	Check electrolyte level. Add if necessary. Check connectors. Clean & tighten. Recharge battery.
Malfunctioning Alternator	Repair or replace alternator.
Malfunctioning circuit board	Replace circuit board.

8. Alternator Lamp Stays Off:

Bulb Burned Out	Replace circuit board.
Loose Wire Connection	Repair or replace connector.
Malfunctioning circuit board	Replace circuit board.

9. Unit Fails To Shutdown:

Defective Low Fuel Shutdown Switch	Pull wire off shutdown solenoid. Replace switch.
Defective Discharge Air Temperature Switch	Pull wire off. Replace switch.
Defective Engine Oil Pressure Switch	Pull wire off. Replace switch.
Defective Shutdown Solenoid	Carefully block air inlet to stop engine. Replace solenoid.
Malfunctioning Relay	Pull wire off shutdown solenoid. Replace relay.
Defective Safety Bypass Switch	Pull wire off shutdown solenoid. Replace defective item.

10. Excessive Compressor Oil Temperature:

	Corrective Action
Ambient Temp. > 125°F (52°C)	Above spec limit.
Out of Level > 15 degrees	Relocate or reposition unit.
Low Oil Level	Add oil. Look for any leaks.
Wrong Lube Oil	Check spec in this manual.
Dirty Cooler	Clean exterior surfaces.
Dirty Operating Conditions	Move unit to cleaner environment.
Clogged Oil Filter Elements	Replace elements. Change oil.
Loose or Broken Belts	Tighten or replace belt set.
Operating Pressure Too High	Reduce pressure to spec.
Recirculation Of Cooling Air	Close side doors. Replace belly pan.
Malfunctioning Thermostat	Replace thermostat in bypass valve.
Malfunctioning Fan	Check fan belt tension. Tighten or replace belt set.
Defective Oil Cooler Relief Valve	Replace valve.
Defective Minimum Pressure Valve	Repair or replace valve.
Blocked or Restricted Oil Lines	Clean by flushing or replace.
Airend Malfunctioning	See Complaint 11, 12, 13, 15, 16 or 18.

11. Engine RPM Down:

Clogged Fuel Filter	Clean primary filter. Replace final filter. Drain tanks. Add CLEAN fuel.
Operating Pressure Too High	Reduce pressure to spec limit.
Incorrect Pressure Regulator Adjustment	See Section 6 in this manual.
Malfunctioning Pressure Regulator	Replace regulator.
Incorrect Linkage Adjustment	See Section 6 in this manual.
Dirty Air Filter	Clean or replace elements.
Malfunctioning Air Cylinder	Replace air cylinder and adjust per Section 6.
Wrong Air Filter Element	Install correct element.
Defective Separator Element	Install new element per page 21.
Engine Malfunctioning	See Trouble Shooting in Engine Manual.
Airend Malfunctioning	Refer to Airend Rebuild Manual.

12. Excessive Vibration:

Rubber Mounts, Loose or Damaged	Tighten or replace.
Defective Fan	Replace fan.
Drive Coupling Defective	Replace coupling.
Engine Malfunctioning	See Trouble Shooting in Engine Manual.
Airend Malfunctioning	See Complaint 15 and 17.
Anti-rumble valve not working.	Repair or Replace.
Engine idle speed too low.	Raise “No Load” speed per Section 6.

13. Low CFM:

Dirty Air Filter	Clean or replace elements.
Incorrect Linkage Adjustment	See Section 6 in this manual.
Incorrect Pressure Regulator Adjustment	See Section 6 in this manual.
Malfunctioning Pressure Regulator	Replace regulator.
Malfunctioning Inlet Unloader/Butterfly Valve	Inspect valve. Make adjustment per Section 6.
Malfunctioning Air Cylinder	Replace air cylinder.
Defective Minimum Pressure Valve	Repair or replace valve.
Defective Separator Element	Install new element per Page 21.
Wrong Air Filter Element	Install correct element.

14. Short Air Cleaner Life:

	Corrective Action
Dirty Operating Conditions	Move unit to cleaner environment.
Inadequate Element Cleaning	Install new element.
Incorrect Stopping Procedure	Read procedure in this manual.
Wrong Air Filter Element	Install proper element.
Oil Pump Drive Coupling	Inspect coupling. If necessary, replace coupling.

15. Excessive Oil In Air:

High Oil Level	Read procedure in this manual.
Out of Level > 15 degrees	Relocate or reposition unit.
Clogged Scavenge Orifice	Remove scavenge orifice. Clean and Replace.
Scavenge Tube Blocked	Remove scavenge tube. Clean and Replace.
Defective Scavenge Check Valve	Remove check valve. Replace with new valve.
Sep. Tank Blow Down Too Quickly	Allow unit to blow down automatically.
Defective Minimum Pressure Valve	Remove valve. Repair valve and replace.

16. Oil Seal Leak:

Contaminated Lube Oil	Drain and flush system. Add new CLEAN oil.
Blocked or Restricted Oil Line(s)	Remove, clean and replace line(s).
Malfunctioning Seal	Refer to Airend Rebuild Manual.
Scored Shaft	See instructions in new seal kit.

17. Will Not Unload:

Leak in Regulator Piping	Find and repair leak(s).
Incorrect Pressure Regulator Adjustment	Refer to Section 6 in this manual.
Malfunctioning Pressure Regulator	Replace regulator.
Malfunctioning Inlet Butterfly Valve	Inspect valve fit. Readjust per Section 6.
Ice in Regulation Lines/Orifice	Apply heat to line(s) and or orifice.

18. Oil In Air Cleaner:

Incorrect Stopping Procedure	Read Procedure in this manual.
Oil Pump Drive Coupling	Inspect coupling. Replace if necessary.
Discharge Check Valve Faulty	Replace.

19. Safety Valve Relieves:

Operating Pressure Too High	Reduce pressure to spec limit.
Leak In Regulator Piping	Repair leak(s).
Incorrect Pressure Regulator Adjustment	Refer to Section 6 in this manual.
Malfunctioning Pressure Regulator	Replace regulator.
Malfunctioning Inlet Unloader/Butterfly Valve	Inspect valve fit. Readjust per Section 6.
Defective Safety Valve	Replace safety valve.
Defective Separator Element	Remove element. Install new.
Ice in Regulation Lines/Orifice	Apply heat to lines and/or orifice.

SECTION 9 - PARTS ORDERING

GENERAL

This publication, which contains an illustrated parts breakdown, has been prepared as an aid in locating those parts which may be required in the maintenance of the unit. All of the compressor parts, listed in the parts breakdown, are manufactured with the same precision as the original equipment. For the greatest protection always insist on genuine Ingersoll-Rand Company parts for your compressor.

NOTICE

Ingersoll-Rand Company can bear no responsibility for injury or damages resulting directly from the use of non-approved repair parts.

Ingersoll-Rand Company service facilities and parts are available worldwide. There are Ingersoll- Rand Company Construction Equipment Group Sales Offices and authorized distributors located in the principal cities of the United States. In Canada our customers are serviced by the Canadian Ingersoll-Rand Company, Limited. There are also Ingersoll-Rand International autonomous companies and authorized distributors located in the principal cities throughout the free world.

Special order parts may not be included in this manual. Contact the Mocksville Parts Department with the unit serial number for assistance with these special parts.

DESCRIPTION

The illustrated parts breakdown illustrates and lists the various assemblies, subassemblies and detailed parts which make up this particular machine. This covers the standard models and the more popular options that are available.

A series of illustrations show each part distinctly and in location relative to the other parts in the assembly. The part number, the description of the part and the quantity of parts required are shown on each illustration or on adjacent page. The quantities specified are the number of parts used per one assembly and are not necessarily the total number of parts used in the machine. Where no quantity is specified the quantity is assumed to be one.

Each description of a part is based upon the "noun first" method, i.e., the identifying noun or item name is always the first part of the description. The noun name is generally followed by a single descriptive modifier. The descriptive modifier may be followed by words or abbreviations such as upper, lower, inner, outer, front, rear, RH, LH, etc. when they are essential.

In referring to the rear, the front or to either side of the unit, always consider the **drawbar end** of the unit as the **front.** Standing at the rear of the unit facing the drawbar (front) will determine the right and left sides.

FASTENERS

Both SAE/inch and ISO/metric hardware have been used in the design and assembly of these units. In the disassembly and reassembly of parts, extreme care must be taken to avoid damaging threads by the use of wrong fasteners. In order to clarify the proper usage and for exact replacement parts, all standard fasteners have been identified by part number, size and description. This will enable a customer to obtain fasteners locally rather than ordering from the factory. These parts are identified in tables that will be found at the rear of the parts illustrations. Any fastener that has not been identified by both part number and size is a specially engineered part that must be ordered by part number to obtain the exact replacement part.

MARKINGS AND DECALS

NOTICE

Do not paint over safety warnings or instructional decals. If safety warning decals become illegible, immediately order replacements from the factory.

Part numbers for original individual decals and their mounting locations are shown within Parts List Section. These are available as long as a particular model is in production.

Afterwards, service sets of exterior decals and current production safety warning decals are available. Contact the Product Support Group at Mocksville for your particular needs and availability.

HOW TO USE PARTS LIST

a. Turn to Parts List.

b. Locate the area or system of the compressor in which the desired part is used and find illustration page number.

c. Locate the desired part on the illustration by visual identification and make note of part number and description.

HOW TO ORDER

The satisfactory ordering of parts by a purchaser is greatly dependent upon the proper use of all available information. By supplying your nearest sales office, autonomous company or authorized distributor, with complete information, you will enable them to fill your order correctly and to avoid any unnecessary delays.

In order that all avoidable errors may be eliminated, the following instructions are offered as a guide to the purchaser when ordering replacement parts:

a. Always specify the model number of the unit as shown on the general data decal attached to the unit.

b. Always specify the serial number of the unit. THIS IS IMPORTANT. The serial number of the unit will be found stamped on a plate attached to the unit. (The serial number on the unit is also permanently stamped in the metal of the frame side rail.)

c. Always specify the number of the parts list publication.

d. Always specify the quantity of parts required.

e. Always specify the part number, as well as the description of the part, or parts, exactly as it is given on the parts list illustration.

In the event parts are being returned to your nearest sales office, autonomous company or authorized distributor, for inspection or repair, it is important to include the serial number of the unit from which the parts were removed.

TERMS AND CONDITIONS ON PARTS ORDERS

Acceptance: Acceptance of an offer is expressly limited to the exact terms contained herein. If purchaser's order form is used for acceptance of an offer, it is expressly understood and agreed that the terms and conditions of such order form shall not apply unless expressly agreed to by Ingersoll-Rand Company ("Company") in writing. No additional or contrary terms will be binding upon the Company unless expressly agreed to in writing.

Taxes: Any tax or other governmental charge now or hereafter levied upon the production, sale, use or shipment of material and equipment ordered or sold is not included in the Company's price and will be charged to and paid for by the Purchaser.

Shipping dates shall be extended for delays due to acts of God, acts of Purchaser, acts of Government, fires, floods, strikes, riot, war, embargo, transportation shortages, delay or default on the part of the Company's vendors, or any other cause beyond the Company's reasonable control.

Should Purchaser request special shipping instruction, such as exclusive use of shipping facilities, including air freight when common carrier has been quoted and before change order to purchase order can be received by the Company, the additional charges will be honored by the Purchaser.

Warranty: The Company warrants that parts manufactured by it will be as specified and will be free from defects in materials and workmanship. The Company's liability under this warranty shall be limited to the repair or replacement of any part which was defective at the time of shipment provided Purchaser notifies the Company of any such defect promptly upon discovery, but in no event later than three (3) months from the date of shipment of such part by the Company. The only exception to the previous statement is the extended warranty as it applies to the special airend exchange program.

Repairs and replacements shall be made by the Company F.O.B. point of shipment. The Company shall not be responsible for costs of transportation, removal or installation.

Warranties applicable to material and equipment supplied by the Company but wholly manufactured by others shall be limited to the warranties extended to the Company by the manufacturer which are able to be conveyed to the Purchaser.

Delivery: Shipping dates are approximate. The Company will use best efforts to ship by the dates specified; however, the Company shall not be liable for any delay or failure in the estimated delivery or shipment of material and equipment or for any damages suffered by reason thereof.

The company makes no other warranty or representation of any kind whatsoever, expressed or implied, except that of title, and all implied warranties, including any warranty of merchantability and fitness for a particular purpose, are hereby disclaimed.

Limitation of Liability:

The remedies of the Purchaser set forth herein are exclusive, and the total liability of the Company with respect to this order whether based on contract, warranty, negligence, indemnity, strict liability or otherwise, shall not exceed the purchase price of the part upon which such liability is based.

The Company shall in no event be liable to the Purchaser, any successors in interest or any beneficiary of this order for any consequential, incidental, indirect, special or punitive damages arising out of this order or any breach thereof, or any defect in, or failure of, or malfunction of the parts hereunder, whether based upon loss of use, lost profits or revenue, interest, lost goodwill, work stoppage, impairment of other goods, loss by reason of shutdown or non- operation, increased expenses of operation or claims of customers of Purchaser for service interruption whether or not such loss or damage is based on contract, warranty, negligence, indemnity, strict liability or otherwise.

AIREND EXCHANGE PROGRAM

Your Ingersoll-Rand Company Construction Equipment Group Sales Offices and authorized distributors as well as Ingersoll-Rand International autonomous companies and authorized distributors now have an airend exchange program to benefit portable compressor users.

On the airend exchange program the exchange price is determined by the age and condition of the airend and may be classified by one of the following categories.

Category "A": The airend must not be over two years old and must have reusable rotor housing(s) and rotor(s).

Category "B": The airend must be between two and five years old and returned with two or more reusable major castings.

Category "C": The airend must be over five years old.

Your nearest sales office, autonomous company or authorized distributor must first contact the Parts Service Department at the factory at which your portable air compressor was manufactured for an airend exchange number. The airend must be tagged with this preassigned number and returned to the factory prepaid. The airend must be intact, with no excluded parts, otherwise the exchange agreement may be cancelled. The warranty on an exchange or factory rebuilt airend is 365 days.

Airends being returned to the factory in connection with a WARRANTY CLAIM must be processed through the Customer Service Department. If returned without a Warranty MRR (Material Return Request) Number, no warranty claim will be considered.

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PARTS LIST INDEX

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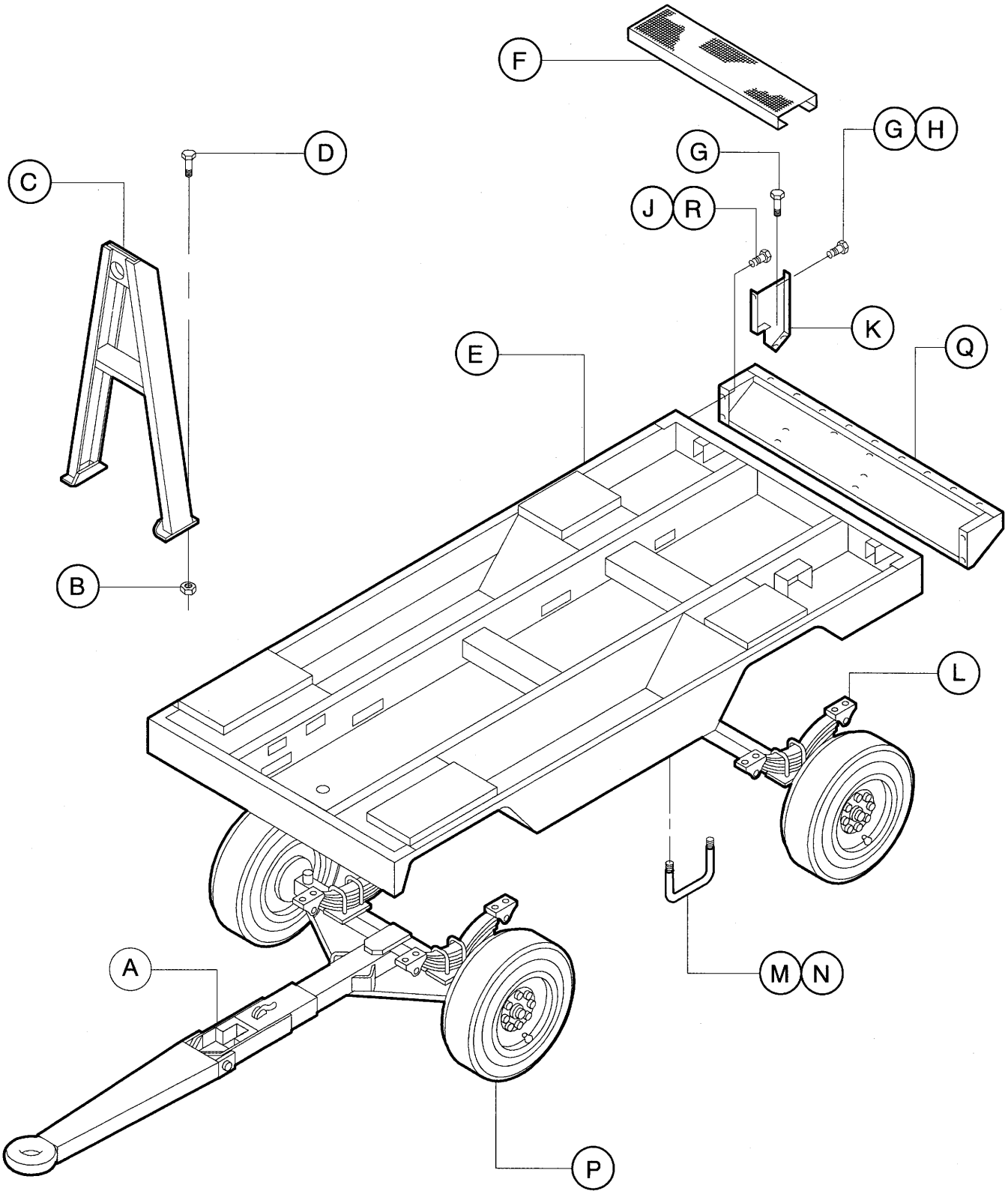
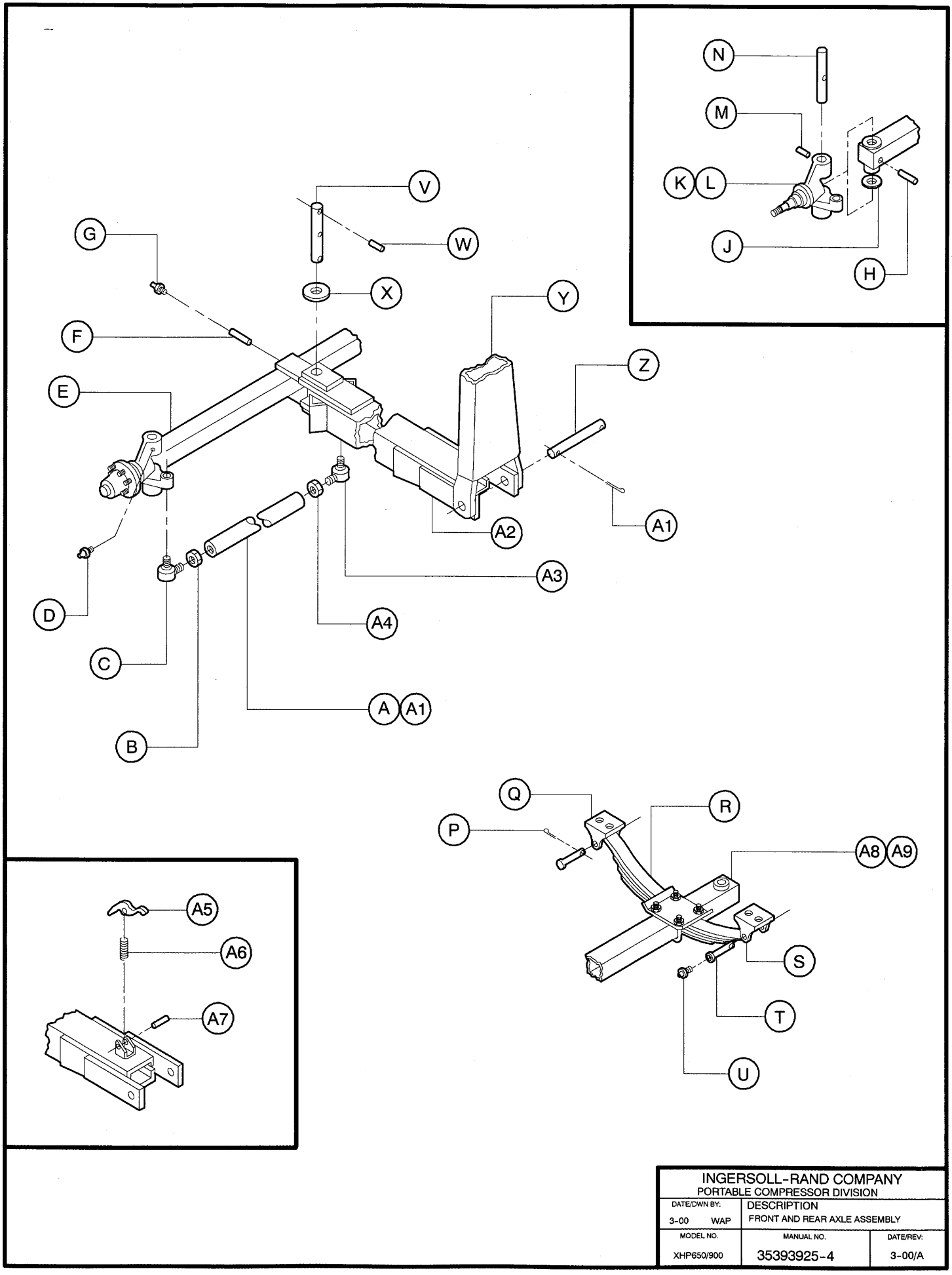
High Speed Running Gear , Sht 4
High Speed Running Gear , Sht 5
High Speed Running Gear , Sht 6



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FRAME AND RUNNING GEAR	
MODEL NO. XHP650/900	MANUAL NO. 35393925-2	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	36845741	1	FRONT AXLE ASSEMBLY
B	16A4C8Z1	6	NUT
C	36754620	1	BAIL , LIFTING
D	35A2D378Z1	6	SCREW
E	36864841	1	FRAME
F	36864809	1	STEP GRIP
G	35144344	4	SCREW
H	35145077	4	NUT
J	35A2D219Z1	4	SCREW
K	36786614	2	SUPPORT , STEP
L	36845758	1	REAR AXLE ASSEMBLY
M	35304666	3	STEP
N	16A4C7Z1	12	NUT
P	35091545	1	TIRE AND WHEEL ASSEMBLY
Q	36865491	1	FRAME EXTENSION
R	16A4C5Z1	4	NUT

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FRAME AND RUNNING GEAR	
MODEL NO. XHP650/900	MANUAL NO. 35393925-3	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FRONT AND REAR AXLE ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-4	DATE/REV: 3-00/A

ITEM	C.P.N.	DESCRIPTION
A	36504389	ROD , TIE
B	36140730	NUT , JAM
C	35588961	BALL JOINT , OUTER
D	W86707	FITTING , LUBE
E	36753259	AXLE , FRONT
F	25A13C283	PIN , ROLL
G	W86707	FITTING , LUBE
H	25A13C301	PIN , ROLL
J	95239927	WASHER
K	36851566	L.H. KNUCKLE ASSEMBLY
L	36851574	R.H. KNUCKLE ASSEMBLY
M	25A13C281	PIN , ROLL
N	35319045	PIN , KING
P	11A13C66E	PIN , COTTER
Q	36719169	BRACKET
R	36719466	SPRING
S	36719177	BRACKET
T	35111590	BOLT , SHACKLE
U	250A10X1613C	FITTING , LUBE
V	35588755	PIN , CENTER
W	25A13C298	PIN , ROLL
X	12A5D13Z1	WASHER
Y	36719557	DRAWBAR
Z	35107168	PIN , HINGE
A1	11A13C83E	PIN , COTTER
A2	36753242	ARM , CENTER
A3	35588953	BALLJOINT , INNER
A4	35140722	NUT , JAM
A5	36719219	LATCH
A6	35141167	SPRING
A7	25A13C332	PIN , ROLL
A8	36851376	FRONT AXLE ASSEMBLY
A9	36851384	REAR AXLE ASSEMBLY
B1	36853042	TIE ROD ASSEMBLY (INCLUDES A,B,C,A3,A4)

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FRONT AND REAR AXLE ASSEMBLY	
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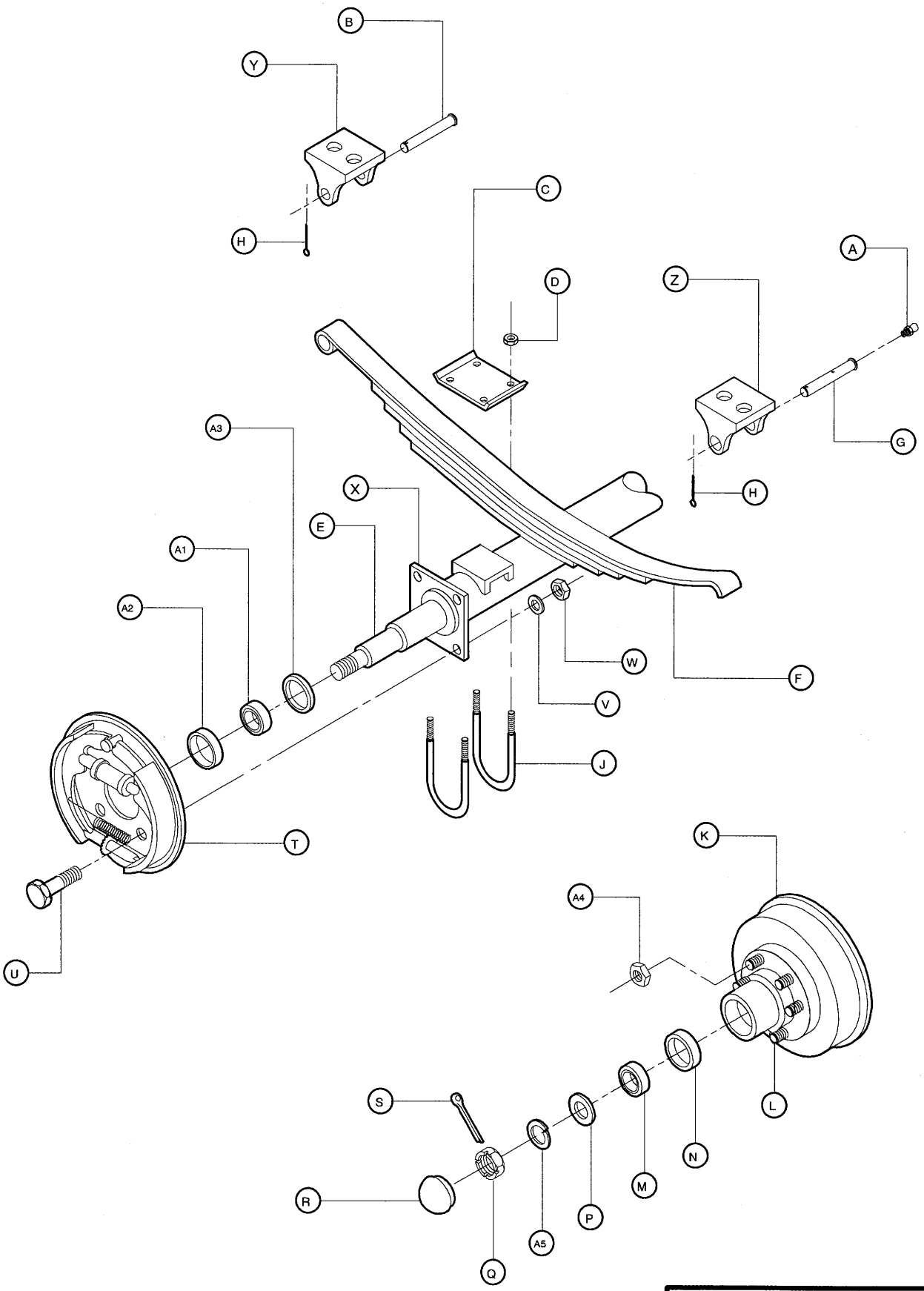
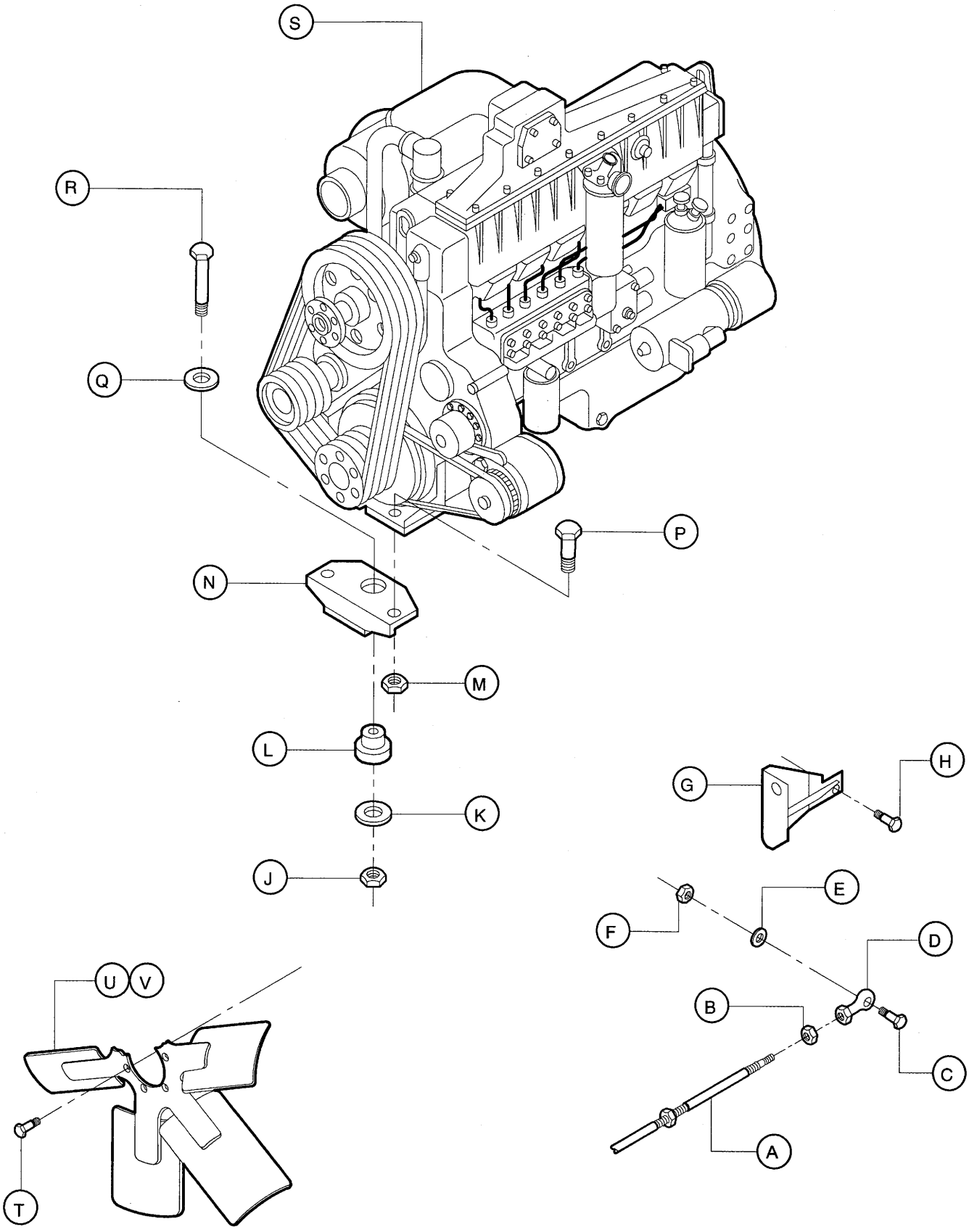


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FRONT AND REAR AXLE ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-6	DATE/REV: 3-00/A

ITEM	C.P.N.	DESCRIPTION
A	250A10X1613C	FITTING , LUBE
B	35588839	RIVET
C	35589241	PLATE , CLAMP
D	35111566	NUT
E	36851640	AXLE , REAR
F	36719466	SPRING
G	35111590	BOLT , SHACKLE
H	11A13C66E	PIN , COTTER
J	35834621	U-BOLT
K	36851665	HUB ASSEMBLY (INCLUDES ITEMS N, L, A2)
L	36764983	STUD
M	36851590	OUTTER BEARING
N	36851616	OUTER RACE
P	36853109	WASHER , FLAT
Q	36853091	NUT
R	36776813	CAP , GREASE
S	11A13C41E	PIN , COTTER
T	36781920	PARKING BRAKE ASSEMBLY
U	36A2D326Z1	BOLT
V	14A5C120Z1	WASHER , FLAT
W	22A4C7G	NUT
X	36776839	FLANGE , BRAKE MTG
Y	36719177	BRACKET
Z	36719169	BRACKET
A1	36851608	INNER BEARING
A2	36851624	INNER RACE
A3	36851632	SEAL
A4	36776821	NUT , STUD
A5	36853117	WASHER , LOCK

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FRONT AND REAR AXLE ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-7	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENGINE ASSEMBLY (650/825)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-8	DATE/REV: 3-00/A

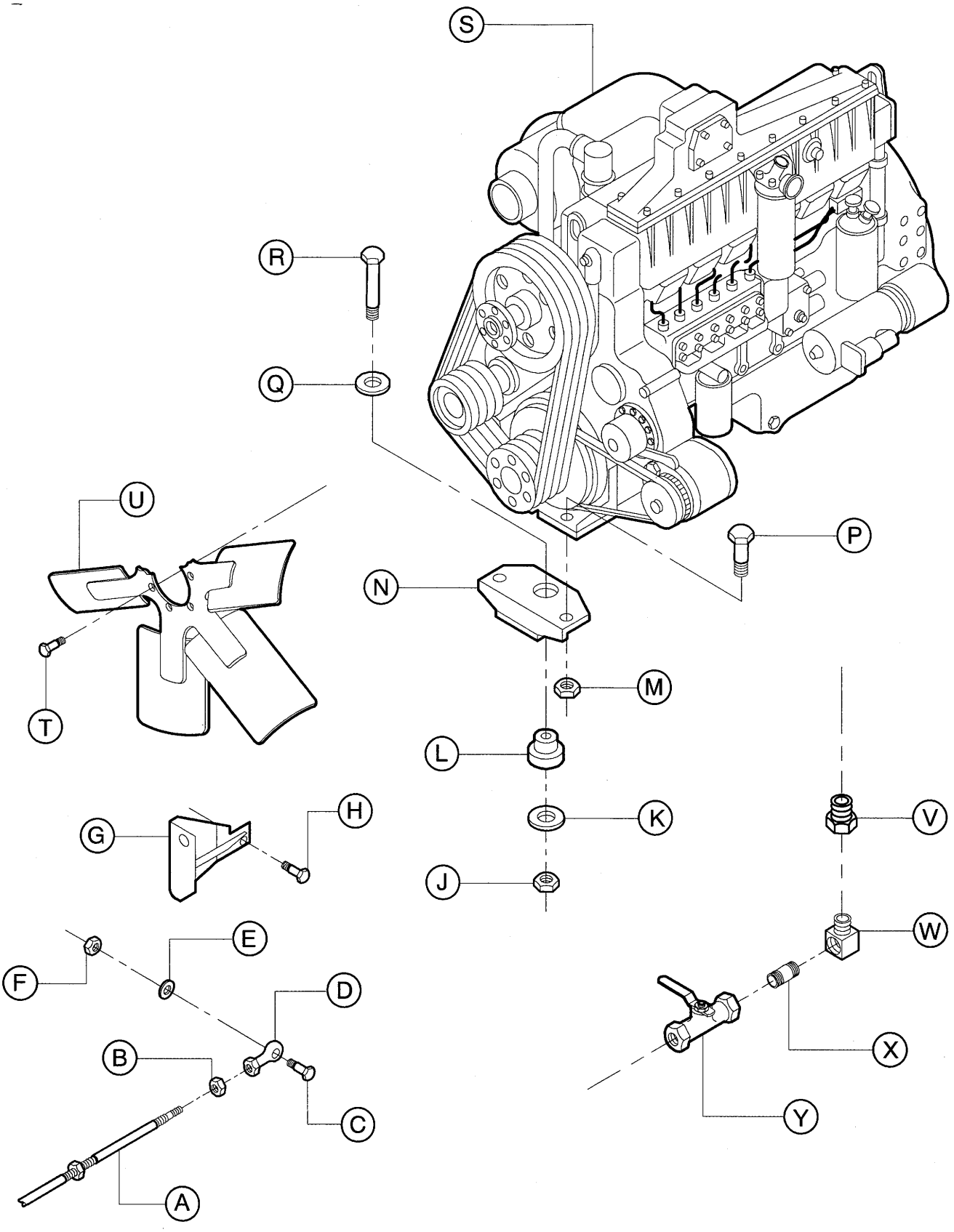
(A)	35586437	CABLE , CONTROL	
(B)	23A4C1Z1	NUT , JAM	
(C)	35A2D5Z1	SCREW	
(D)	W78185	BEARING	
(E)	12A5D2Z1	WASHER	
(F)	67A4C1Z1	NUT	
(G)	36763761	BRACKET	
(H)	35A2D56G	SCREW	(2 REQD)
(J)	16A4C8G	NUT	
(K)	35273937	WASHER	
(L)	35599950	MOUNT , RUBBER	
(M)	35145077	NUT	(2 REQD)
(N)	43209139	BRACKET	
(P)	35144344	SCREW	(2 REQD)
(Q)	35306760	WASHER	
(R)	35A2D386G	SCREW	
(S)	36763027	ENGINE , CAT 3306B	
(T)	35A2D117G	SCREW	(6 REQD)
(U)	36758035	FAN	
(V)	36762920	SPACER	

35310549 ——— ENGINE FUEL FILTER

35310556 ——— ENGINE OIL FILTER

35607605 ——— ENGINE WATER SEPARATOR FILTER

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENGINE ASSEMBLY (650/825)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-9	DATE/REV: 11-01/B

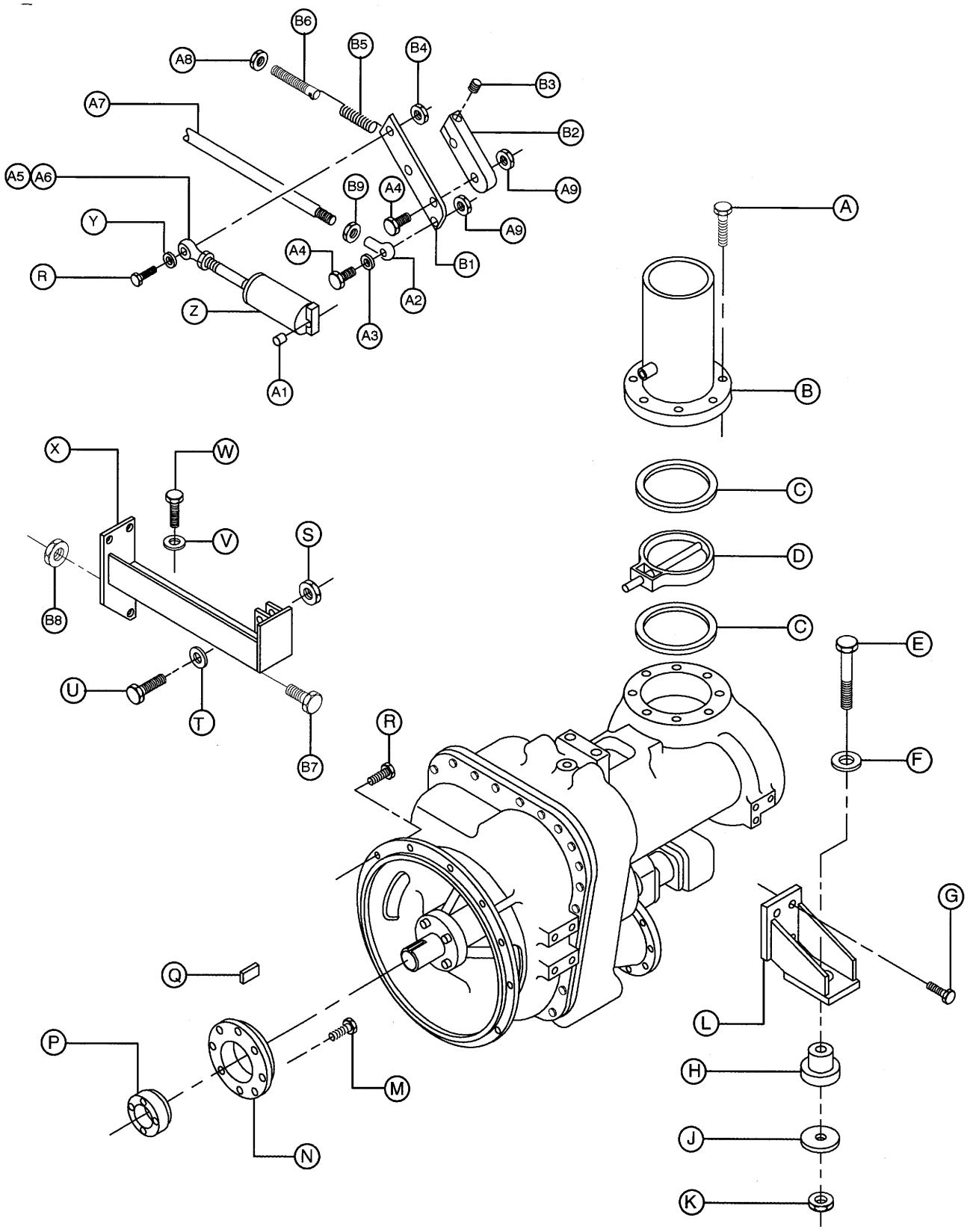


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENGINE ASSEMBLY (900)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-10	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	35279579	1	CABLE , CONTROL
B	23A4C1Z1	1	NUT , JAM
C	35A2D5Z1	1	SCREW
D	W78185	1	BEARING
E	12A5G2	1	WASHER
F	67A4C1G	1	NUT
G	36763761	1	BRACKET
H	35A2D56G	2	SCREW
J	16A4C8G	1	NUT
K	35273937	1	WASHER
L	35302835	1	MOUNT , RUBBER
M	35145077	2	NUT
N	43209139	1	BRACKET
P	35144344	2	SCREW
Q	35306760	1	WASHER
R	35A2D386G	1	SCREW
S	36765477	1	ENGINE
T	35A2D221	6	SCREW
U	36771988	1	FAN
V	23A7S11	1	BUSHING
W	67A7M25	1	ELBOW
X	19A7J5Z1	1	NIPPLE
Y	36777399	1	VALVE , BALL

35362243 ——— **ENGINE FUEL FILTER**
35362235 ——— **ENGINE OIL FILTER**
35362268 ——— **ENGINE WATER SEPARATOR FILTER**
35362250 ——— **PRIMARY FUEL FILTER**

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENGINE ASSEMBLY (900)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-11	DATE/REV: 11-01/B



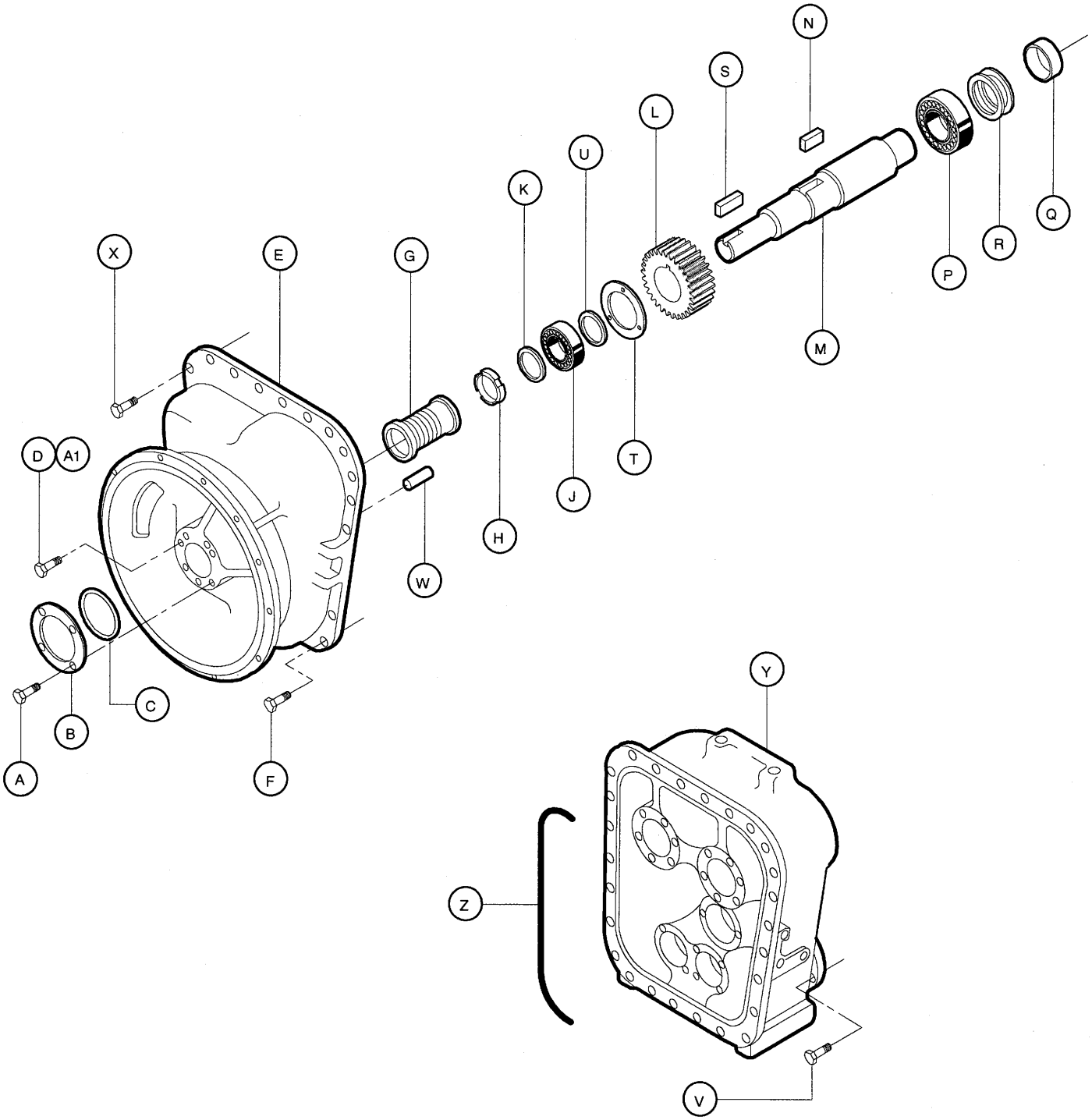
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-12	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	35375963	8	SCREW
B	36769263	1	FLANGE , INTAKE
C	36786515	2	GASKET
D	35285626	1	VALVE , BUTTERFLY
E	35A2D386Z1	2	SCREW
F	35101468	2	WASHER , SNUBBER
G	35375856	8	SCREW
H	35599950	2	MOUNT , RUBBER (XHP-750)
	35302835	2	MOUNT , RUBBER (XHP-900)
J	35273937	2	WASHER , SNUBBER
K	16A4C8Z1	2	NUT
L	36766988	2	BRACKET , CPRSR MTG
M	35A2D121G	8	SCREW
N	36730380	1	COPLING
P	35103852	1	BUSHING
Q	35364975	1	KEY
R	35A2D168Z1	13	SCREW
S	67A4C2Z1	1	NUT
T	12A5D3Z1	1	WASHER , FLAT
U	35288893	1	PIVOT , LEVER REG
V	12A5D9Z1	2	WASHER , FLAT
W	35375856	2	SCREW
X	36844819	1	BRACKET , AIR CYLINDER
Y	11A5D4Z1	1	WASHER , FLAT
Z	35584689	1	CYLINDER , AIR
A1	35288885	1	BUSHING
A2	W78185	1	BEARING , ROD END
A3	12A5D2Z1	1	WASHER , FLAT
A4	35A2D10Z1	2	SCREW
A5	35300532	1	BEARING , ROD END
A6	23A4C4Z1	1	NUT
A7	35279579	1	CABLE , CONTROL
A8	35145077	2	NUT
A9	67A4C1Z1	1	NUT
B1	356079010	1	LEVER , REGULATION
B2	35264951	1	LEVER , CONTROL
B3	119A2A146Z1	1	SCREW , SET
B4	67A4C4Z1	1	NUT
B5	35579523	1	SPRING
B6	35605799	1	ROD , ADJUSTER
B7	35611680	1	BOLT
B8	16A4C3Z1	1	NUT , JAM
B9	23A4C1Z1	1	NUT , JAM

SEE PAGE 15 FOR AIR END ASSEMBLY NUMBER

EXCHANGE AIREND OPTION: INGERSOLL-RAND OFFERS FACTORY REMANUFACTURED AIRENDS THAT ARE BUILT TO THE LATEST DESIGNS. MEANING IT WILL REFLECT ALL THE ENGINEERING UPGRADES AND PERFORMANCE ENHANCEMENTS MADE TO THAT SIZE UNIT. ALL EXCHANGE AIRENDS COME WITH A ONE YEAR WARRANTY. THESE BENEFITS MAKE A FACTORY REBUILT AIREND THE ONLY COST EFFECTIVE OPTION. CALL YOUR LOCAL IR DEALER FOR MORE DETAILS. PLEASE PROVIDE YOUR AIREND SERIAL NUMBER.

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-13	DATE/REV: 3-00/A



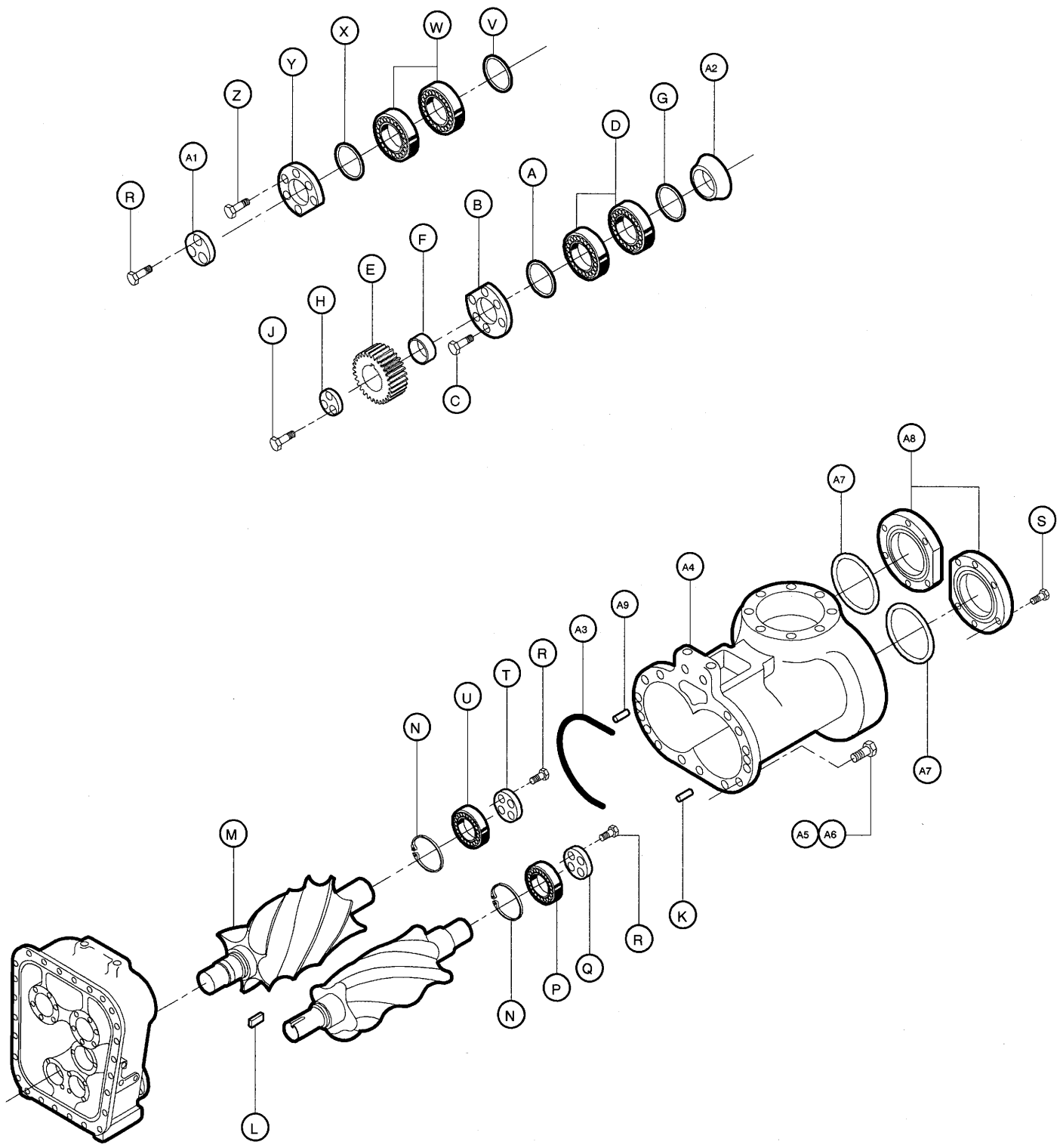
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-14	DATE/REV: 3-00/A

STARTING WITH SERIAL NO. 318481

A	36846988	BOLT
B	39860192	COVER ASSEMBLY
	39860184	COVER
	95533469	PIN
C	95022372	O-RING
D	35361286	BOLT
E	36750909	CASE , GEAR
F	35318146	BOLT
G	39919485	SEAL , OIL
H	35104082	NUT , LOCK
J	35610195	BEARING , TAPER ROLLER
K	35372002	SPACER
L	SEE GEAR SET CHART	
M	36504116	SHAFT , DRIVE
N	35355809	KEY
P	35610203	BEARING , TAPER ROLLER
Q	35372010	SPACER
R	35372028	SHIM SET
S	35364975	KEY
T	35610153	PLATE , RETAINING
U	35371996	SPACER
V	35372533	BOLT
W	35336122	DOWEL
X	35272541	BOLT
Y	36861367	HOUSING , MAIN
Z	35355775	O-RING
A1	39101449	PLUG

CFM	INPUT SPEED	GEAR SET PART NO.	A/E ASSY. NO.
600	2100	36746436	35086339
650	1850	36746410	35086347
750-S	2100	36746410	35086347
750-W	1850	36763183	35096205
825	1850	36746428	35086354
900	1800	36765113	35097468
900	2100	36746428	35086354

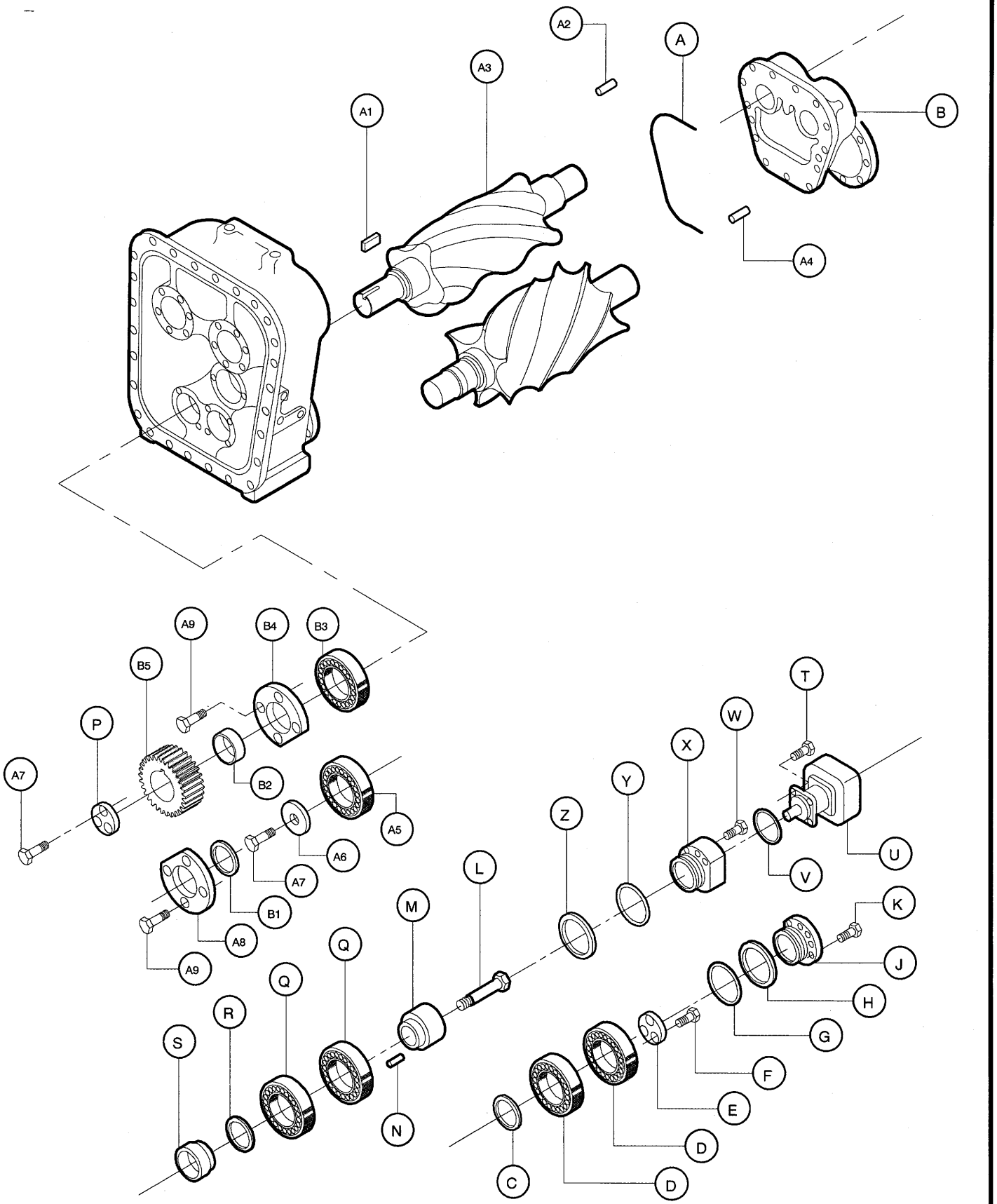
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-15	DATE/REV: 1-8/B



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-16	DATE/REV. 3-00/A

A	35355767	SHIM SET
B	36501013	PLATE , RETAINING
C	34M2AB412	BOLT
D	35605203	BEARING , TAPERED ROLLER
E	SEE GEAR SET CHART / SHEET 2 OF 6	
F	35355841	SPACER
G	35355825	SHIM SET
H	35355858	CLAMP , PLATE
J	34M2AB462	BOLT
K	35336122	DOWEL
L	35355817	KEY
M	35082114	ROTOR SET , 1ST STAGE
N	161A13S433	RING , SNAP
P	35600030	BEARING , ROLLER
Q	35300193	CLAMP , PLATE
R	35311463	BOLT
S	92329309	BOLT
T	35300193	CLAMP , PLATE
U	35600022	BEARING , ROLLER
V	35355833	SHIM SET
W	35600105	BEARING , TAPERED ROLLER
X	35355767	SHIM SET
Y	35856418	PLATE , RETAINER
Z	92304393	BOLT
A1	36508414	CLAMP , PLATE
A2	35602457	PISTON , THRUST
A3	35355783	O-RING
A4	36738797	HOUSING , 1ST STAGE ROTOR
A5	35356039	BOLT
A6	35295344	BOLT
A7	35355502	O-RING
A8	35331883	PLATE , COVER
A9	35336130	DOWEL

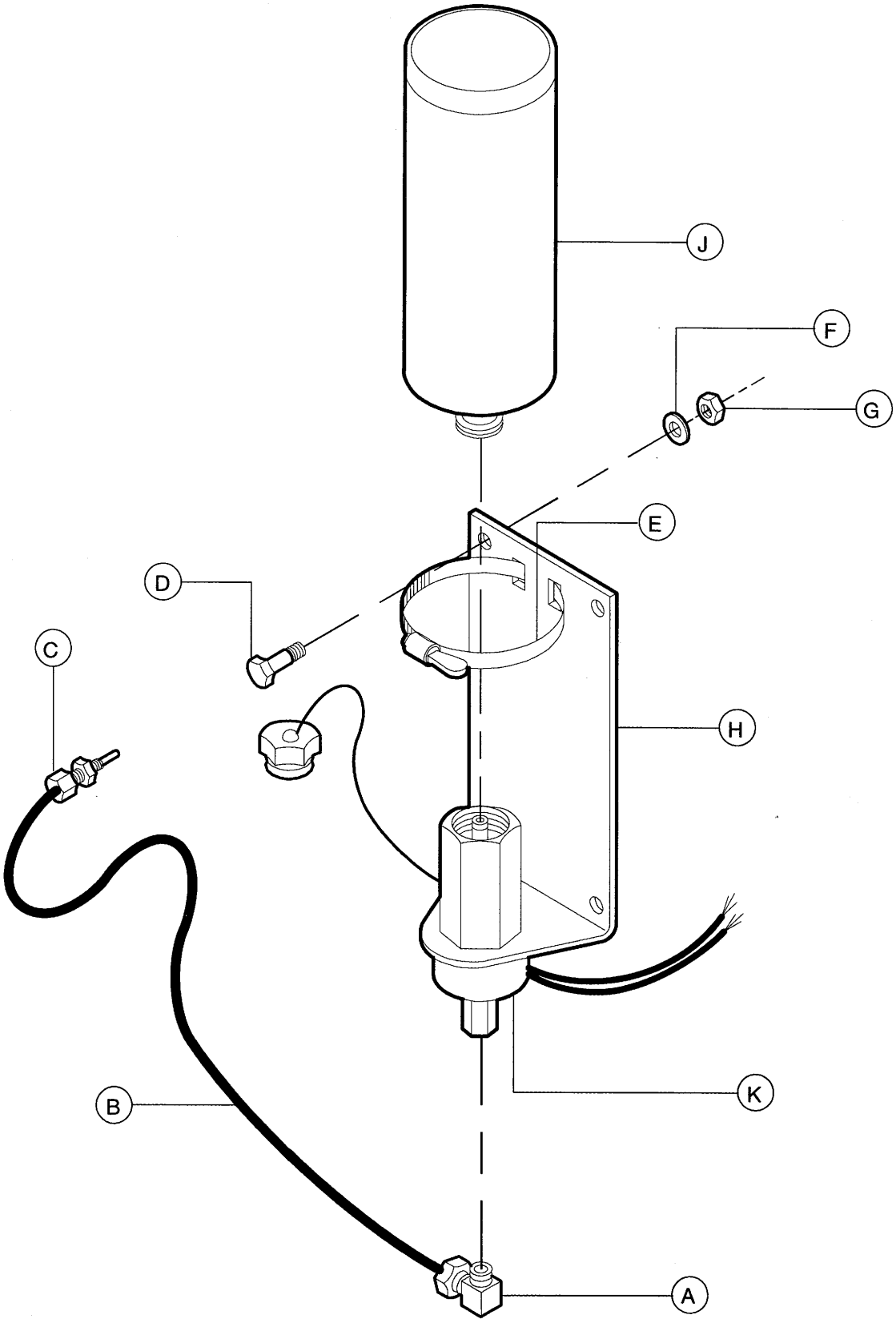
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-17	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-18	DATE/REV: 3-00/A

A	35355791	O-RING
B	36738128	HOUSING , REAR BEARING
C	35355874	SHIM SET
D	35600113	BEARING , TAPERED ROLLER
E	35355957	CLAMP , PLATE
F	35311463	BOLT
G	95026290	O-RING
H	35355924	SHIM SET
J	35856350	COVER , REAR BEARING
K	34M2AB411	BOLT
L	36851277	BOLT
M	35864644	COUPLING
N	95069522	PIN , DOWEL
P	35300193	CLAMP , PLATE
Q	35600113	BEARING , TAPERED ROLLER
R	35355874	SHIM SET
S	35355940	PISTON , THRUST
T	35272533	BOLT
U	35366657	PUMP , OIL
V	20A11EM155	O-RING
W	39138128	BOLT
X	36500734	COVER , BEARING
Y	95026290	O-RING
Z	35355916	SHIM SET
A1	35355817	KEY
A2	35336122	DOWEL
A3	36006732	ROTOR SET , 2ND STAGE
A4	35336130	DOWEL
A5	35600014	BEARING , ROLLER
A6	35300201	CLAMP , PLATE
A7	35311463	BOLT
A8	35355999	PLATE , RETAINING
A9	35273408	BOLT
B1	35355973	SPACER , BEARING
B2	35355866	SPACER
B3	35600022	BEARING , ROLLER
B4	35355965	PLATE , RETAINING
B5	SEE GEAR SET CHART / SHEET 2 OF 6	

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-19	DATE/REV: 3-00/A

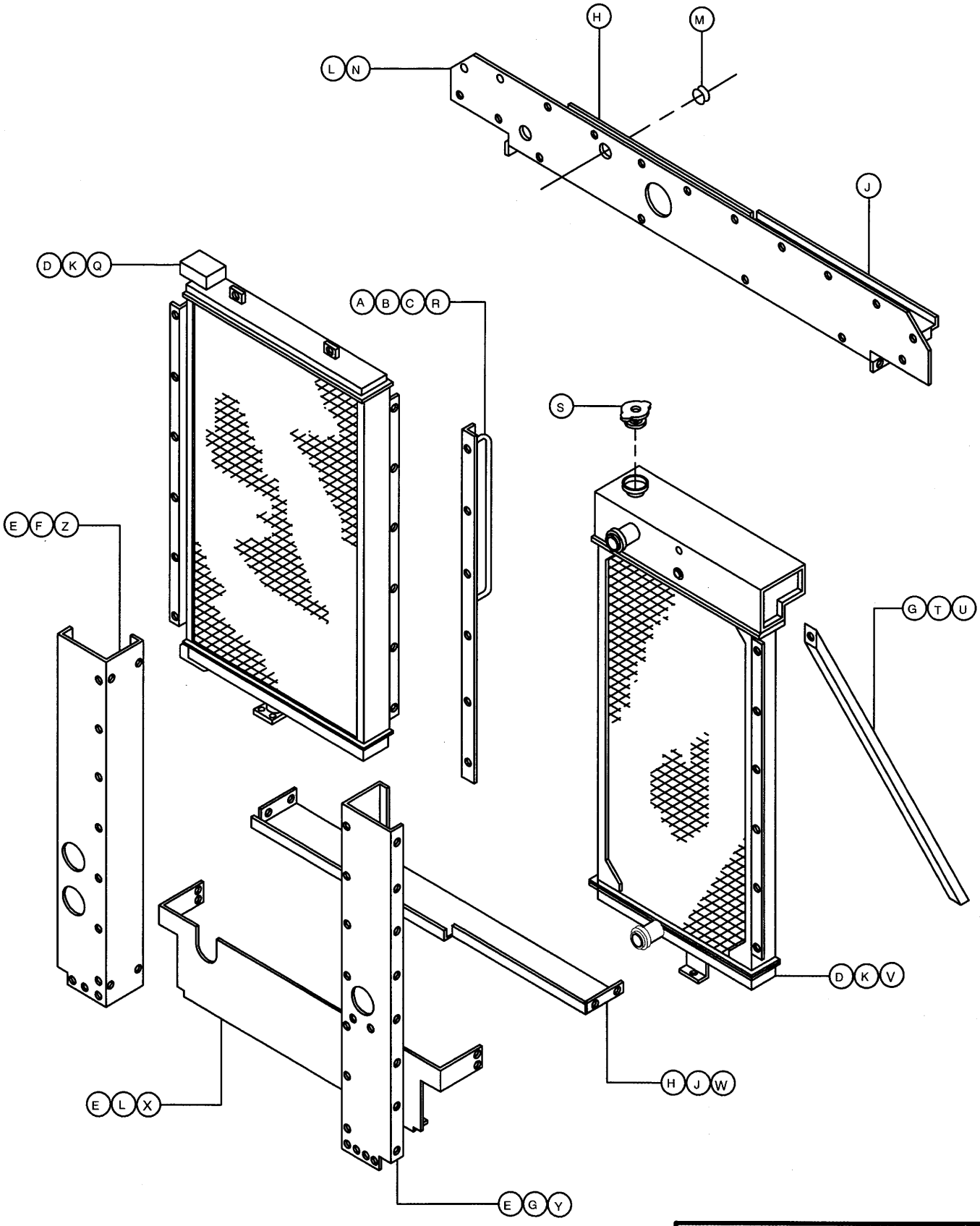


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION STARTING AID ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-20	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	35103498	1	ELBOW , 90°
B	35132174	84"	TUBING
C	35306166	1	ATOMIZER
D	92368687	4	SCREW
E	35103506	1	CLAMP
F	14A5C55	4	WASHER
G	92304500	4	NUT
H	35103506	1	VALVE & BRACKET ASSEMBLY
J	35112911	1	CYLINDER , ETHER
K	35306158	1	VALVE

35306182 **STARTING AID KIT COMPLETE**

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION STARTING AID ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-21	DATE/REV: 3-00/A

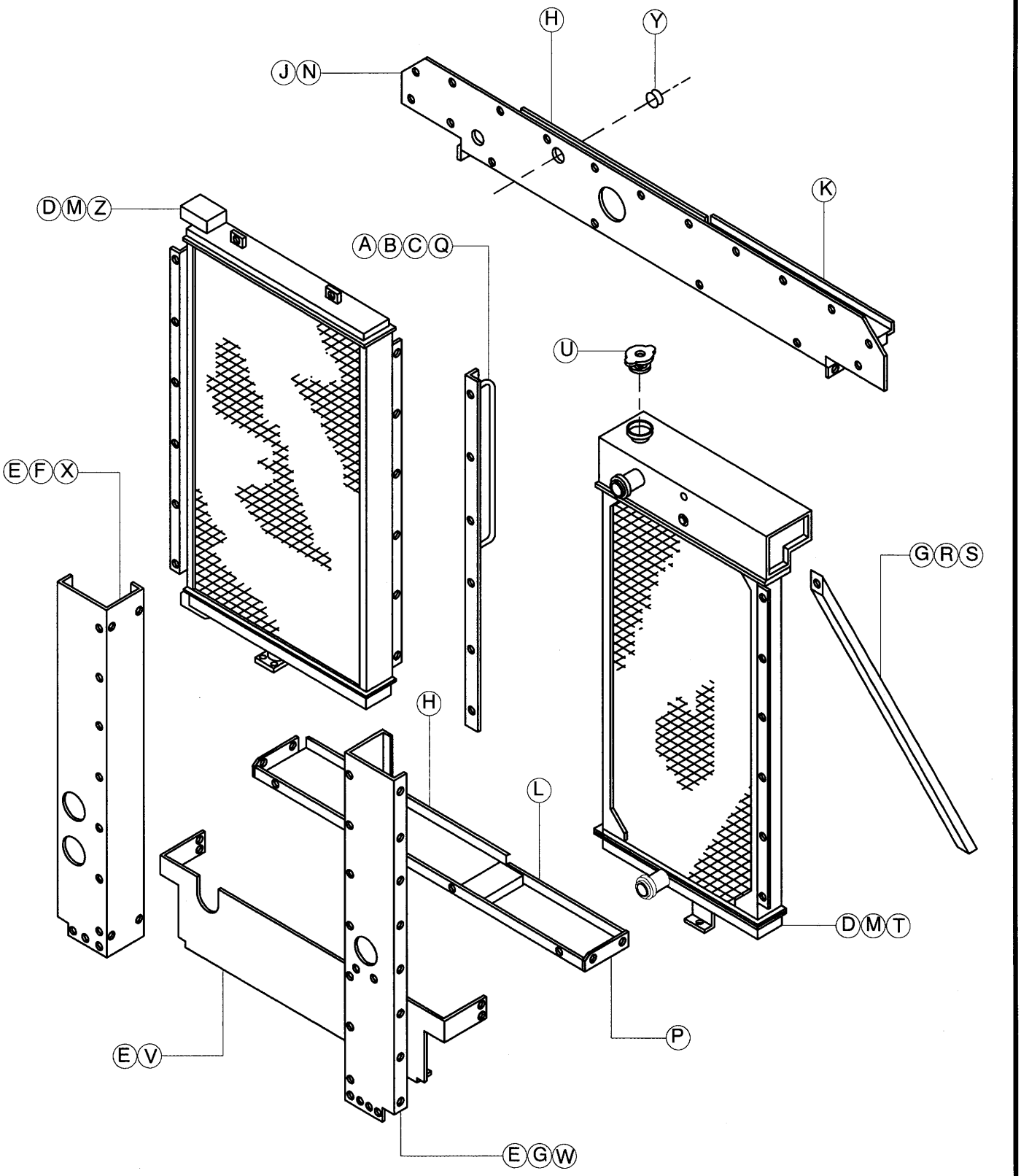


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION RADIATOR & OIL COOLER (650/825)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-22	DATE/REV: 3-00/A

A	35144344	SCREW	(AS REQD.)
B	35145077	NUT	(AS REQD.)
C	35252725	SCREW	(AS REQD.)
D	35252568	SCREW	(AS REQD.)
E	92368687	SCREW	(AS REQD.)
F	35138171	SCREW	(AS REQD.)
G	35134550	SCREW	(AS REQD.)
H	36796985	ANGLE , R.H. SHROUD ADJ.	
J	36797280	ANGLE , L.H. SHROUD ADJ.	
K	35252618	NUT	(AS REQD.)
L	35A2D1G	SCREW	(AS REQD.)
M	35285162	GROMMET	
N	36798619	SHROUD , TOP BAFFLE	
P	PART NOT USED		
Q	36757516	COOLER ,OIL	
R	36762433	BRACKET , CENTER	
S	36765634	CAP , RADIATOR	
T	36762359	SUPPORT , L.H.	
U	36762342	SUPPORT , R.H.	
V	36757540	RADIATOR	
W	36798601	SHROUD , BOTTOM	
X	36762334	BAFFLE , BOTTOM COOLER	
Y	36762326	SUPPORT , L.H.	
Z	36762409	SUPPORT , R.H.	

INGERSOLL-RAND COMPANY
PORTABLE COMPRESSOR DIVISION

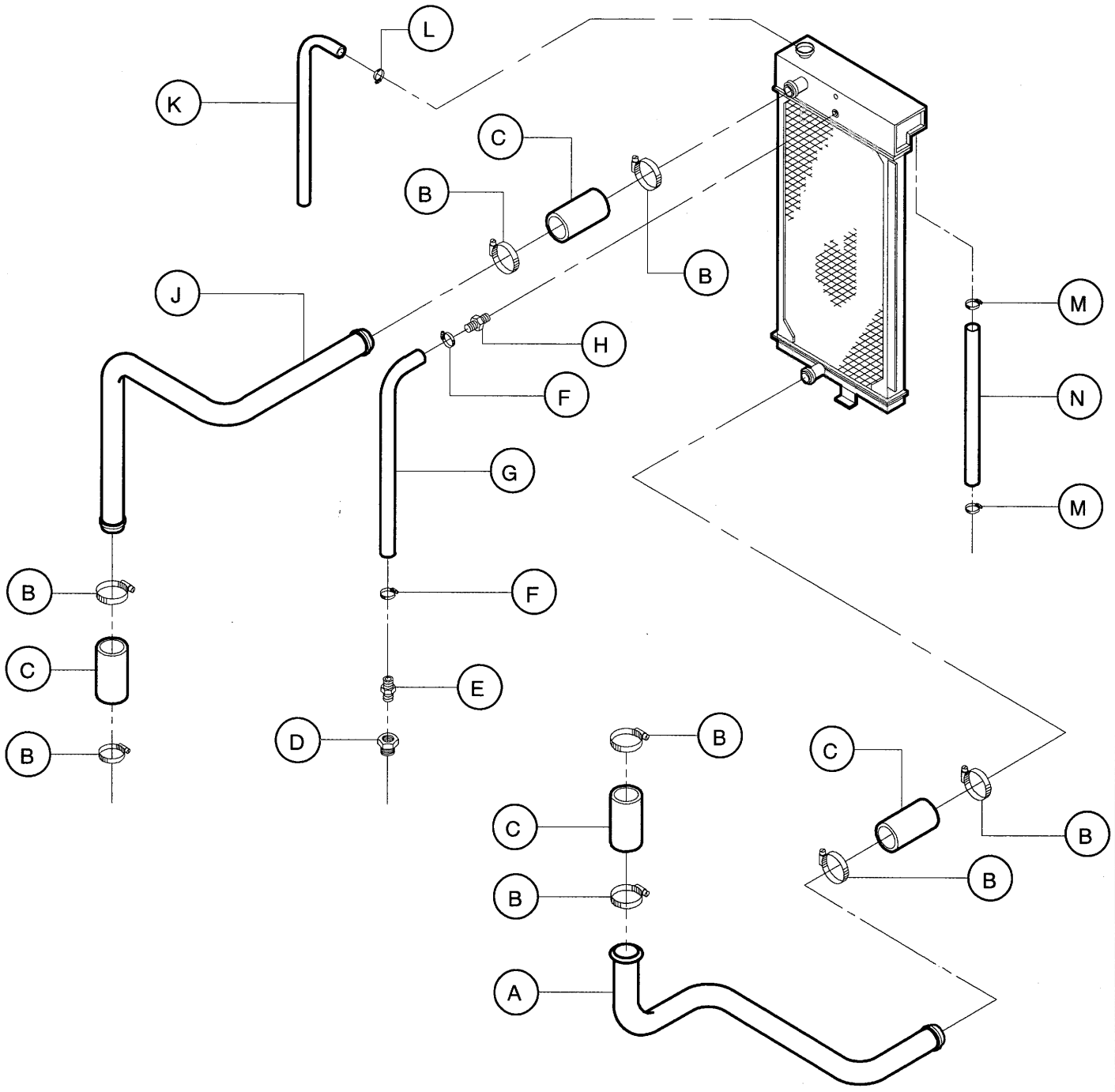
DATE/DWN BY:	DESCRIPTION	
3-00 WAP	RADIATOR & OIL COOLER (650/825)	
MODEL NO.	MANUAL NO.	DATE/REV:
XHP650/900	35393925-23	3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION RADIATOR & OIL COOLER (900)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-24	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	35144344	6	SCREW
B	35145077	6	NUT
C	35252725	6	SCREW
D	35252568	3	SCREW
E	92368687	38	SCREW
F	35138171	5	SCREW
G	35134550	9	SCREW
H	36796985	2	ANGLE , R.H. SHROUD ADJ.
J	35A2DZ1	8	SCREW
K	36797330	1	ANGLE , L.H. SHROUD ADJ.
L	36797348	1	ANGLE , L.H. SHROUD ADJ.
M	35252618	3	NUT
N	36798593	1	SHROUD , TOP BAFFLE
P	36796944	1	SHROUD , BOTTOM
Q	36757862	1	BRACKET , CENTER
R	36755114	1	SUPPORT , RADIATOR VERTICAL
S	36755106	1	SUPPORT , OIL COOLER VERTICAL
T	36864387	1	RADIATOR
U	36765634	1	CAP , RADIATOR
V	36755650	1	BAFFLE , BOTTOM COOLER
W	36756468	1	SUPPORT , RADIATOR SHROUD
X	36767994	1	SUPPORT , OIL COOLER SHROUD
Y	35285162	1	GROMMET
Z	36766103	1	COOLER , OIL

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION RADIATOR & OIL COOLER (900)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-25	DATE/REV: 3-00/A

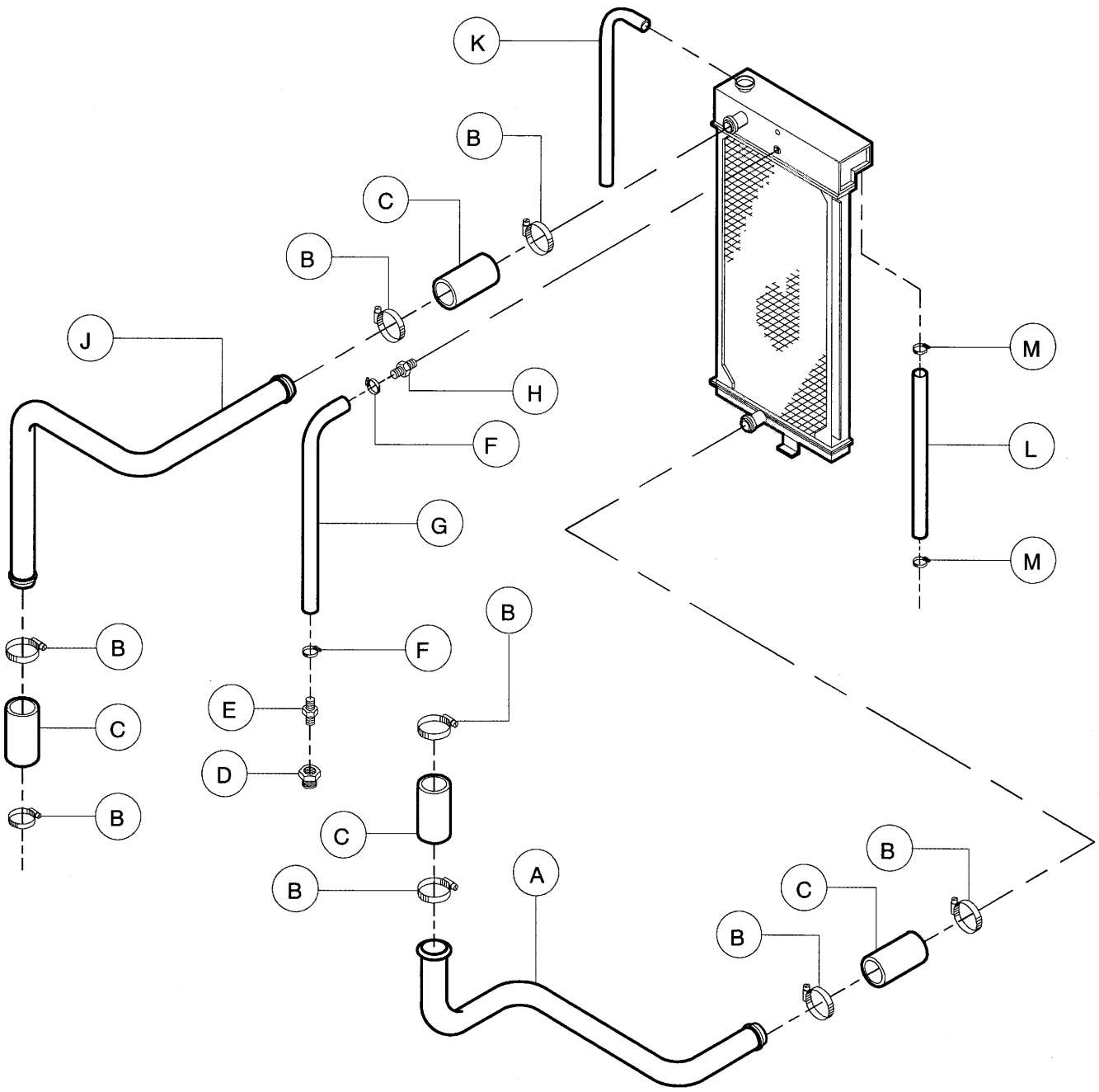


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION RADIATOR PIPING (650/825)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-26	DATE/REV: 3-00/A

A	36762953	TUBE , LOWER	
B	W86683	CLAMP , HOSE	
C	35330570	HOSE	(5 INCHES)
D	23A7SZ5	BUSHING	
E	35310598	ADAPTER	
F	122A23S6	CLAMP , HOSE	
G	35282086	HOSE	(68 INCHES)
K	35360775	TUBING	(80 INCHES)
L	W88678	CLAMP	(3 REQD)
M	122A23S20	CLAMP , HOSE	
N	35135458	HOSE	(53 INCHES)
H	35305234	ADAPTER	
J	36762946	TUBE , UPPER	

INGERSOLL-RAND COMPANY
PORTABLE COMPRESSOR DIVISION

DATE/DWN BY:	DESCRIPTION	
3-00 WAP	RADIATOR PIPING (650/825)	
MODEL NO.	MANUAL NO.	DATE/REV:
XHP650/900	35393925-27	3-00/A

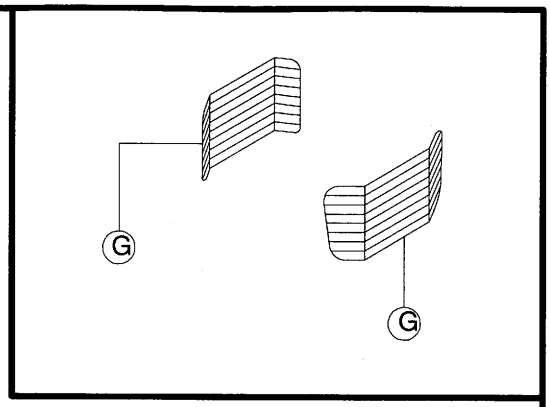


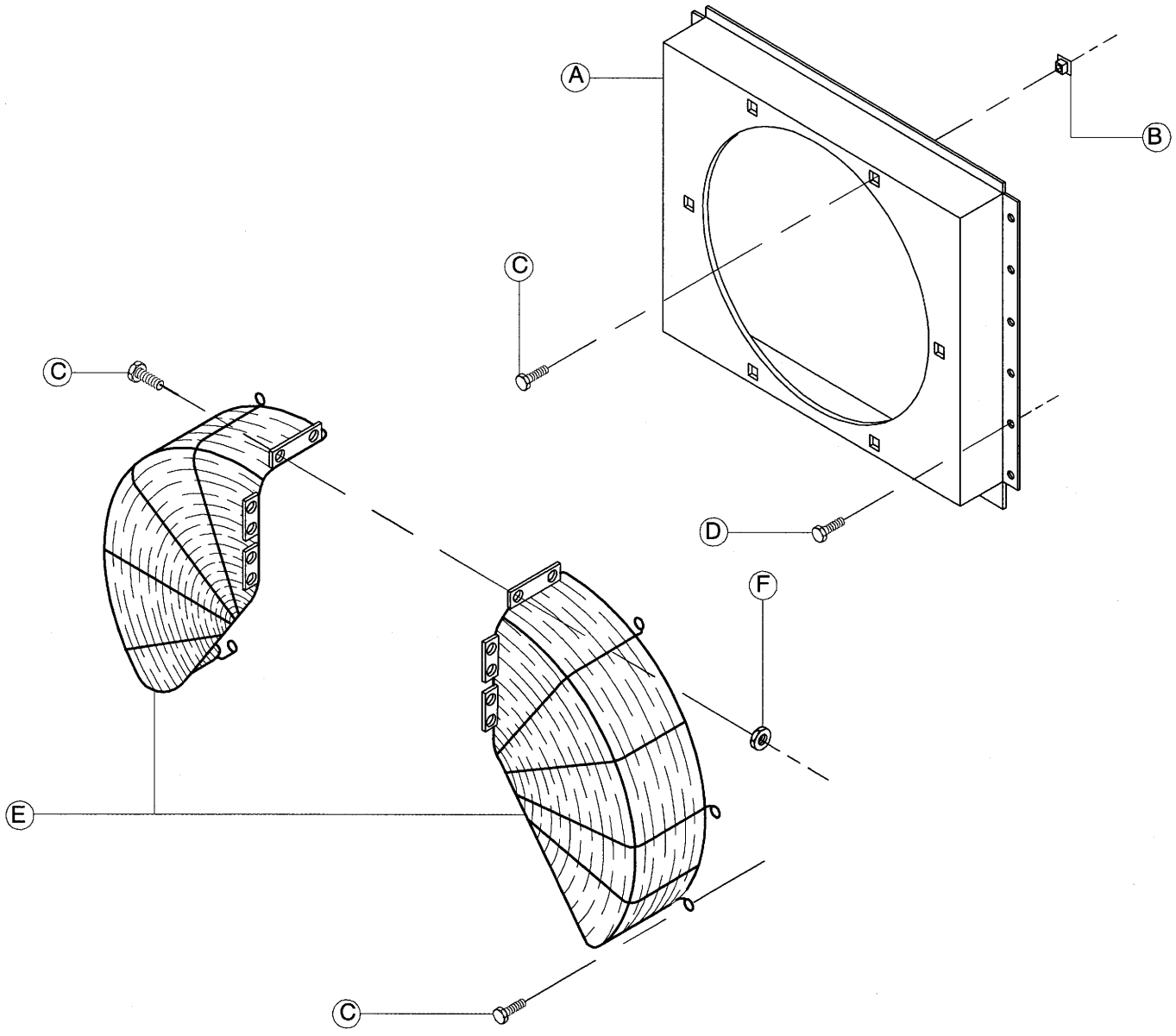
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION RADIATOR PIPING (900)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-28	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	36762953	1	TUBE , LOWER
B	W86683	8	CLAMP , HOSE
C	35330570	3 at 5"	HOSE
D	23A7SZ5	1	BUSHING
E	35310598	1	ADAPTER
F	122A23S6	2	CLAMP , HOSE
G	35282086	68"	HOSE
H	35305234	1	ADAPTER
J	36762946	1	TUBE , UPPER
K	35360775	80"	TUBING
L	35135458	53"	HOSE
M	122A23S20	2	CLAMP , HOSE

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION RADIATOR PIPING (900)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-29	DATE/REV: 3-00/A

DRAWBAR END

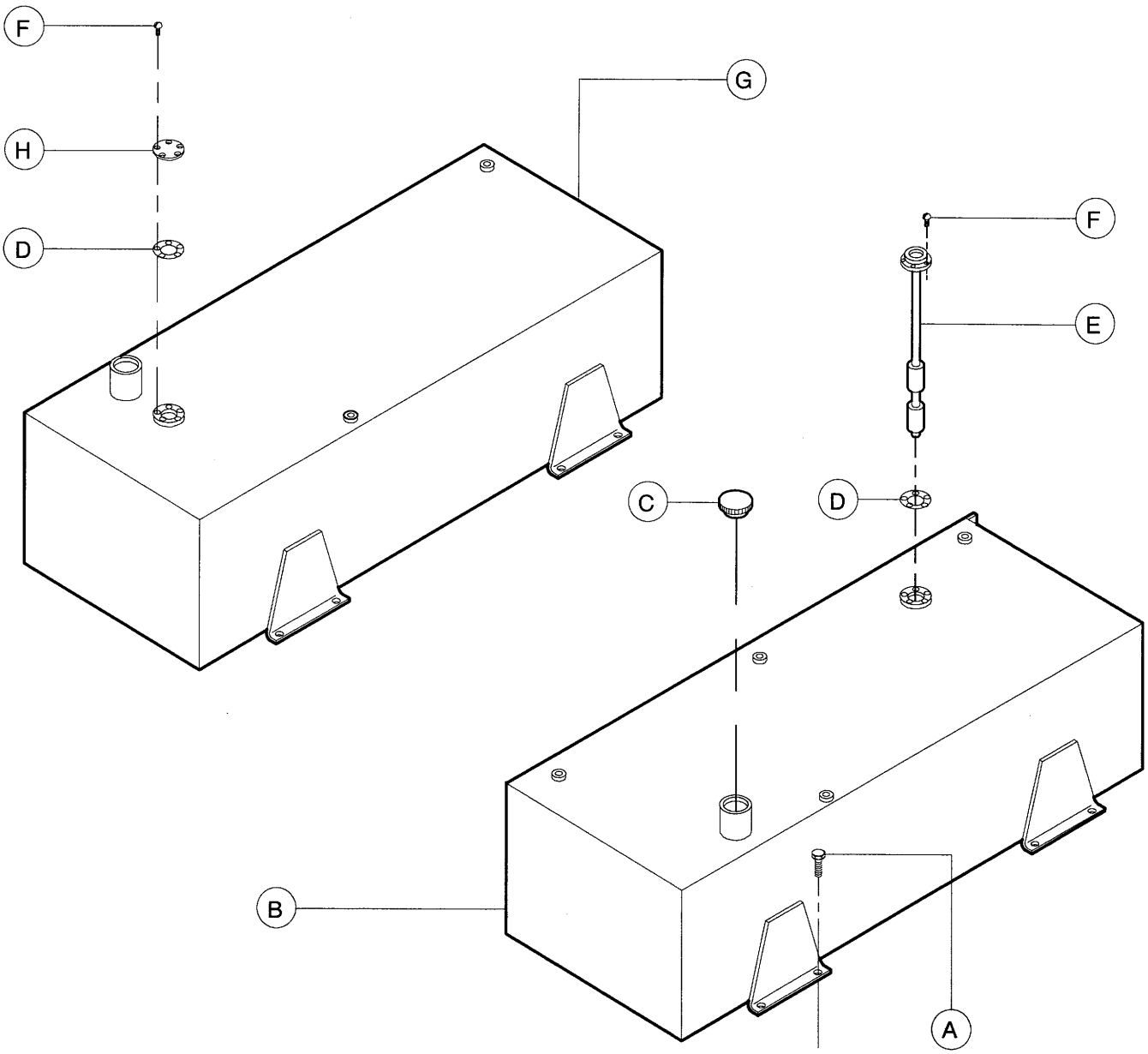




INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FAN GUARDS AND ORIFICE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-30	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	36768901	1	ORIFICE
B	W90555T1	8	RETAINER
C	35144336	14	SCREW
D	35300771	22	SCREW
E	36770667	1	GUARD
F	35252600	6	NUT
G	36798205	2	GUARD , AIR END

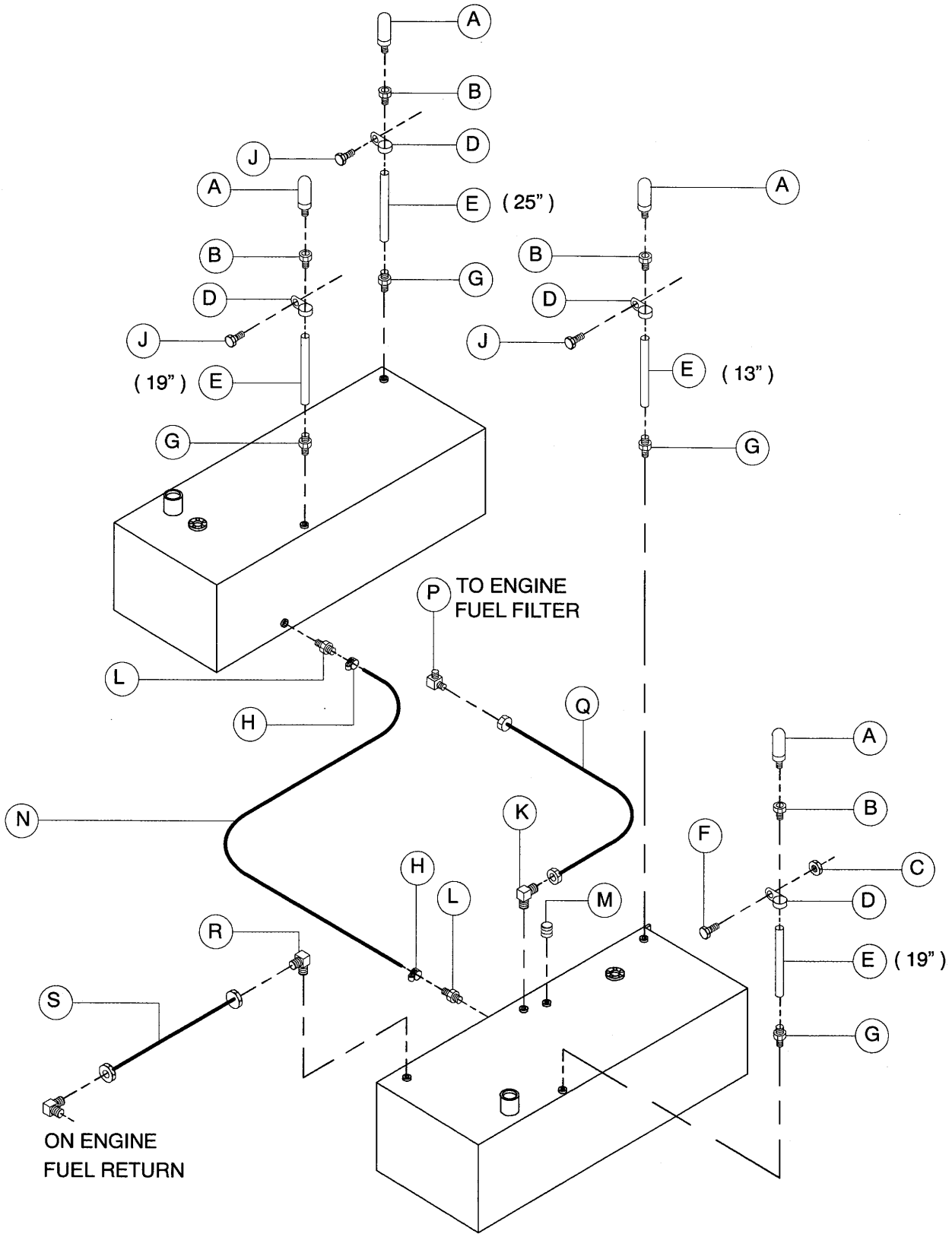
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FAN GUARDS AND ORIFICE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-31	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FUEL TANK ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-32	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	35130293	12	SCREW
B	36789428	1	TANK , RIGHT FUEL
C	35603679	2	FUEL CAP
D	35358159	2	GASKET
E	36840783	1	SENDER , FUEL LEVEL
F	35252279	10	SCREW
G	36755072	1	TANK , LEFT FUEL
H	36792828	1	COVER

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FUEL TANK ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-33	DATE/REV: 3-00/A

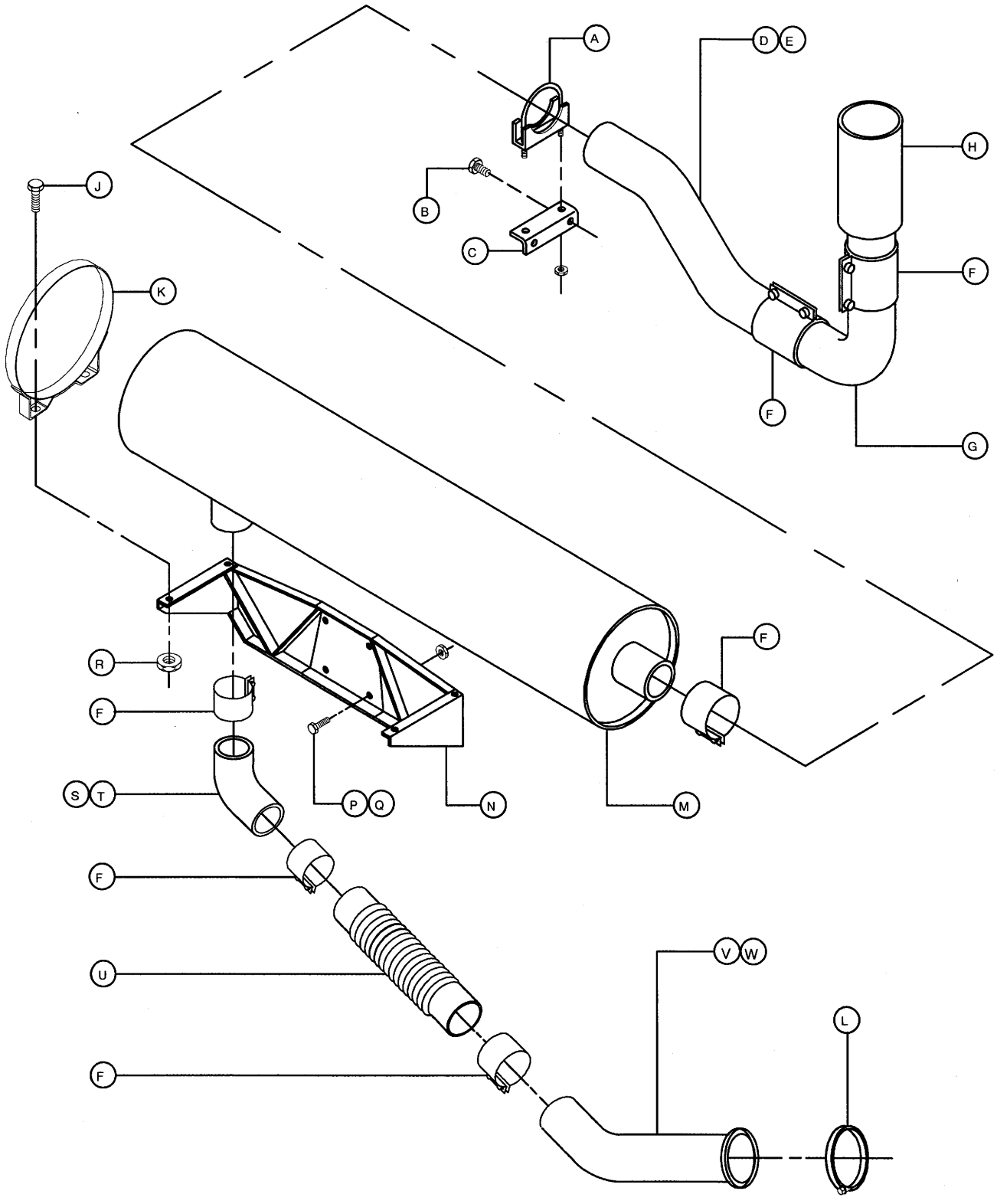


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FUEL PIPING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-34	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	35322395	4	SILENCER
B	35369339	4	CONNECTOR
C	35144492	1	NUT
D	W88678	4	CLAMP
E	35356484	★	TUBING
F	35144328	1	SCREW
G	35369347	4	CONNECTOR
H	35295773	2	CLAMP
J	92368687	3	SCREW
K	35309210	1	ELBOW , 90
L	36860039	2	CONNECTOR
M	35A7S7Z1	1	PLUG
N	35139500	1	HOSE
P	35283118	1	ELBOW , 90
Q	35310234	1	HOSE ASSY.
R	35279926	1	ELBOW , 90
S	35310994	1	HOSE ASSY.

★ SEE LENGTH REQD ON PAGE 1 of 2

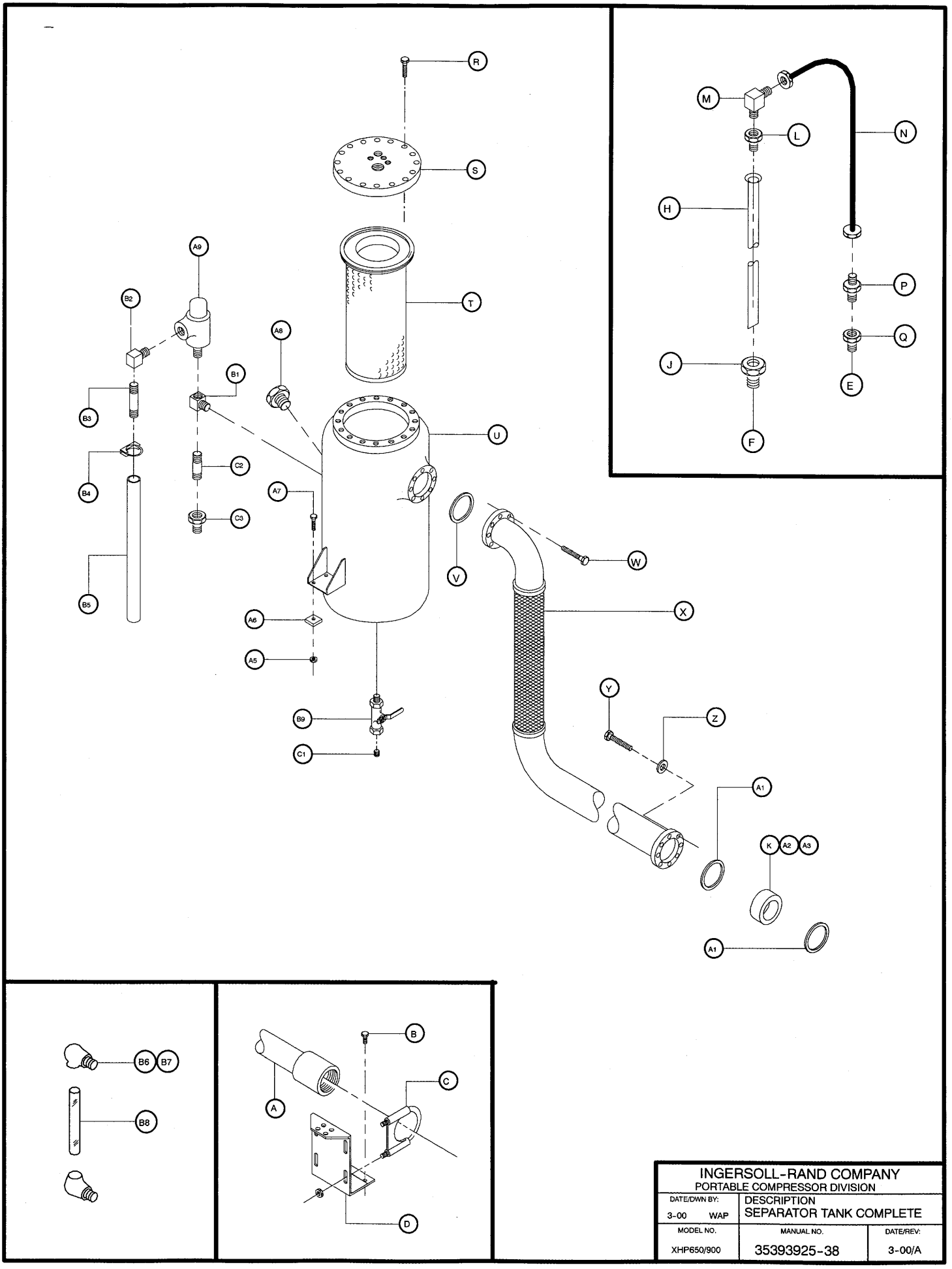
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION FUEL PIPING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-35	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION EXHAUST SYSTEM COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-36	DATE/REV: 3-00/A

A	35127653	CLAMP , MUFFLER
B	35138171	SCREW (2 REQD)
C	35611235	BRACKET
D	36765063	PIPE , TAIL (750)
E	36765402	PIPE , TAIL (900)
F	35307131	CLAMP , SEAL
G	36765071	ELBOW , EXHAUST (900)
H	36762581	EXTENSION , EXHAUST
J	35144344	SCREW (4 REQD)
K	36506079	BAND , MOUNTING
L	36758407	CLAMP , V-BAND
M	36755643	MUFFLER
N	36755569	BRACKET , MUFFLER
P	35144344	SCREW (4 REQD)
Q	35145077	NUT (4 REQD)
R	35145077	NUT (4 REQD)
S	36762755	ELBOW (750)
T	36506228	ELBOW (900)
U	36506095	PIPE , FLEX
V	36762748	PIPE , TURBO (750)
W	36506236	PIPE , TURBO (900)

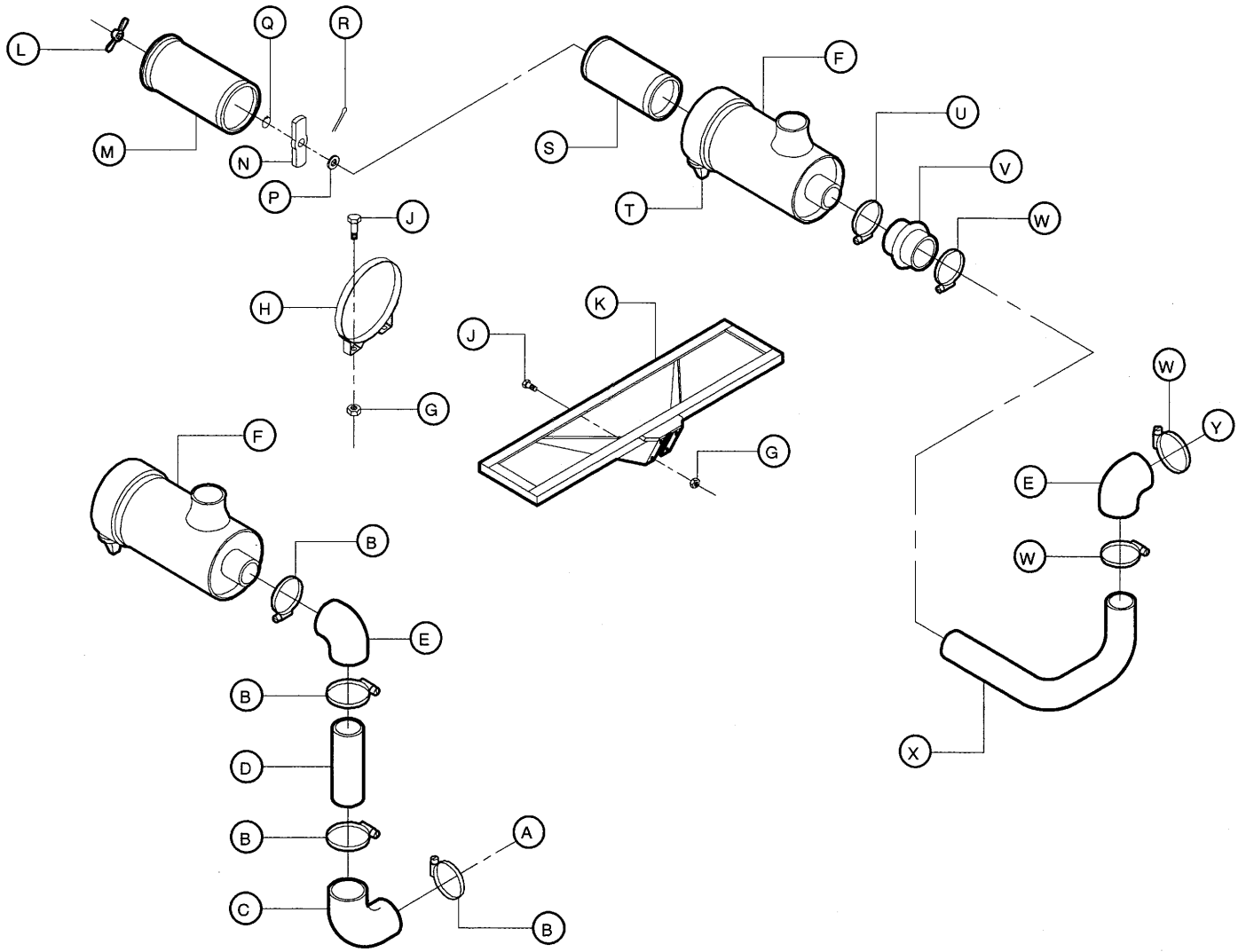
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION EXHAUST SYSTEM COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-37	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION SEPARATOR TANK COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-38	DATE/REV: 3-00/A

A	SEE AIR PIPING DRAWING		
B	35138171	SCREW	(2 REQD)
C	36799419 & 35586288	U-BOLTS	
D	36797702	BRACKET , SERV. PIPE	
E	TO AIR END		
F	TO SEPARATOR TANK COVER		
G	NOT OFFERED		
H	35593201	TUBE , SCAVENGE	
J	35329309	FITTING ,LENZ	
K	35392299	SEAL	
L	37081528	.063 ORIFICE	
M	35283464	ELBOW ,90	
N	35322494	HOSE	
P	35283076 & 35306109	CONN. & NUT	
Q	35306091	REDUCER	
R	35A2D382G	SCREW	(12 REQD)
S	36762318	COVER	
T	36762250	ELEMENT , SEP.	
U	36849180	TANK , SEPARATOR	
V	33A11C8	GASKET	
W	35A2D380G	SCREW	(8 REQD)
X	36882272	PIPE , DISCHARGE	
Y	35376094	SCREW	(8 REQD)
Z	11A5G8	WASHER	(8 REQD)
A1	33A11C8	GASKET	
A2	36843720	VALVE , CHECK	
A3	35392281	SPRING	
A4	PART ELIMINATED		
A5	36879203	NUT	(4 REQD)
A6	36762565	PAD	(4 REQD)
A7	36877793	SCREW	(4 REQD)
A8	35802933	PLUG , FILLER	
A9	35596733	VALVE , SAFETY	
B1	95953410	TEE	
B2	67A7MZ7	ELBOW , 90	
B3	36762821	NIPPLE	
B4	35261155	CLAMP	
B5	36764868	PIPE	
B6	36860468	FITTING	
B7	35324649	GASKET	(2 REQD)
B8	36845444	TUBE , SIGHT	
B9	36795680	VALVE , BALL	
C1	95947149	PLUG	
C2	95922840	NIPPLE	
C3	95953949	BUSHING	

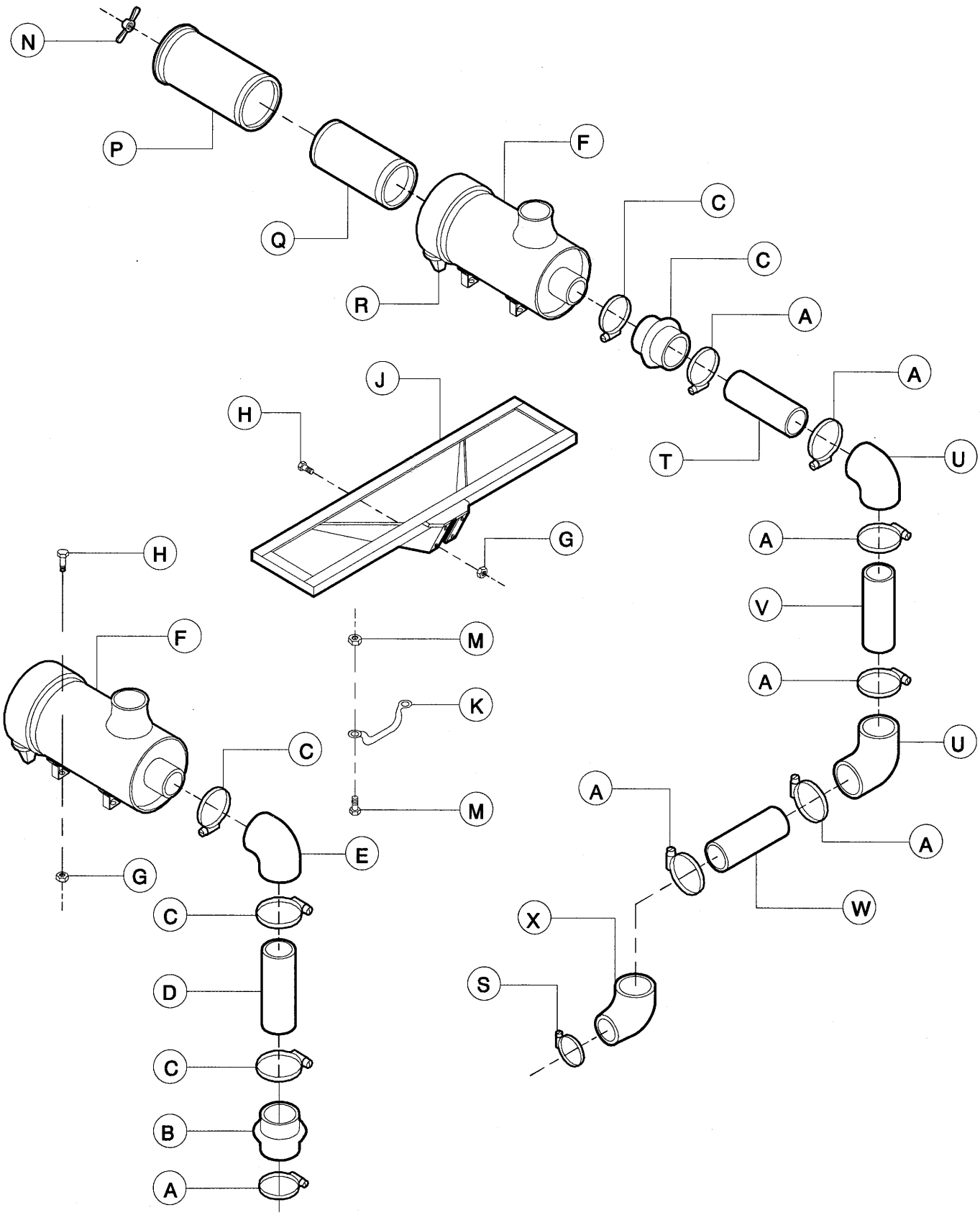
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION SEPARATOR TANK COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-39	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR INTAKE AND MOUNTING (650/825)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-40	DATE/REV: 3-00/A

A	TO AIR END INTAKE	
B	35119858	CLAMP
C	35271683	ELBOW
D	36762474	TUBE , AIR END
E	35135300	ELBOW
F	35711209	AIR END – AIR FILTER
	35851310	ENGINE – AIR FILTER
G	35145077	NUT
H	35502608	AIR END MOUNTING BAND
	35863638	ENGINE MOUNTING BAND
J	35144344	SCREW
K	36762979	BRACKET , MOUNTING
L	35123553	AIR END WING NUT
	35355403	ENGINE WING NUT
M	35123512	AIR END PRIMARY ELEMENT
	35355395	ENGINE PRIMARY ELEMENT
N	35325869	AIR END NUT
	35355379	ENGINE NUT
P	35123546	AIR END GASKET
	35355361	ENGINE GASKET
Q	35123561	AIR END CLIP
	35355411	ENGINE CLIP
R	35123538	AIR END PIN
	35355387	ENGINE PIN
S	35123520	AIR END SAFETY ELEMENT
	35355353	ENGINE SAFETY ELEMENT
T	35123587	AIR END VALVE
	35109230	ENGINE VALVE
U	35123496	CLAMP
V	35264415	HOSE , HUMP
W	W30485	CLAMP
X	36763043	TUBE , ENGINE
Y	TO ENGINE INTAKE	

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR INTAKE AND MOUNTING (650/825)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-41	DATE/REV: 3-00/A

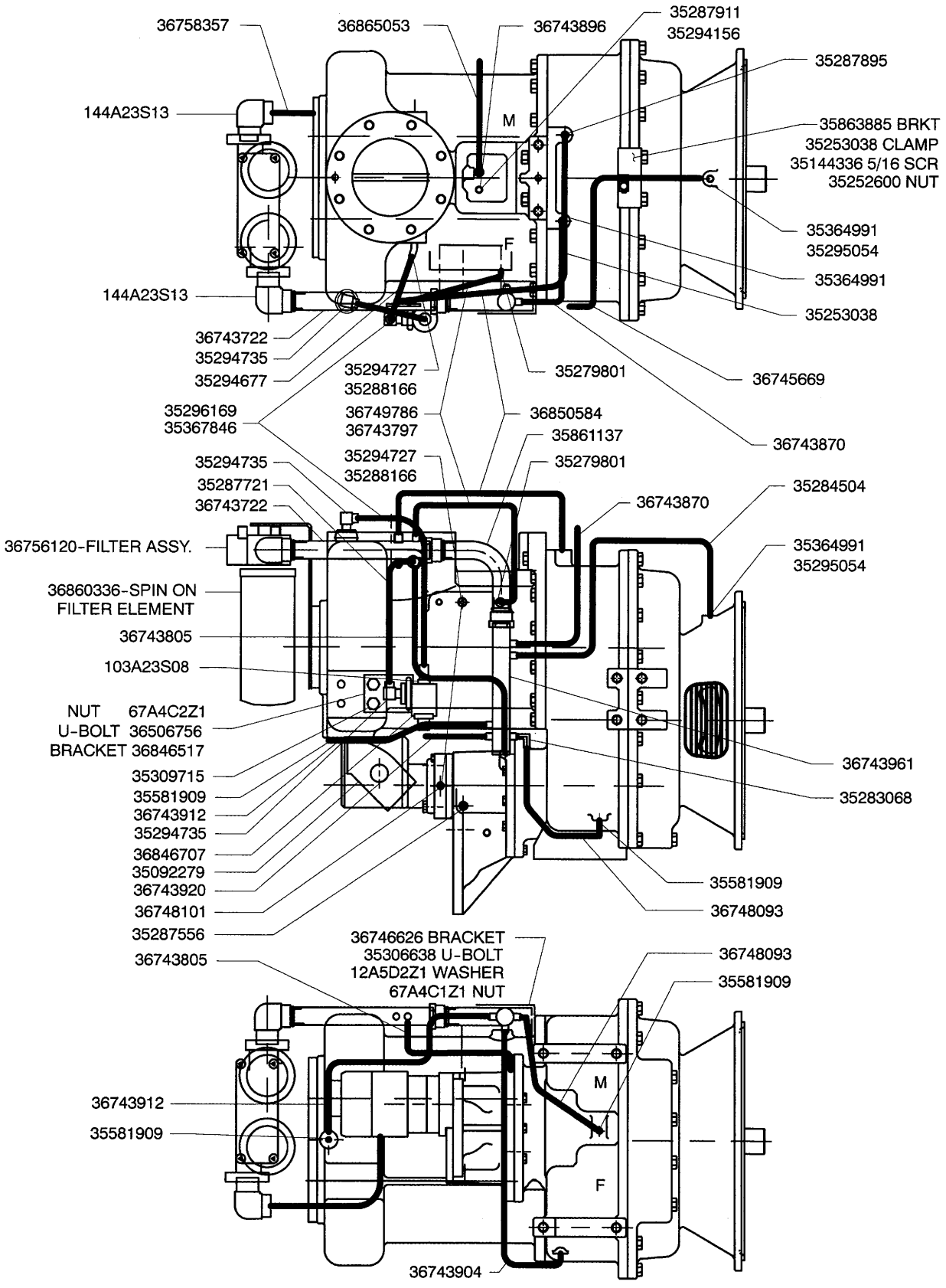


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR INTAKE AND MOUNTING (900)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-42	DATE/REV: 3-00/A

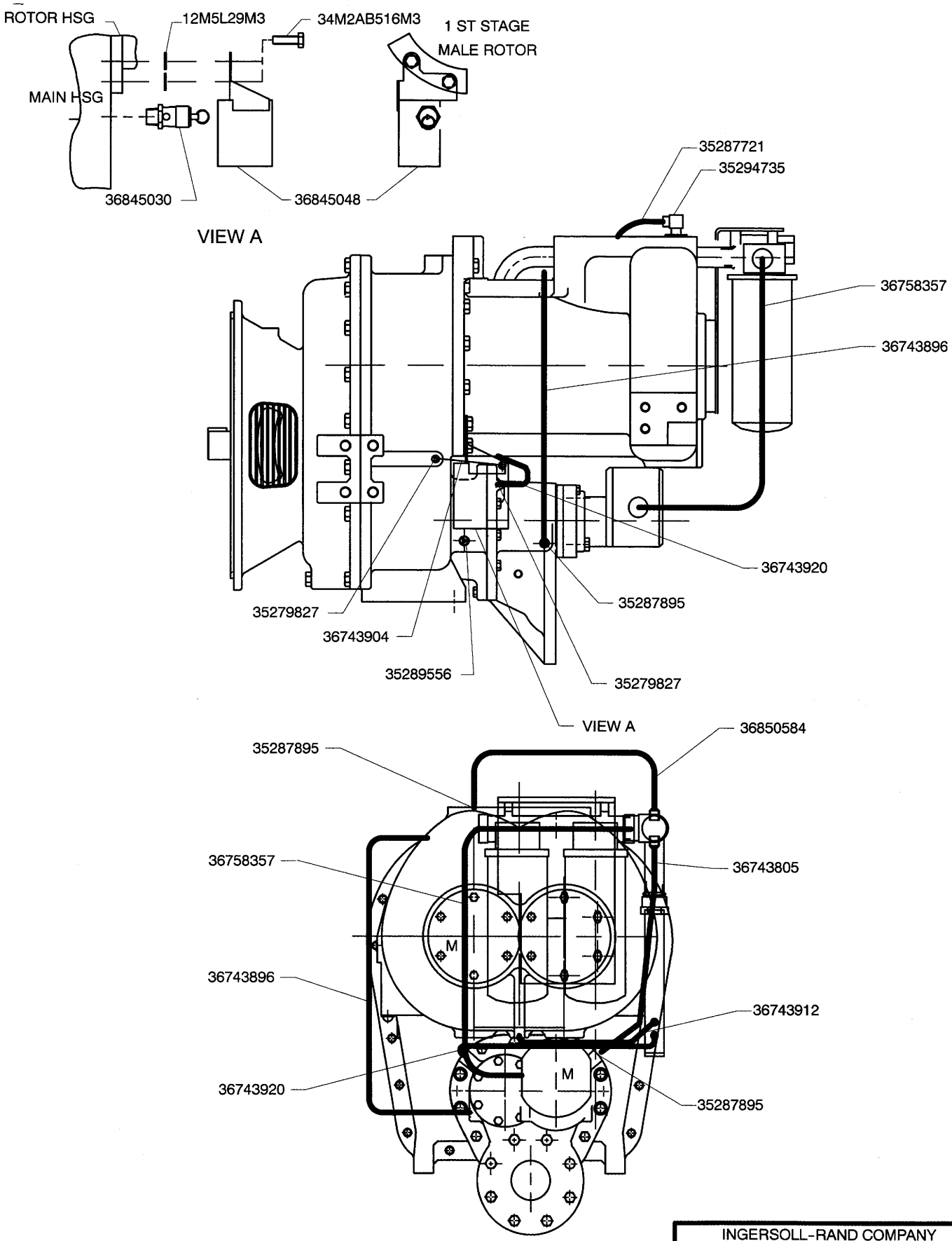
ITEM		C.P.N.	QTY	DESCRIPTION
A		35119858	7	CLAMP
B		35141290	2	HOSE , REDUCER HUMP
C		35129071	4	CLAMP
D		36864726	1	TUBE , CONNECTOR
E		35120211	1	ELBOW , RUBBER
F		36864346	2	AIR CLEANER ASSEMBLY
G		35145077	12	NUT
H		35144344	12	SCREW
J		36755163	1	BRACKET , AIR CLEANER
K		35130707	1	HOLD , HAND
L		35252600	2	NUT
M		35321108	2	SCREW
N	★	35388982	2	NUT , WING
P	★	36864361	1	ELEMENT , PRIMARY
Q	★	36864379	1	ELEMENT , SAFETY
R	★	35388990	1	EJECTOR , DUST
S		35123496	1	CLAMP
T		36794964	1	TUBE , CONNECTOR
U		35271683	2	ELBOW , RUBBER
V		35505866	1	TUBE , CONNECTOR
W		36505790	1	TUBE , CONNECTOR
X		35583236	1	ELBOW , RUBBER

★ ITEMS INCLUDED IN AIR CLEANER ASSEMBLY 36864346

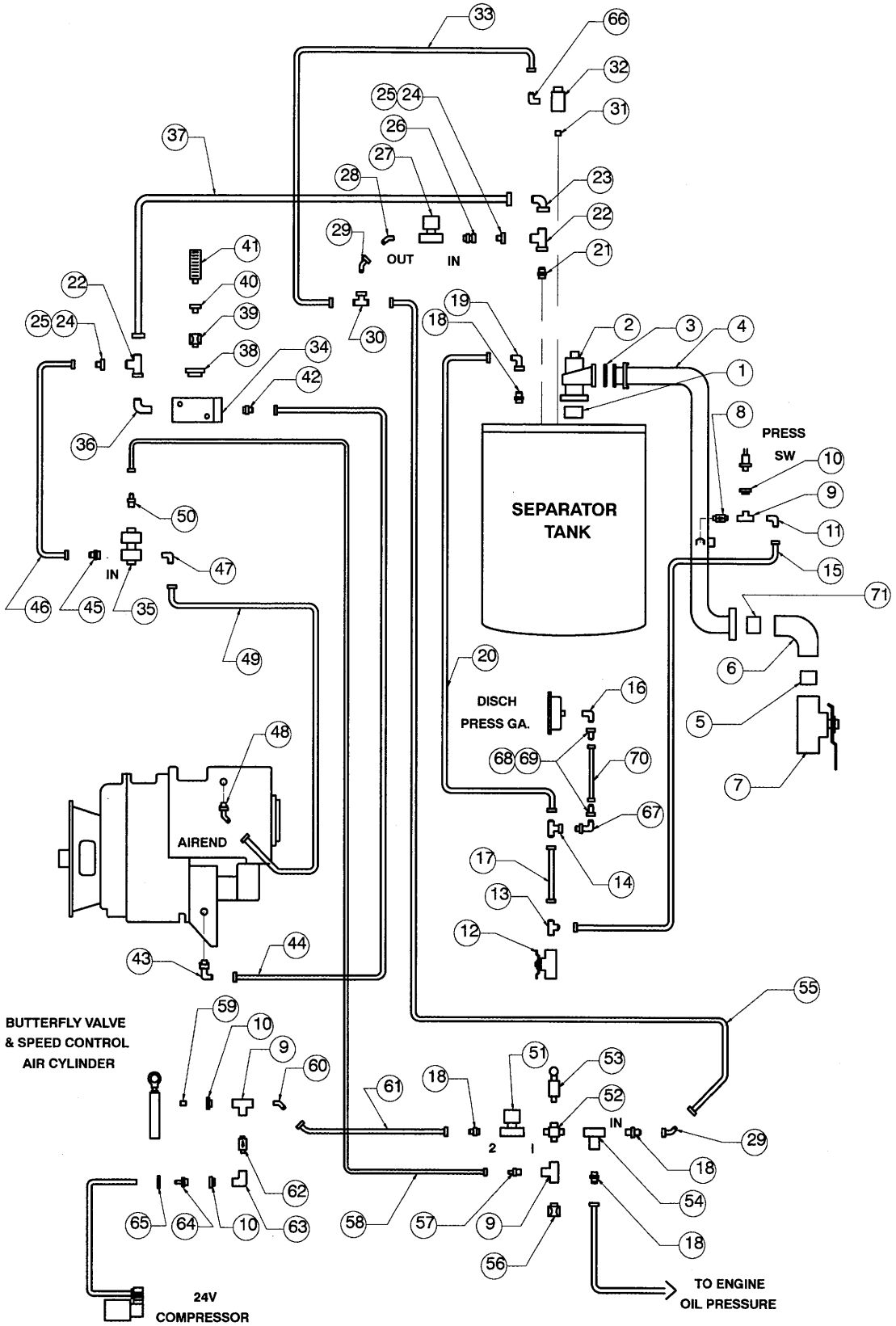
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR INTAKE AND MOUNTING (900)	
MODEL NO. XHP650/900	MANUAL NO. 35393925-43	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END PIPING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-44	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR END PIPING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-45	DATE/REV: 3-00/A

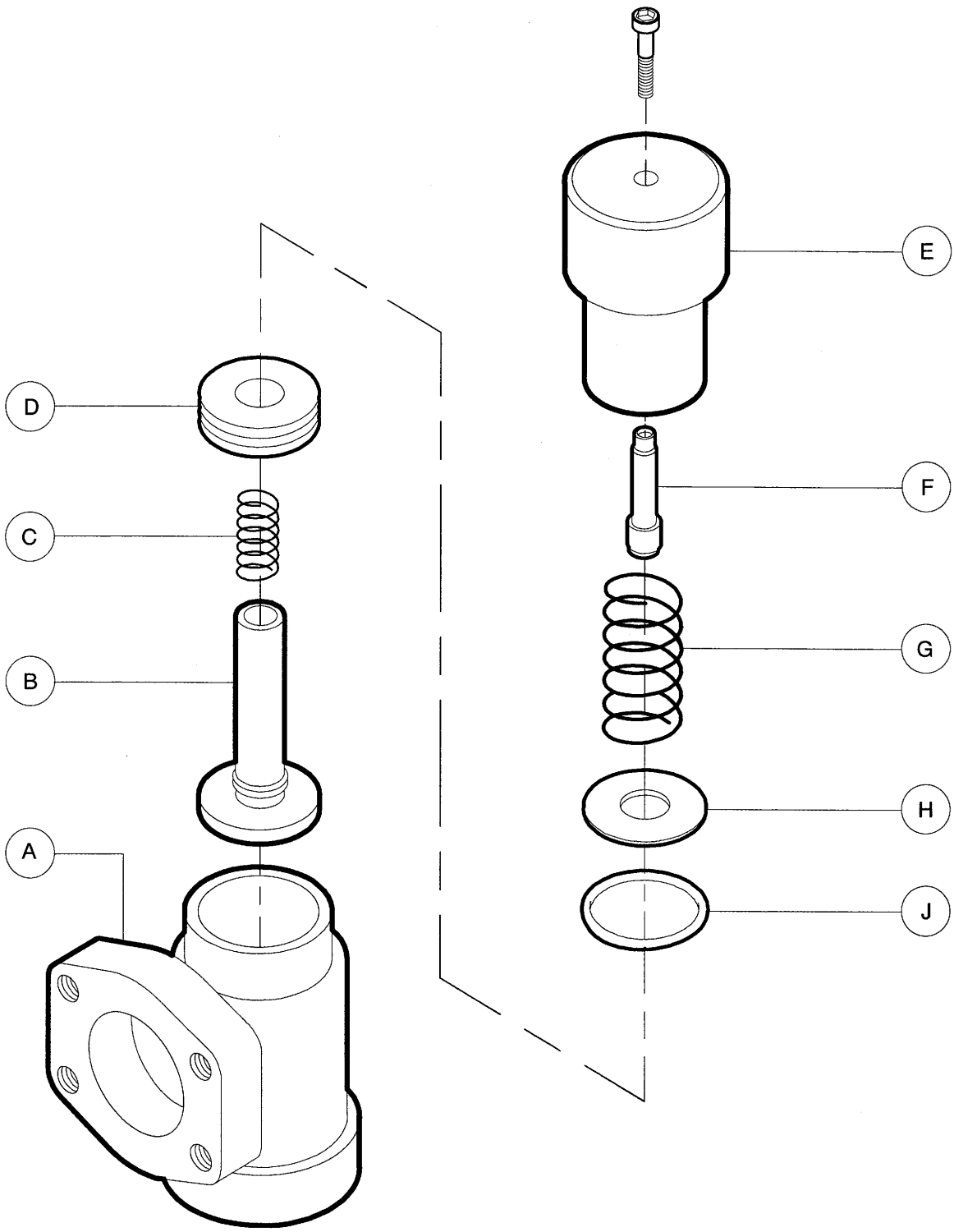


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR PIPING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-46	DATE/REV: 11-01/B

ITEM	C.P.N.	DESCRIPTION
1	19A7S11Z1	NIP CLNPT300X262
2	36762268	V 3.0 IN. MIN PRESS
3	20A11C2M237	ORING
4	36797827	PIPE SERV
5	19A7S29Z1	NIP SHTNPT300X300
6	100A7M10Z1	ELL NPT300X90
7	36755718	V 3.0 BALL
8	35248145	VALVE 1/4 CHECK
9	35321272	TEE 1/4 NPT
10	23A7S1Z1	BSHG RDCNPTO25X012
11	35279934	ELL,90,1/4NPT,-6JIC
12	35324839	VALVE BALL 1/4 NPT
13	35283050	TEE,RUN 1/4NPT -6JIC
14	35283092	TEE,BR,SWV NUT,-6JIC
15	35282953	HOSE,JIC -6 X 13
16	35280098	ELL,90,1/4NPT FEM,6JIC
17	35330513	HOSE, JIC -6 X 12
18	35284082	CONN,1/4 NPT X -6JIC
19	35283068	ELL,90,SWV NUT,-6JIC
20	35294701	HOSE, JIC -6 X 37
21	108A23S12D	ADPTR 3/4PX3/4JIC
22	35287739	RUN TEE -12 JIC
23	35301506	ELB 90 SWIV NUT -12
24	35321165	REDUCER TUBE
25	35324987	NUT TUBE -12
26	35368927	3/8NPT X -6 FML SWL
27	36842300	V SOL 24V NC .375NPT
28	35294743	ELBOW 45
29	35283100	ELL,45,SWV NUT,-6JIC
30	35283092	TEE,BR,SWV NUT,-6JIC
31	19A7J2Z1	NIP CL NPT 025X088
32	35315795	VALVE, REGULATOR
33	35282946	HOSE, JIC -6 X 9.5
34	35849215	VALVE AUTO BLOWDOWN
35	35316405	VALVE ANTI-RUMBLE
36	35294735	ELB,3/4NPT X -12JIC
37	35376110	HOSE, -12 X 54.00
38	23A7S9Z1	BSHG RDCNPT075X025
39	35322346	ORF CONN .156
40	305A10S8Z1	ADPTR NPT 050X025
41	35132299	SILENCER,BLOWDN EPA
42	35290147	CONN 3/8 NPT -6 JIC
43	35279827	ELL,90,9/16-18X-6JIC
44	35282987	HOSE, JIC -6 X 34
45	35320878	CONN 1/2 NPT X-6 JIC
46	35282961	HOSE, JIC -6 X 13
47	109A23S8	ELBOW
48	35279835	ELL,45,9/16-18X-6JIC
49	35283027	HOSE,JIC -6 X 56.5
50	35283472	CONN, 1/4 NPT -4JIC
51	36842318	V SOL 24V NO .250NPT
52	35321264	CROSS 1/4 NPT
53	35325133	VALVE, SAFETY
54 *	35322379	BLOWDOWN VALVE
55	35322502	HOSE ASSY -6 X 22
56	35248319	ORIFIC .094
57	35283472	CONN, 1/4 NPT -4JIC
58	35282912	HOSE, JIC -4 X 27
59	19A7J1Z1	NIP CLNPT012X075
60	35290253	ELB 45-1/4NPTX-6JIC
61	35282979	HOSE, JIC -6 X 21
62	35248145	VALVE 1/4 CHECK
63	65A7M2Z1	ELB .25 NPT
64	108A23S2	ADPTR BARB012X012NPT
65	35296342	CLP WMGRMOO6-16
66	35301126	ELL 90 1/8NPT X -6
67	36852499	ELB BULKHEAD -6
68	35306091	REDUCER TUBE -6 X -4
69	35306109	NUT TUBE -6
70	35282904	HOSE JIC -4 X 11.25
71	54393210	NIPPLE

* 35379064 KIT BLWDN V DIAPH

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION AIR PIPING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-47	DATE/REV: 11-01/B



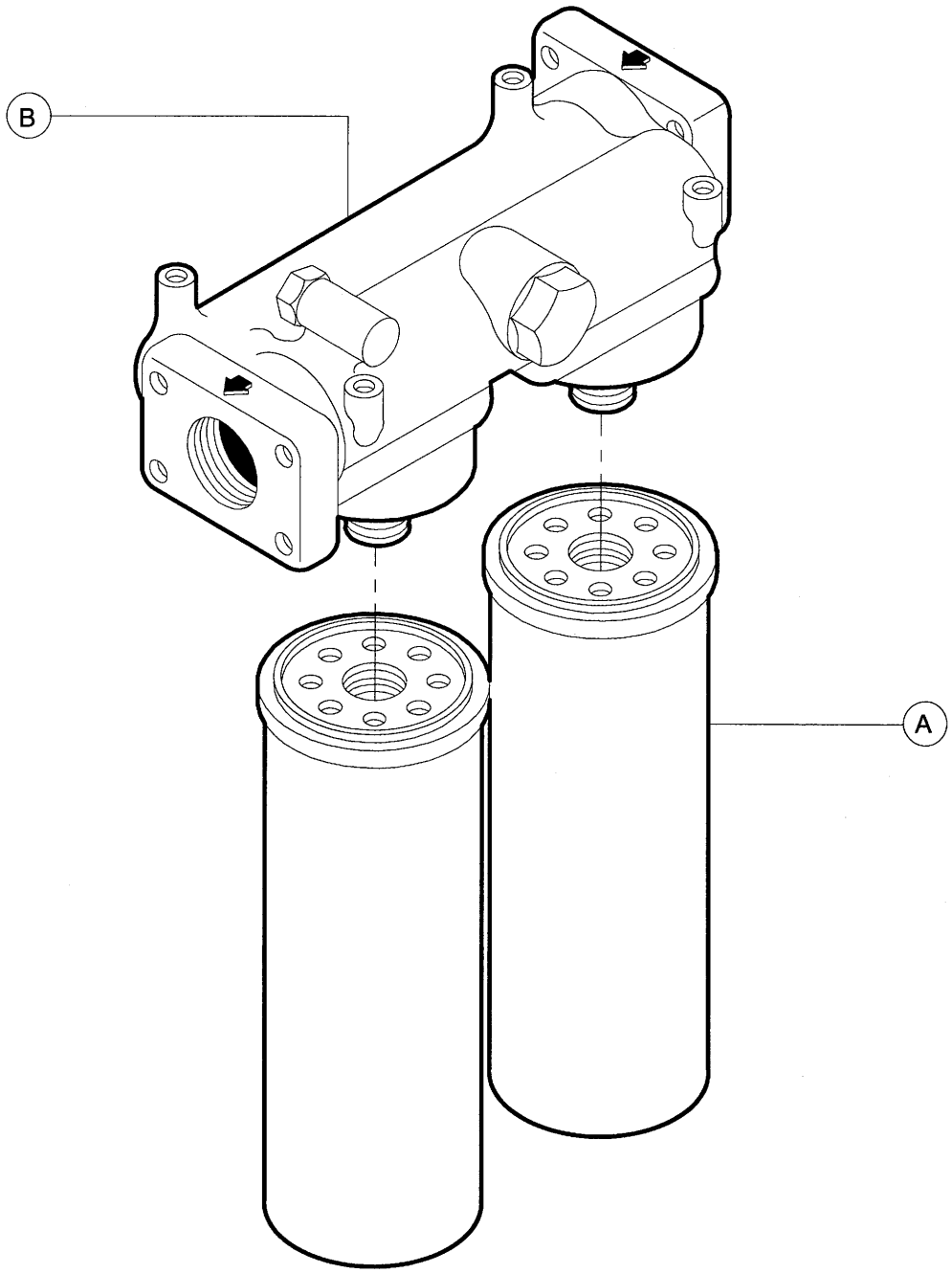
MINIMUM PRESSURE CHECK VALVE ASSEMBLY 36762268

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION MINIMUM PRESSURE CHECK VALVE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-48	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	36792323	1	BODY
B	36792307	1	VALVE , CHECK
C	36792356	1	SPRING , CHECK VALVE
D	36792315	1	PISTON
E	36792331	1	CAP
F	36792372	1	GUIDE
G	36792349	1	SPRING , MAIN
H	36792380	1	SPACER
J	36792364	1	O-RING

MINIMUM PRESSURE CHECK VALVE ASSEMBLY 36762268

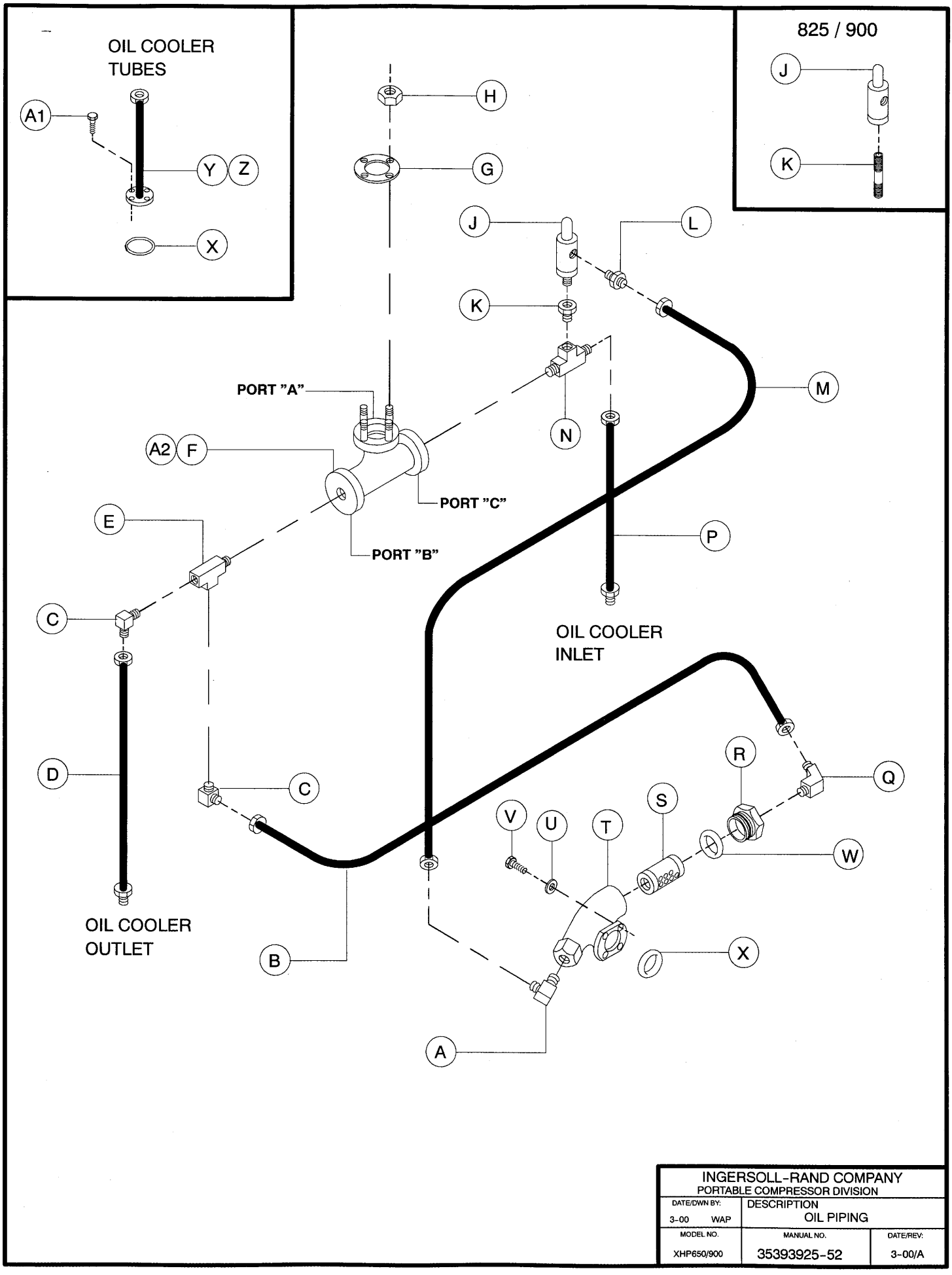
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION MINIMUM PRESSURE CHECK VALVE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-49	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION OIL FILTER ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-50	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	36860336	2	ELEMENT , FILTER
B	36756120	1	FILTER HEAD ASSEMBLY

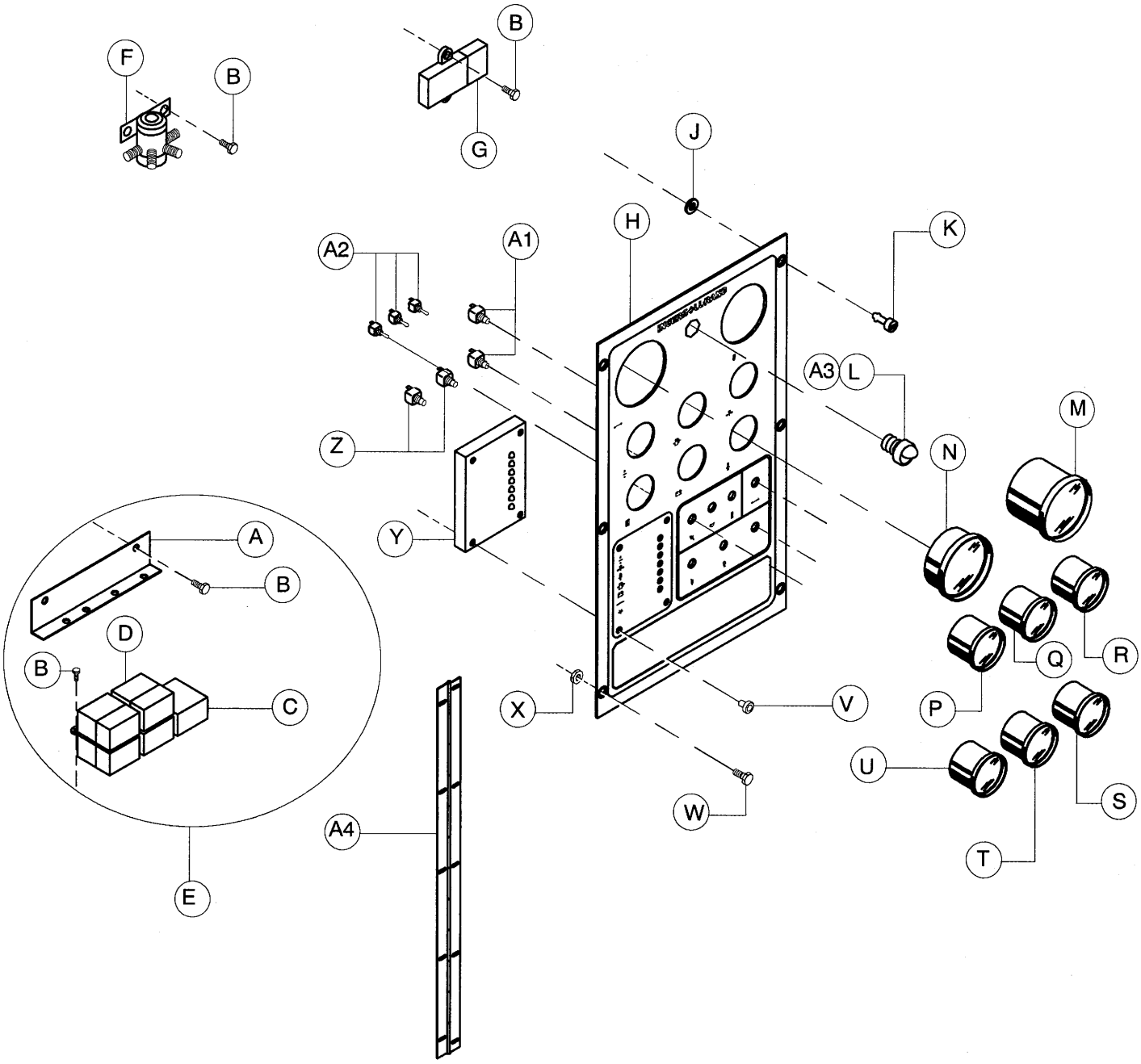
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION OIL FILTER ASSEMBLY	
MODEL NO. XHP650/900	MANUAL NO. 35393925-51	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION OIL PIPING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-52	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION	
A	35294750	1	ELBOW , 90 °	
B	35130863	1	HOSE ASSEMBLY	
C	35296417	2	ELBOW , 90 °	
D	36860096	1	TUBE , OIL COOLER	
E	35334945	1	TEE , RUN	
F	36852747	1	VALVE , OIL TEMP. BY-PASS	
G	36786580	1	GASKET	
H	16A4C8Z1	4	NUT	
J	35321876	1	VALVE , PRESS. RELIEF	
K	23A7S11Z1	1	BUSHING	
L	108A23S16	1	ADAPTER	
M	35323864	1	HOSE ASSEMBLY	
N	36859965	1	TEE , RUN	
P	36860104	1	TUBE , OIL COOLER	
Q	35296425	1	ELBOW , 45 °	
R	35609098	1	PLUG	
S	35370063	1	ELEMENT	
T	36751295	1	BODY	
U	14A5C101	4	WASHER	
V	119A2A254	4	SCREW	
W	35277797	1	O-RING	
X	20A11C2M225	1	O-RING	
Y	36763340	1	TUBE , OIL COOLER INLET	650 / 750
	36767986	1	TUBE , OIL COOLER INLET	900
Z	36763332	1	TUBE , OIL COOLER OUTLET	650 / 750
	36767978	1	TUBE , OIL COOLER OUTLET	900
A1	35A2D221Z1	8	SCREW	
A2	35371079	1	THERMOSTAT	

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION OIL PIPING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-53	DATE/REV: 3-00/A

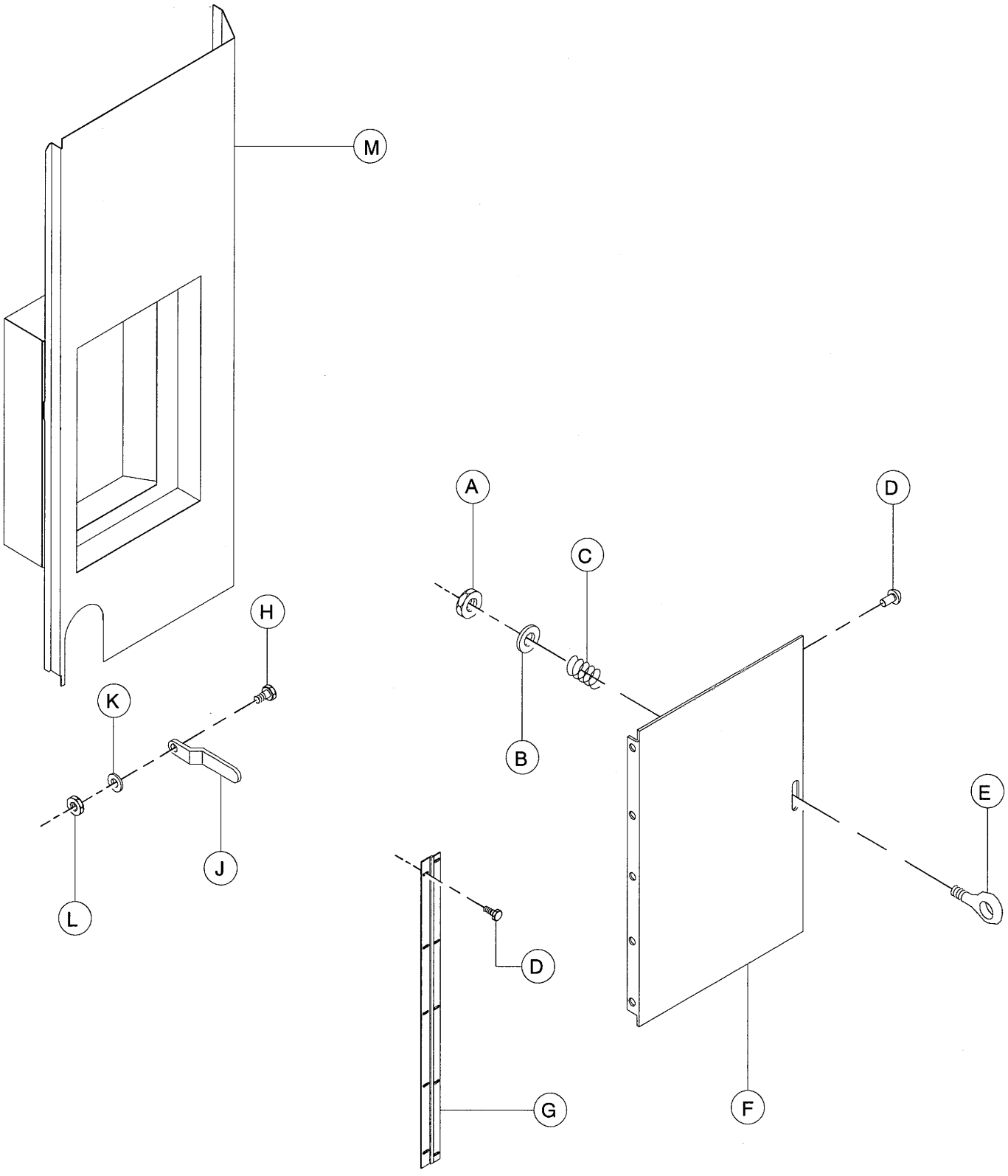


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION INSTRUMENT / CONTROL PANEL	
MODEL NO. XHP650/900	MANUAL NO. 35393925-54	DATE/REV: 3-00/A

ITEM		C.P.N.	DESCRIPTION
A	★	36840924	BRACKET , RELAY
B		92368687	SCREW
C	★	35583442	RELAY , POWER SUPPLY
D	★	35586130	RELAY
E		36008522	RELAY ASSEMBLY
F		35577873	SWITCH , SOLENOID
G		35356781	MODULE , LOW WATER
H		36840239	PANEL , INSTR/CONTROL
J		35369180	RETAINER
K		36844124	STUD
L		36841252	LIGHT , INDICATOR
M		36861177	TACHOMETER
N		36841468	GAGE , DISCHARGE PRESS.
P		35604115	GAGE , AIR TEMP.
Q		35604099	GAGE , FUEL LEVEL
R		35373729	GAGE , ENG. OIL PRESS.
S		35604115	GAGE , WATER TEMP.
T		36841153	GAGE , VOLTMETER
U		36841245	GAGE , HOURMETER
V		36775484	RIVET
W		35365386	SCREW
X		35144492	NUT
Y		36771434	MODULE , DIAGNOSTIC
Z		35255553	SWITCH , ETHER/START
A1		35255561	SWITCH , BYPASS/AIR
A2		35337435	SWITCH , TOGGLE
A3		35290089	BULB , LIGHT
A4		36840908	HINGE

★ INCLUDED IN RELAY ASSEMBLY 36008522

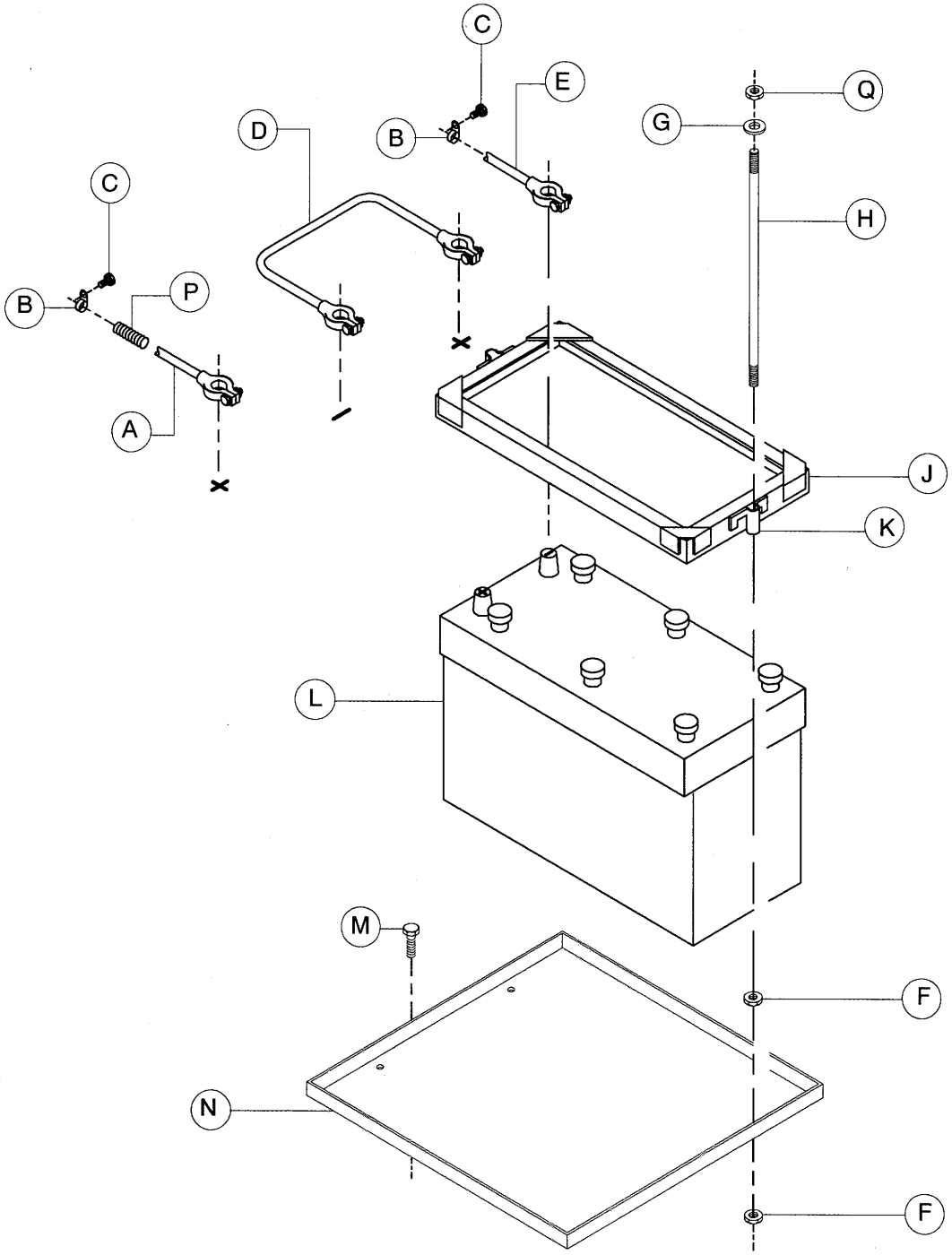
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION INSTRUMENT / CONTROL PANEL	
MODEL NO. XHP650/900	MANUAL NO. 35393925-55	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION INSTRUMENT / CONTROL PANEL MOUNTING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-56	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	67A4C2Z1	1	NUT
B	11A5D3Z1	1	WASHER
C	35327311	1	SPRING
D	36797652	7	SCREW
E	35327303	1	EYEBOLT
F	36738565	1	DOOR , CONTROL PANEL
G	36740405	1	HINGE , CONTROL PANEL
H	35357995	1	STUD
J	35603349	1	HOLDER , DOOR
K	11A5D4Z1	1	WASHER
L	35273366	1	NUT
M	36863710	1	PANEL , L.F. VERTICAL CORNER

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION INSTRUMENT / CONTROL PANEL MOUNTING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-57	DATE/REV: 3-00/A

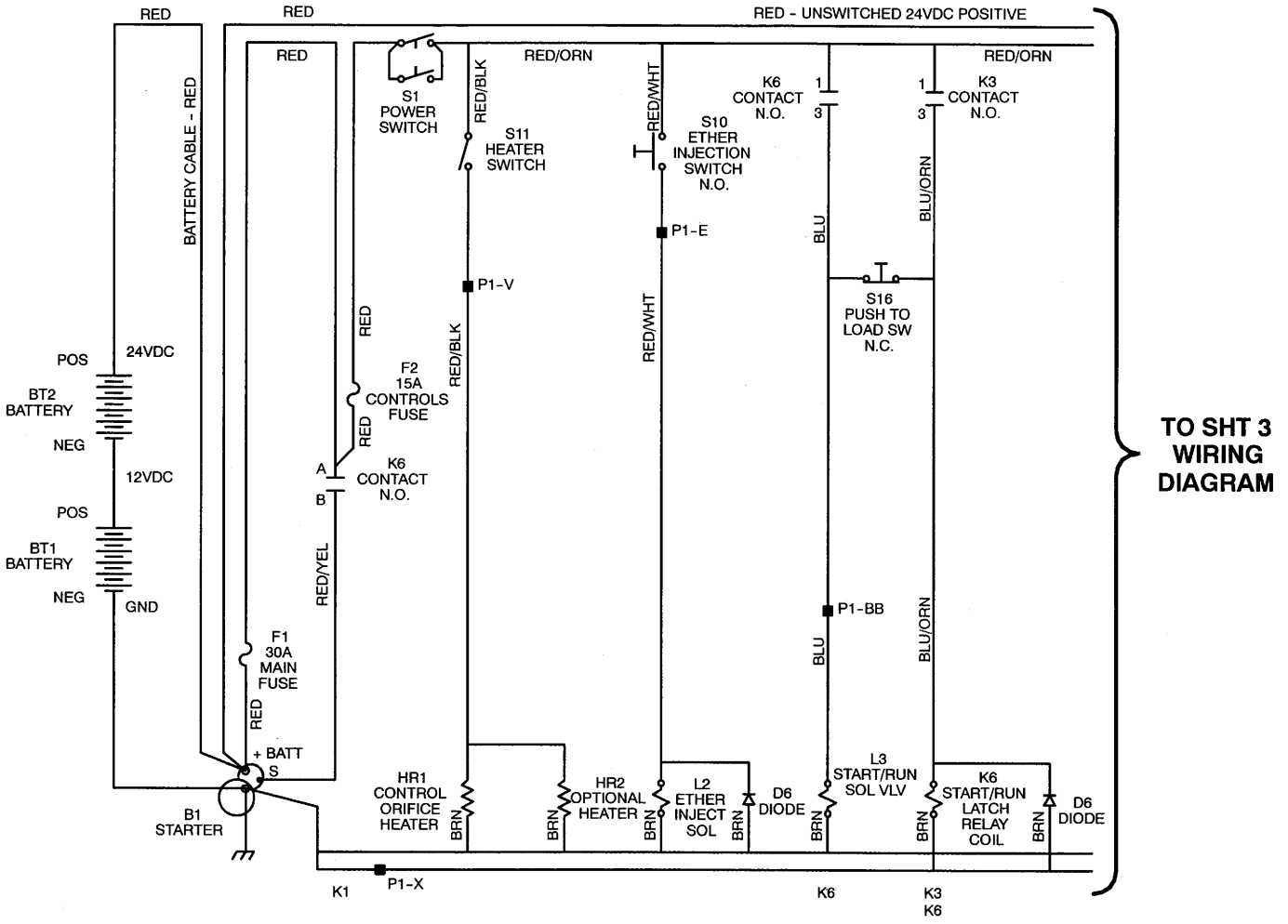


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION BATTERY AND MOUNTING	
MODEL NO. XHP650/900	MANUAL NO. 35393925-58	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	35579150	1	CABLE , POS.
B	W88421	4	CLAMP
C	35134550	2	SCREW
D	35128982	1	CABLE , JUMPER
E	35587088	1	CABLE , NEG.
F	35145077	8	NUT
G	11A5D4Z1	4	WASHER
H	35608116	4	STUD
J	R35343	2	FRAME
K	35108216	4	CLIP
L	W90195	2	BATTERY
M	92368687	3	SCREW
N	36786424	1	TRAY , BATTERY
P	35134519	32"	COIL , PLASTIC
Q	16A4C3Z1	4	NUT

INGERSOLL-RAND COMPANY
PORTABLE COMPRESSOR DIVISION

DATE/DWN BY:	DESCRIPTION	
3-00 WAP	BATTERY AND MOUNTING	
MODEL NO.	MANUAL NO.	DATE/REV:
XHP650/900	35393925-59	3-00/A

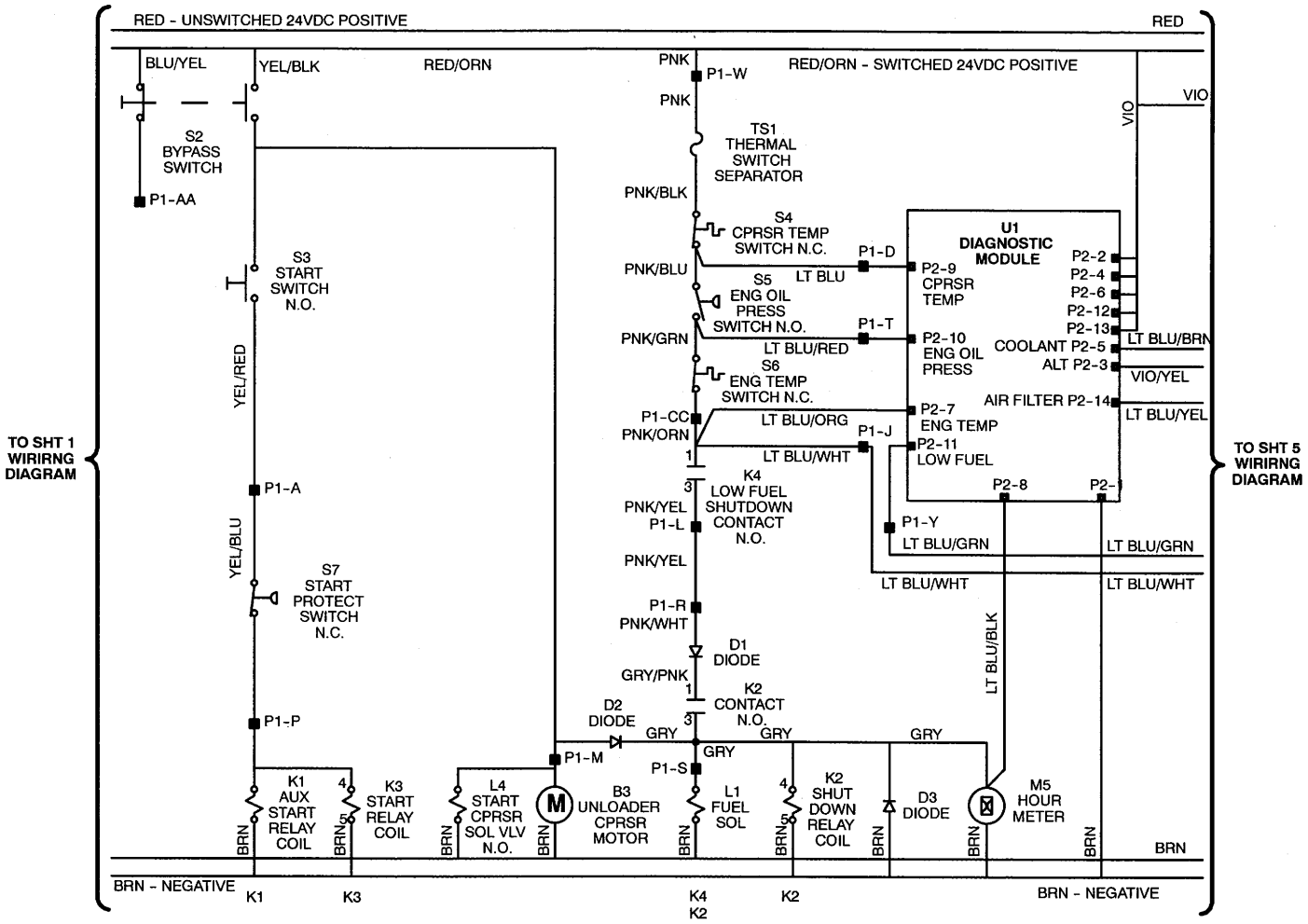


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION WIRING DIAGRAM	
MODEL NO. XHP650/900	MANUAL NO. 35393925-60	DATE/REV: 3-00/A

ITEM	C.P.N.	DESCRIPTION
B1	★	STARTER
BT1	35254168	BATTERY
BT2	35254168	BATTERY
D5	35376169	DIODE
D6	35376169	DIODE
F1	36786259	30A FUSE
F2	36782464	15A FUSE
HR1	36841526	CONTROL HEATER
K3	35586130	RELAY
K6	35586130	RELAY
L2	35306158	ETHER SOLENOID
L3	36842300	START/RUN SOLENOID
S1	35337435	POWER SWITCH
S10	35255553	ETHER SWITCH
S11	35337435	HEATER SWITCH
S16	35255561	SERVICE AIR SWITCH

★ FURNISHED BY ENGINE MANUFACTURER

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION WIRING DIAGRAM	
MODEL NO. XHP650/900	MANUAL NO. 35393925-61	DATE/REV: 3-00/A

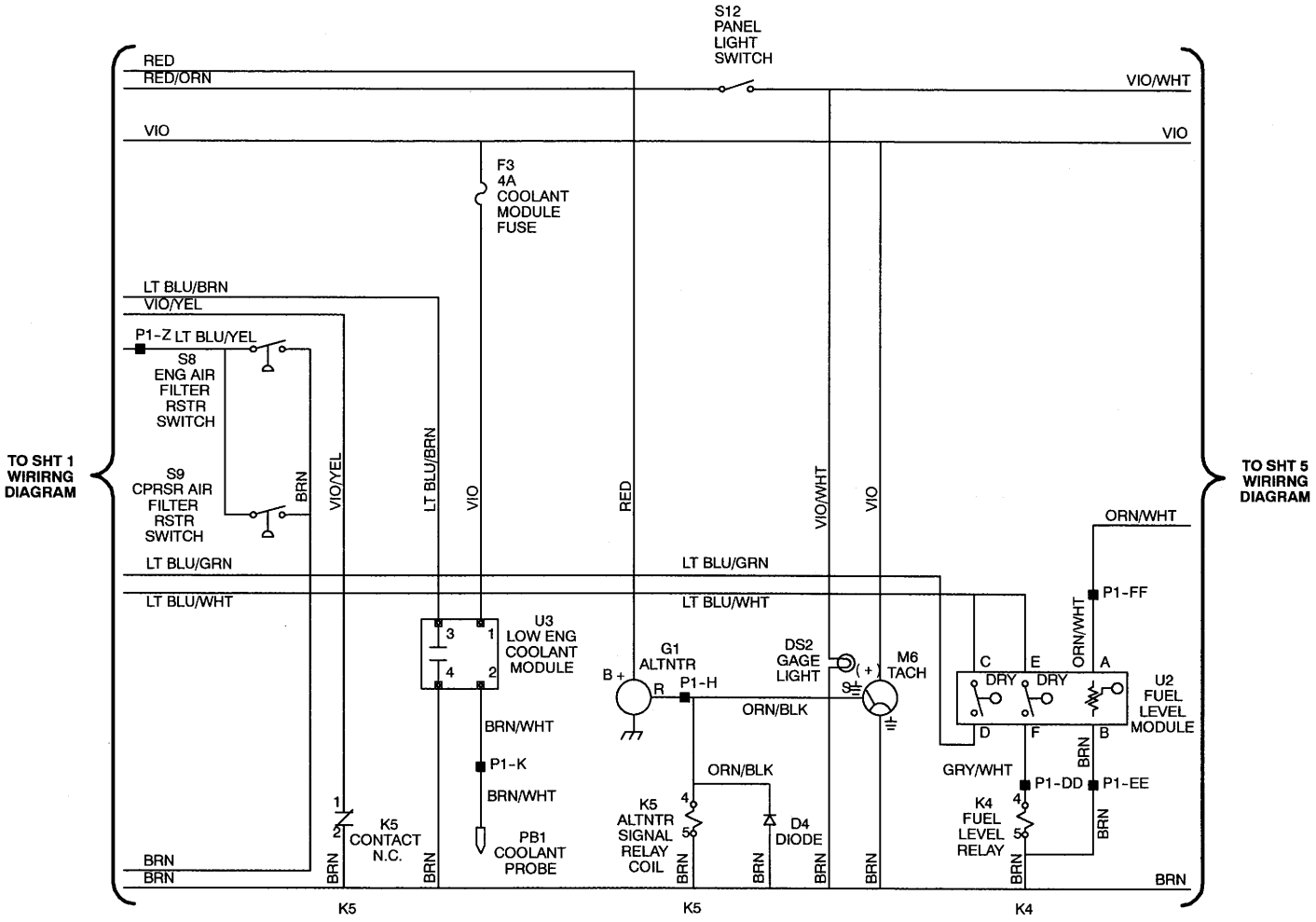


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION WIRING DIAGRAM	
MODEL NO. XHP650/900	MANUAL NO. 35393925-62	DATE/REV: 3-00/A

ITEM	C.P.N.	DESCRIPTION
B3	36850691	COMPRESSOR MOTOR
D1	35376169	DIODE
D2	35376169	DIODE
D3	35376169	DIODE
K1	35577873	RELAY
K2	35586130	RELAY
K3	35586130	RELAY
K4	35586130	RELAY
L1	★	FUEL SOLENOID
L4	36842318	COMPRESSOR SOLENOID
M5	36841245	HOURMETER
S2	35255561	BY-PASS SWITCH
S3	35255553	START SWITCH
S4	35590983	CPRSR TEMP SWITCH
S5	36757581	ENGINE OIL PRESS SWITCH
S6	35327691	ENGINE WATER TEMP SWITCH
S7	36757573	START PROTECTION SWITCH
TS1	36865756	SWITCH
U1	36771434	DIAGNOSTIC MODULE

★ FURNISHED BY ENGINE MANUFACTURER

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION WIRING DIAGRAM	
MODEL NO. XHP650/900	MANUAL NO. 35393925-63	DATE/REV: 5-00/B

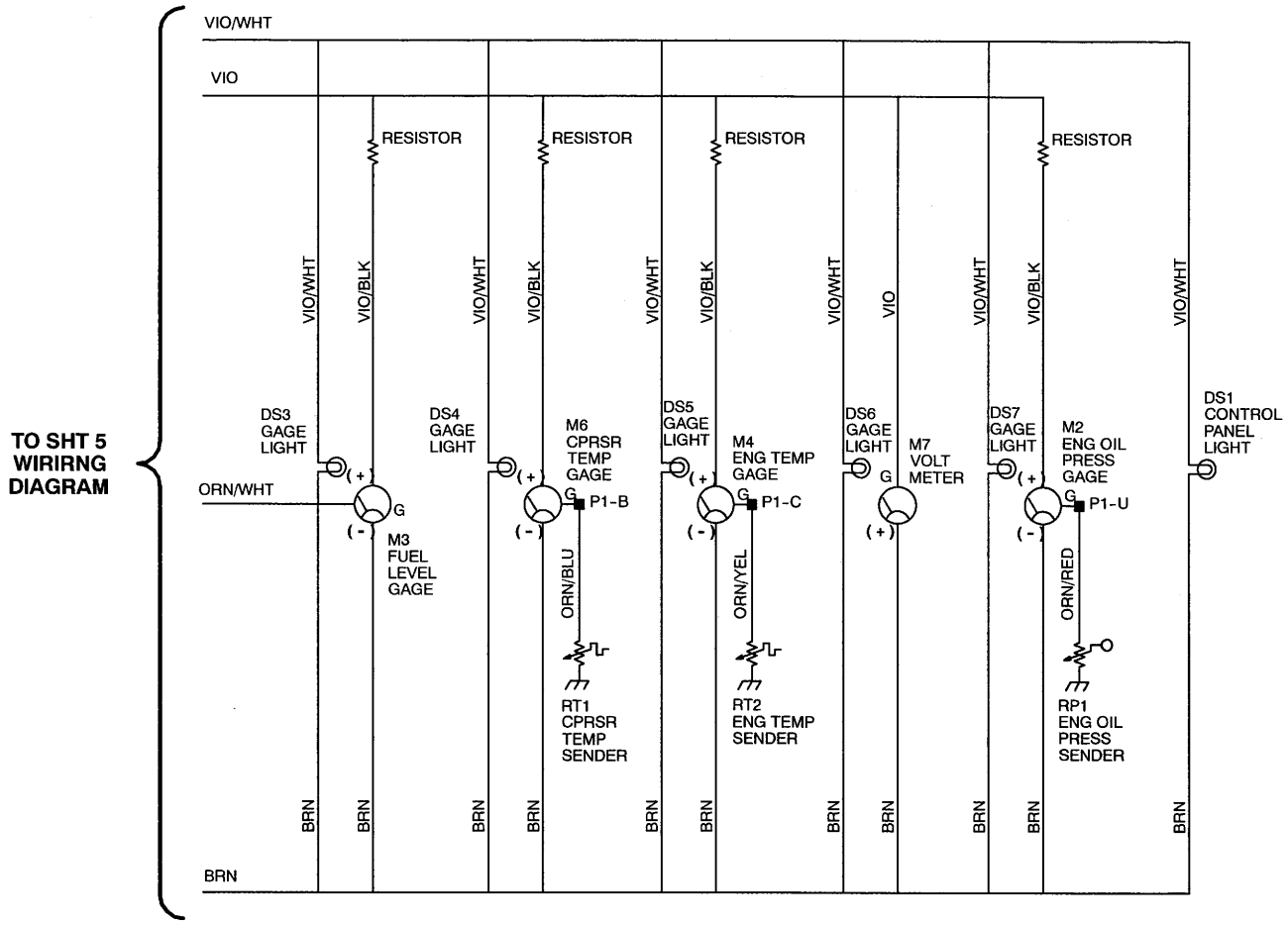


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION WIRING DIAGRAM	
MODEL NO. XHP650/900	MANUAL NO. 35393925-64	DATE/REV: 3-00/A

ITEM	C.P.N.	DESCRIPTION
D4	35376169	DIODE
DS2	36842128	BULB
F3	35363472	4A FUSE
G1	★	ALTERNATOR
K4	35586130	RELAY
K5	35583442	RELAY
M6	36861177	TACHOMETER
PB1	35356799	LOW WATER PROBE
S8	35368992	RESTRICTION INDICATOR SWITCH
S9	35368992	RESTRICTION INDICATOR SWITCH
S12	35337435	PANEL LIGHT SWITCH
U2	36840783	FUEL LEVEL MODULE
U3	35356781	LOW WATER MODULE

★ FURNISHED BY ENGINE MANUFACTURER

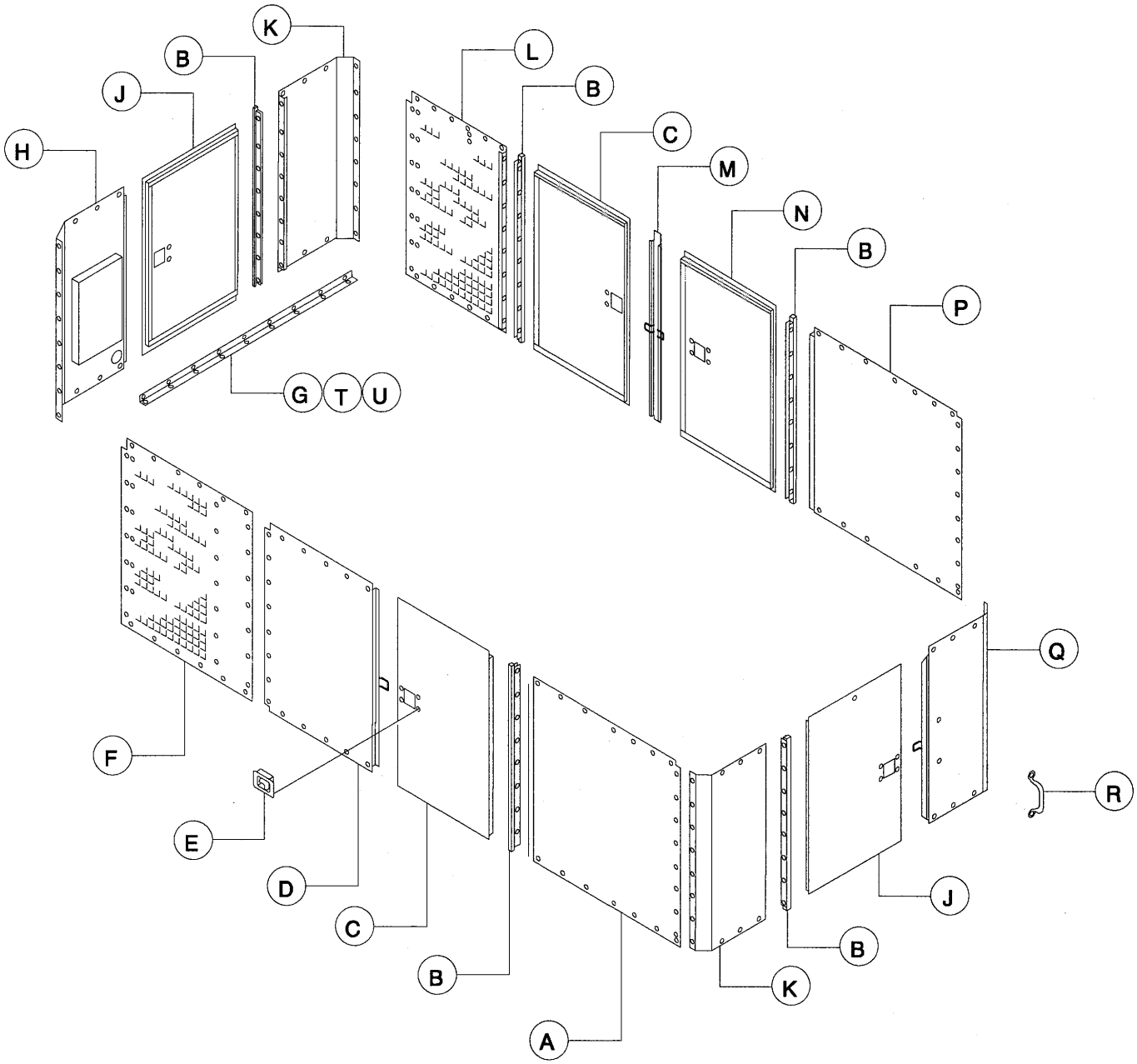
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION WIRING DIAGRAM	
MODEL NO. XHP650/900	MANUAL NO. 35393925-65	DATE/REV: 3-00/A

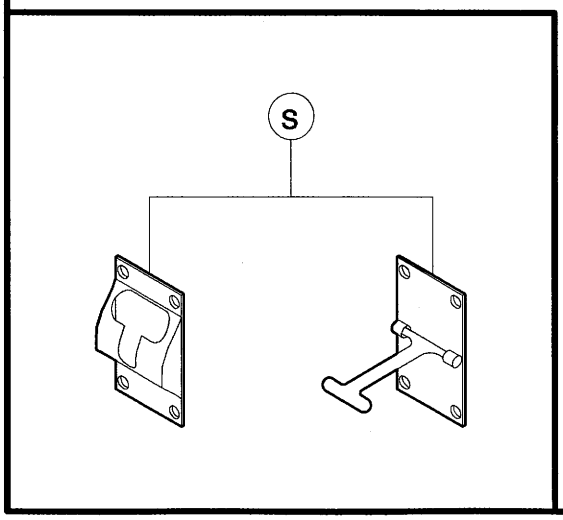


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION WIRING DIAGRAM	
MODEL NO. XHP650/900	MANUAL NO. 35393925-66	DATE/REV: 3-00/A

ITEM	C.P.N.	DESCRIPTION
DS1	36841252	PANEL LIGHT
	35290089	BULB
DS3	36842128	BULB
DS4	36842128	BULB
DS5	36842128	BULB
DS6	36842128	BULB
DS7	36842128	BULB
M2	35373729	ENGINE OIL PRESS GAGE
M3	35604099	FUEL LEVEL GAGE
M4	35604115	ENGINE WATER TEMP GAGE
M6	35604115	COMPRESSOR TEMP GAGE
M7	36841153	VOLTMETER
RP1	36870608	ENGINE OIL PRESS SENDER
RT1	35604180	COMPRESSOR TEMP SENDER
RT2	35604180	ENGINE TEMP SENDER

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION WIRING DIAGRAM	
MODEL NO. XHP650/900	MANUAL NO. 35393925-67	DATE/REV: 3-00/A

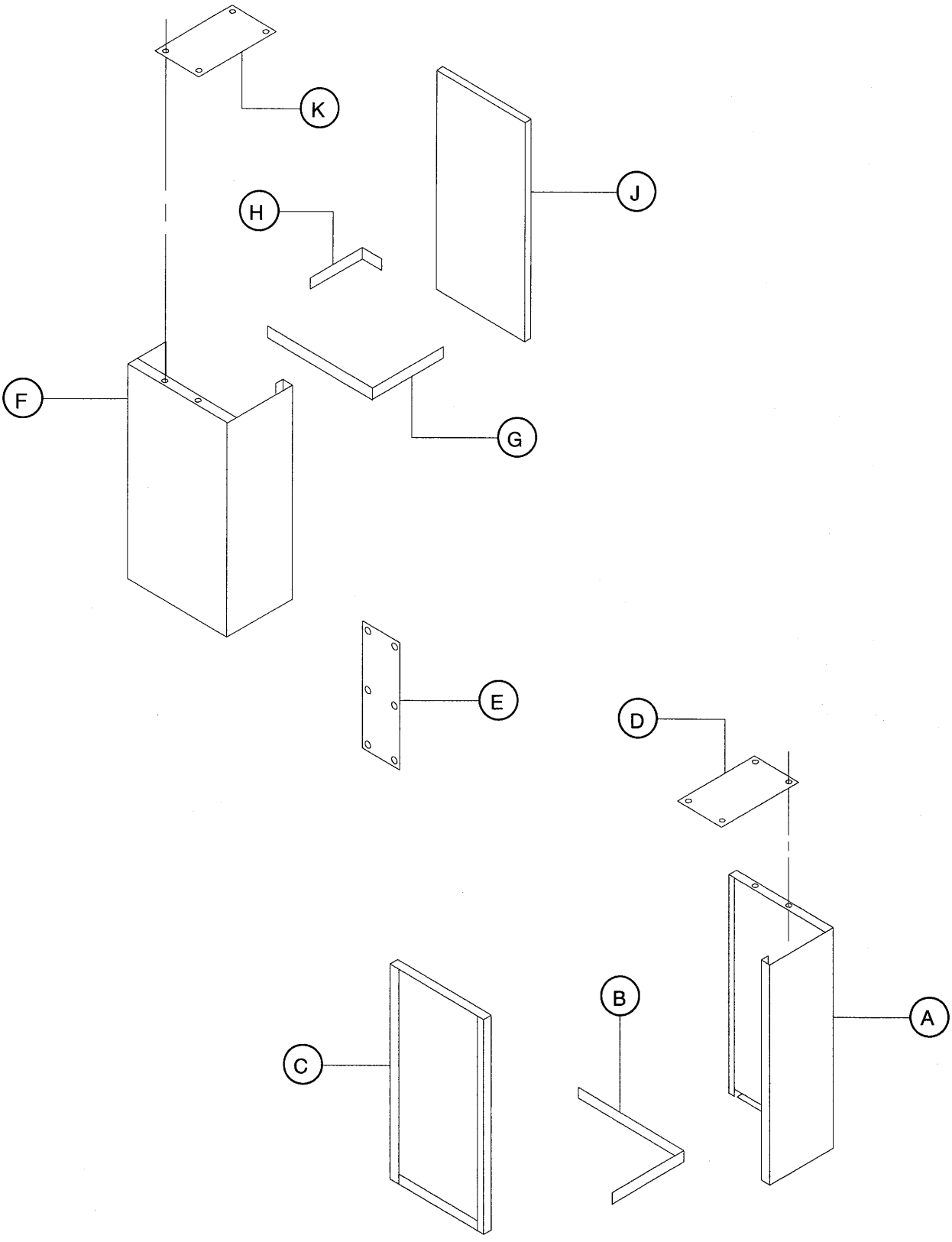




INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENCLOSURE COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-68	DATE/REV: 3-00/A

(A)	36885986	PANEL , L.H. REAR SIDE	
(B)	36863413	HINGE	
(C)	36863652	DOOR , L.H. & R.H. FRONT SIDE	
(D)	36863561	PANEL , L.H. MIDDLE SIDE	
(E)	36793602	LATCH , DOOR SLAM	(5 REQD)
(F)	36863454	PANEL , L.H. FRONT SIDE	
(G)	36863629	ANGLE , R.H. FRONT	
(H)	36863710	PANEL , L.H. FRONT CORNER	
(J)	36863363	DOOR , FRONT & REAR	
(K)	36863330	PANEL , L.H. REAR CORNER	
	36863330	PANEL , R.H. FRONT CORNER	
(L)	36863447	PANEL , R.H. FRONT SIDE	
(M)	36863587	PANEL , R.H. CENTER SIDE	
(N)	36863660	DOOR , R.H. REAR	
(P)	36885978	PANEL , R.H. REAR SIDE	
(Q)	36863348	PANEL , R.H. REAR CORNER	
(R)	35130707	HOLD , HAND	
(S)	36849925	HOLDER , DOOR	(5 REQD)
(T)	36863322	ANGLE , REAR MOUNTING	
(U)	36863645	ANGLE , L.H. FRONT	

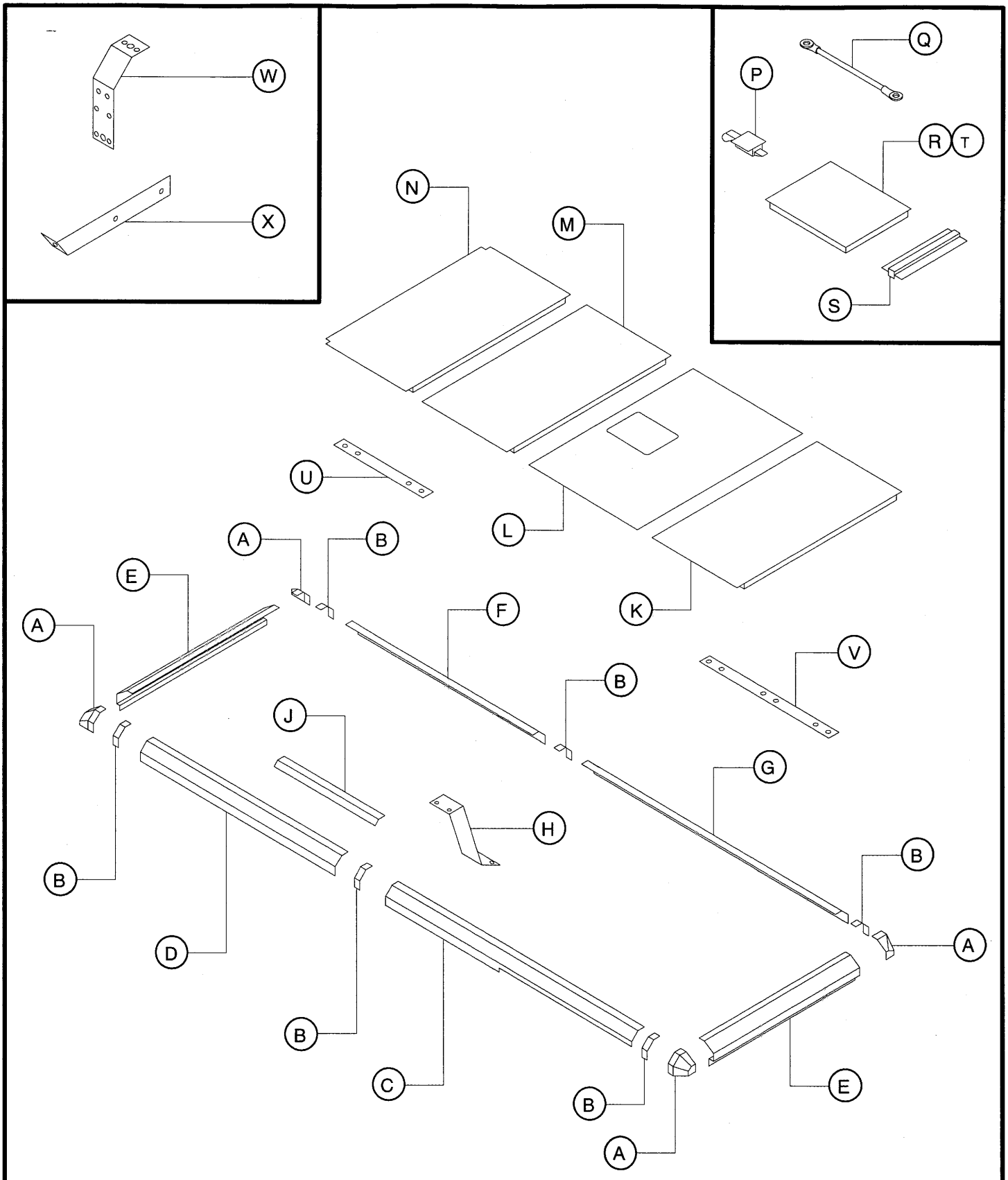
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENCLOSURE COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-69	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENCLOSURE COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-70	DATE/REV: 3-00/A

(A)	36756070	BAFFLE , L.H. AIR INTAKE
(B)	36756005	STRAP , L.H. (3 REQD)
(C)	36757714	BAFFLE , L.H. SPLITTER
(D)	36763878	BRACKET , L.H. BAFFLE SUPPORT
(E)	36763894	SUPPORT , BAFFLE
(F)	36756088	BAFFLE , R.H. AIR INTAKE
(G)	36756013	STRAP , R.H. (3 REQD)
(H)	36764736	BRACKET , SPLITTER BAFFLE
(J)	36757722	BAFFLE , R.H. SPLITTER
(K)	36762912	BRACKET , R.H. BAFFLE SUPPORT

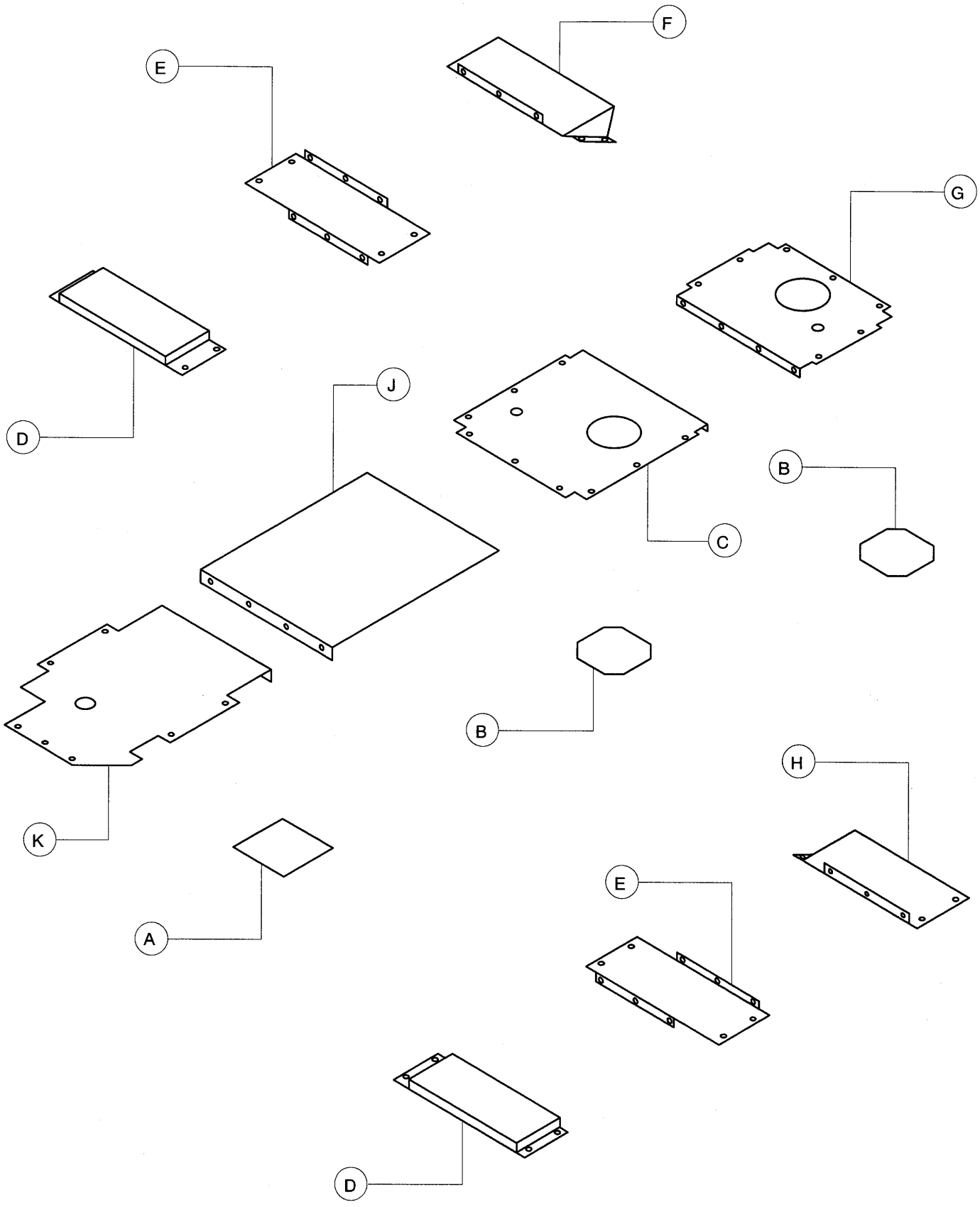
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENCLOSURE COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-71	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENCLOSURE COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-72	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	36755981		CORNER , END CAP
B	36755742		STRIP , CONNECTOR
C	36864023		CHANNEL , L.H. REAR
D	36863975		CHANNEL , L.H. FRONT
E	36863355		CHANNEL , FRONT & REAR
F	36864064		CHANNEL , R.H. FRONT
G	36864015		CHANNEL , R.H. REAR
H	36864312		BRACKET , ROOF SUPPORT (2 REQD)
J	36863371		SHIELD , DOOR RAIN (5 REQD)
K	36863991		PANEL , REAR ROOF
L	36864353		PANEL , CENTER ROOF
M	36864007		PANEL , FRONT MIDDLE
N	36863983		PANEL , FRONT ROOF
P	35131051		LATCH , DOOR
Q	36864304		CABLE , DOOR
R	36864403		DOOR , ROOF
S	36864288		HINGE , DOOR
T	36774495		STRIP , DOOR SEAL
U	36882843		STRAP , ACOUSTIC
V	36882850		STRAP , ACOUSTIC
W	36887933		BRACKET , REAR ROOF CHANNEL
X	36887925		STRIP , CONNECTOR (2 REQD)

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ENCLOSURE COMPLETE	
MODEL NO. XHP650/900	MANUAL NO. 35393925-73	DATE/REV: 3-00/A

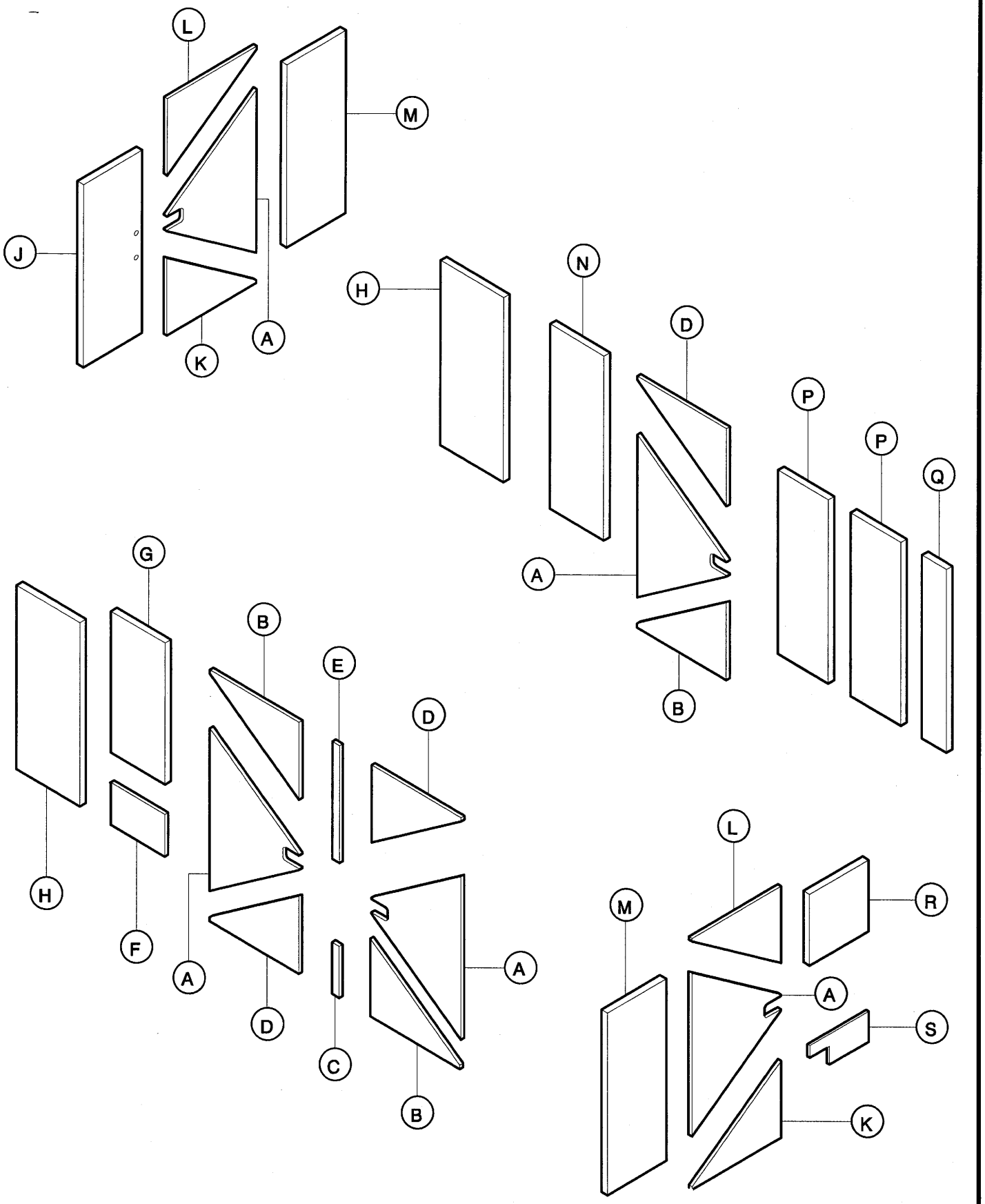


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION BELLY PAN , FRAME & FUEL TANK COVERS	
MODEL NO. XHP650/900	MANUAL NO. 35393925-74	DATE/REV: 3-00/A

A	36798445	COVER , RADIATOR HOSE
B	35279413	COVER , ACCESS
C	36758365	COVER , ENGINE REAR
D	36758548	COVER , FRONT FRAME
E	36781714	COVER , REAR FUEL
F	36759496	COVER , REAR FRAME
G	36758373	COVER , ENGINE FRONT
H	36759504	COVER , REAR FRAME
J	36762037	PAN , AIR END (900)
K	36762029	PAN , FRONT BELLY (900)

INGERSOLL-RAND COMPANY
PORTABLE COMPRESSOR DIVISION

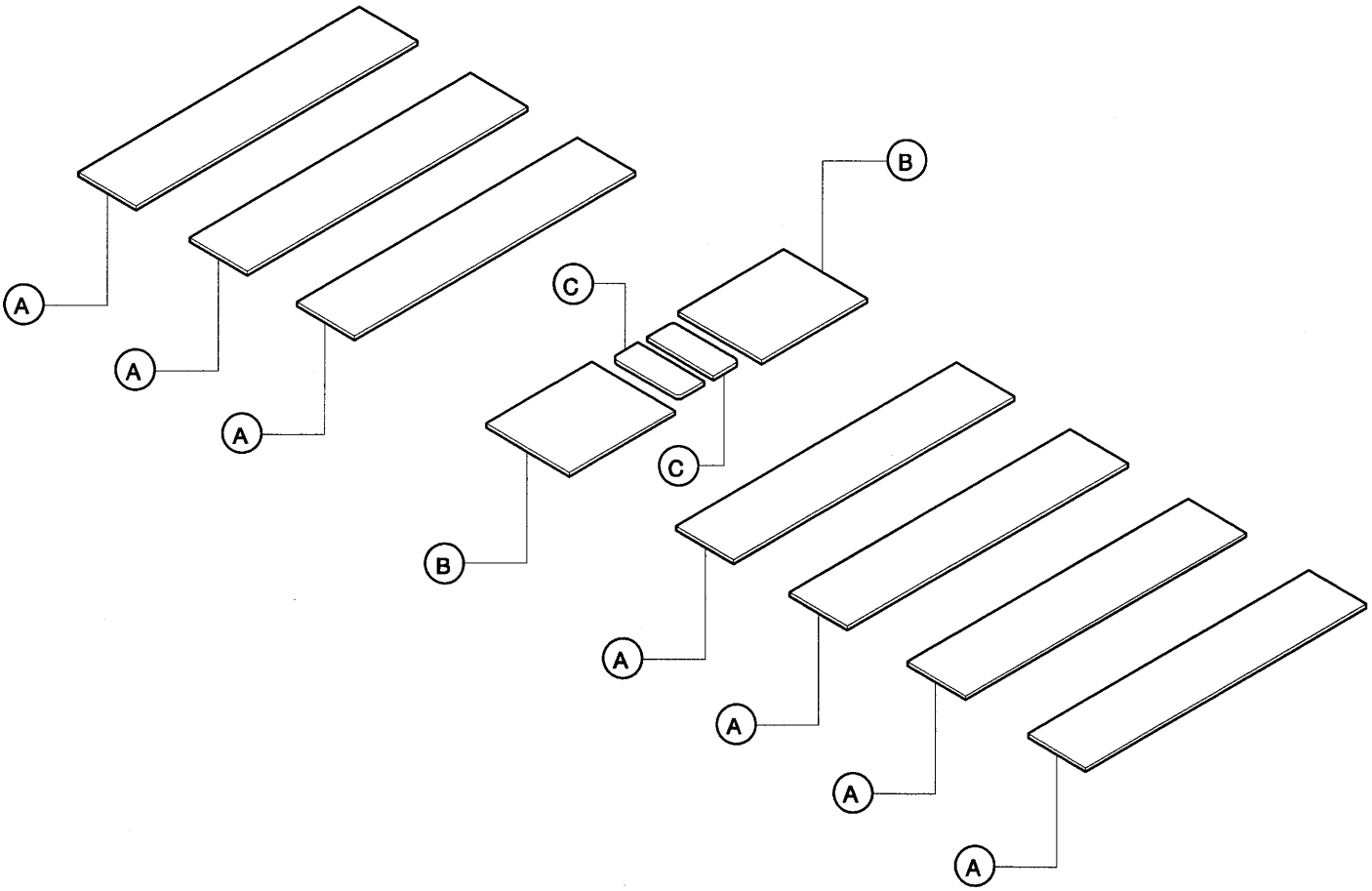
DATE/DWN BY:	DESCRIPTION	
3-00 WAP	BELLY PAN , FRAME & FUEL TANK COVERS	
MODEL NO.	MANUAL NO.	DATE/REV:
XHP650/900	35393925-75	3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ACOUSTIC PANELS	
MODEL NO. XHP650/825	MANUAL NO. 35393925-76	DATE/REV: 3-00/A

(A)	36864940	FOAM , CENTER DOOR
(B)	36864965	FOAM , SIDE DOOR
(C)	36864486	FOAM , CENTER POST BOTTOM
(D)	36864957	FOAM ,SIDE DOOR
(E)	36864494	FOAM , CENTER POST TOP
(F)	36864502	FOAM , R.H. BOTTOM
(G)	36864510	FOAM , R.H. TOP
(H)	36864890	FOAM , R.H. & L.H. REAR
(J)	36864916	FOAM , R.H. REAR CORNER
(K)	36864924	FOAM , FRONT & REAR DOOR
(L)	36864932	FOAM , FRONT & REAR DOOR
(M)	36864908	FOAM , FRONT & REAR CORNER
(N)	36864882	FOAM , L.H. SIDE
(P)	36864874	FOAM , L.H. FRONT SIDE
(Q)	36864866	FOAM , L.H. FRONT SIDE
(R)	36864858	FOAM , L.H. FRONT TOP
(S)	36864536	FOAM , L.H. FRONT BOTTOM

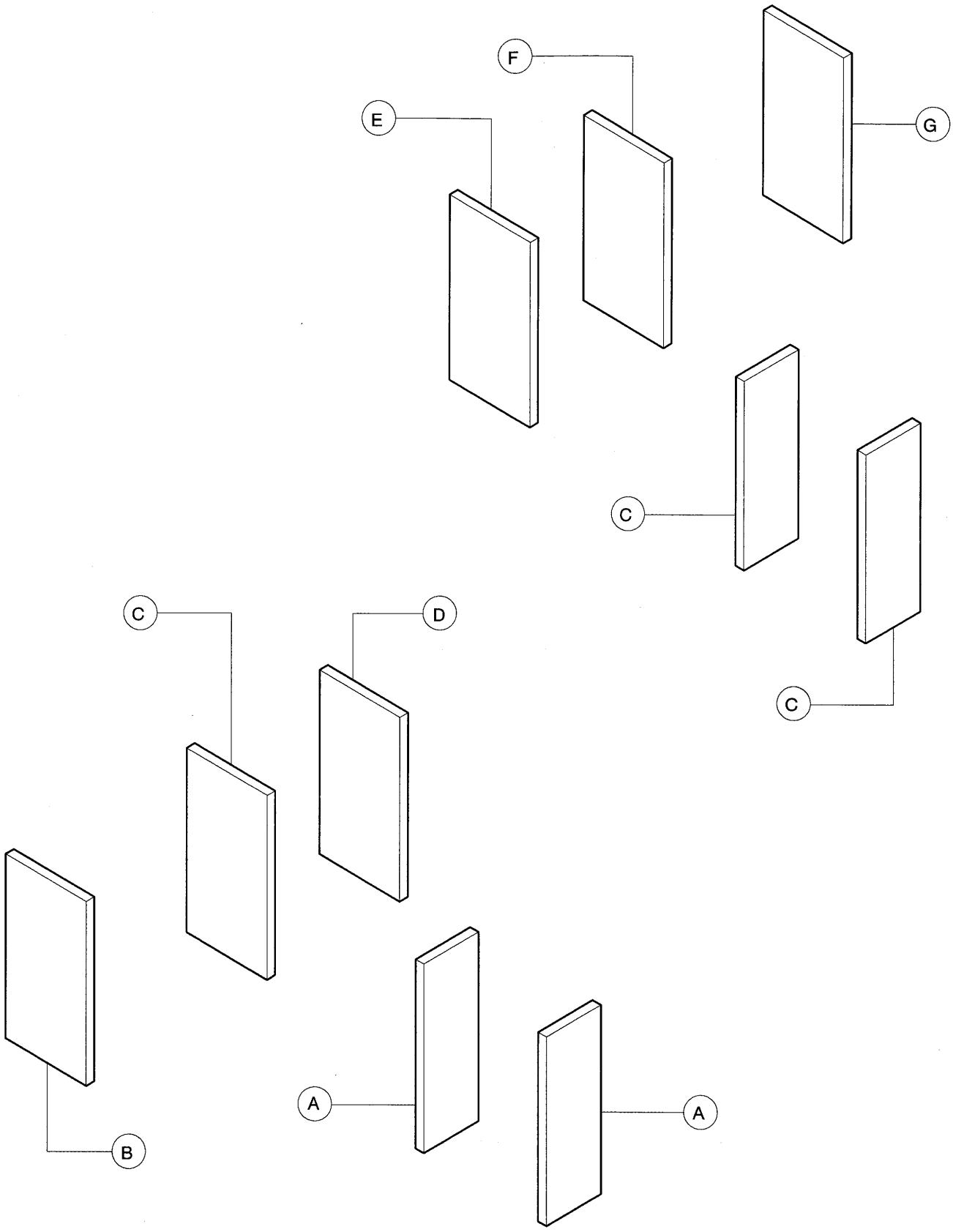
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ACOUSTIC PANELS	
MODEL NO. XHP650/825	MANUAL NO. 35393925-77	DATE/REV: 3-00/A



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ACOUSTIC PANELS	
MODEL NO. XHP650/825	MANUAL NO. 35393925-78	DATE/REV: 3-00/A

A	36864411	FOAM , TOP PANEL
B	36864429	FOAM , TOP CENTER PANEL
C	36864437	FOAM , TOP DOOR

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ACOUSTIC PANELS	
MODEL NO. XHP650/825	MANUAL NO. 35393925-79	DATE/REV: 3-00/A

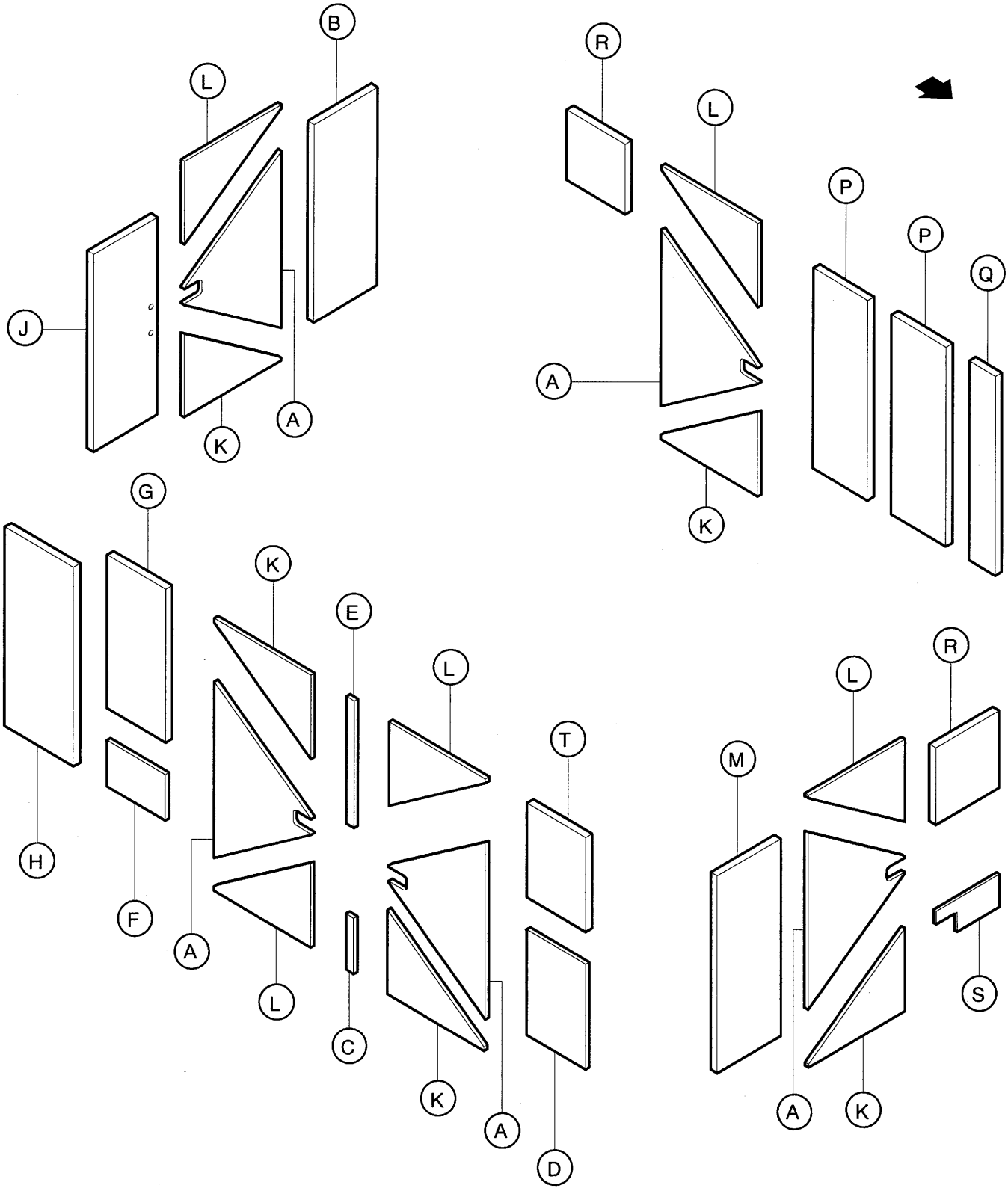


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION BAFFLE WALL FOAM	
MODEL NO. XHP650/825	MANUAL NO. 35393925-80	DATE/REV: 3-00/A

(A)	36757938	ACOUSTIC PANEL
(B)	36757920	ACOUSTIC PANEL
(C)	36757946	ACOUSTIC PANEL
(D)	36761609	ACOUSTIC PANEL
(E)	36761591	ACOUSTIC PANEL
(F)	36757938	ACOUSTIC PANEL
(G)	36757953	ACOUSTIC PANEL

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION BAFFLE WALL FOAM	
MODEL NO. XHP650/825	MANUAL NO. 35393925-81	DATE/REV: 3-00/A

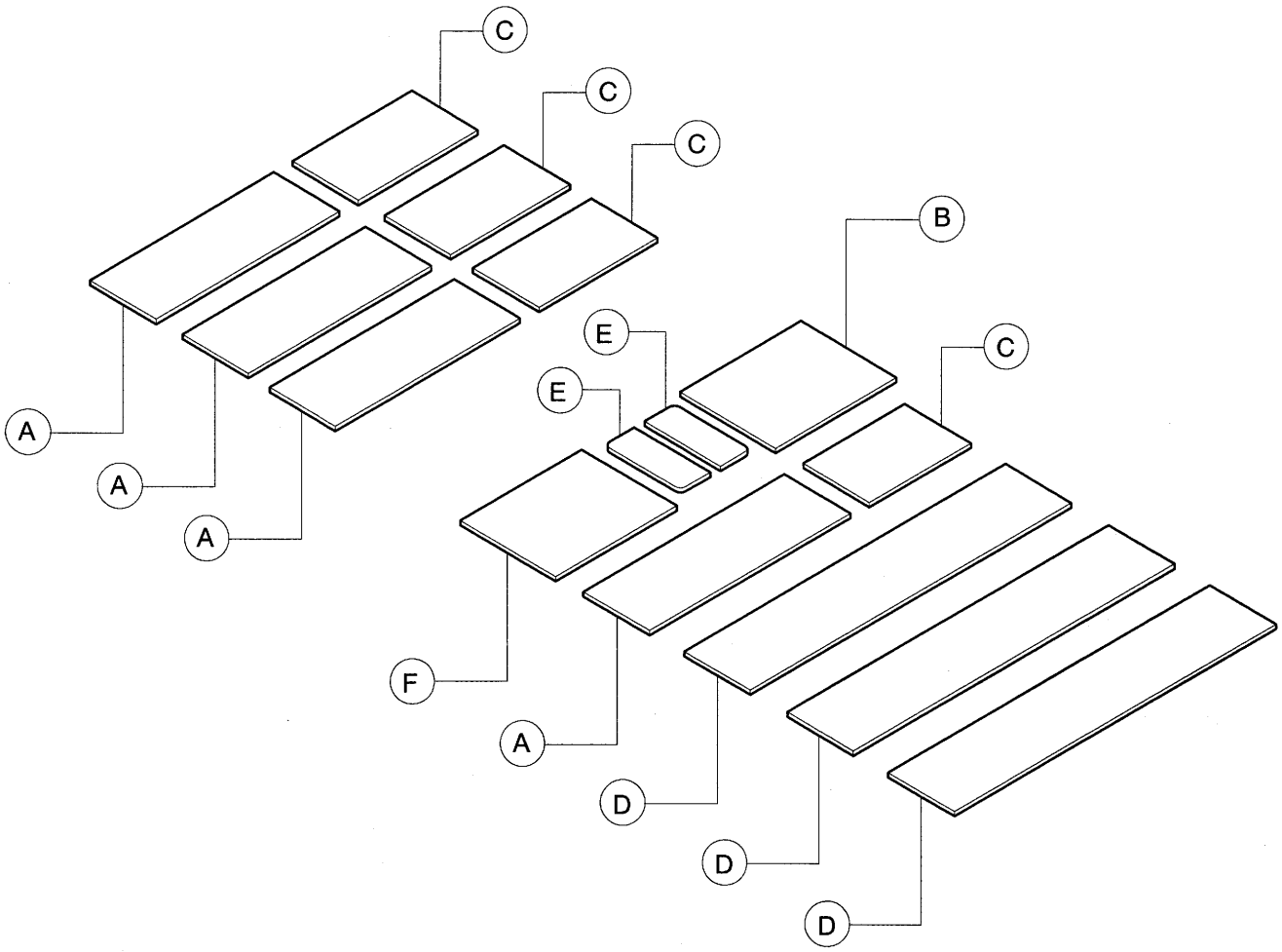
DRAWBAR END



INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ACOUSTIC PANELS	
MODEL NO. XHP900	MANUAL NO. 35393925-82	DATE/REV: 3-00/A

ITEM	C.P.N.	DESCRIPTION
A	36864593	FOAM , CENTER DOOR
B	36882819	PANEL , REAR FIBERGLASS
C	36864486	FOAM , CENTER POST BOTTOM
D	36845196	FOAM , R.H. FRONT BOTTOM GRILLE
E	36864494	FOAM , CENTER POST TOP
F	36864502	FOAM , R.H. BOTTOM
G	36864510	FOAM , R.H. TOP
H	36864445	FOAM , R.H. & L.H. REAR
J	36864460	FOAM , R.H. REAR CORNER
K	36864619	FOAM , FRONT & REAR DOOR
L	36864601	FOAM , FRONT & REAR DOOR
M	36864452	FOAM , FRONT & REAR CORNER
N	36864478	FOAM , L.H. SIDE
P	36864551	FOAM , L.H. FRONT SIDE
Q	36864544	FOAM , L.H. FRONT SIDE
R	36864528	FOAM , L.H. FRONT TOP
S	36864536	FOAM , L.H. FRONT BOTTOM
T	36845188	FOAM , R.H. FRONT TOP GRILLE

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ACOUSTIC PANELS	
MODEL NO. XHP900	MANUAL NO. 35393925-83	DATE/REV: 3-00/A

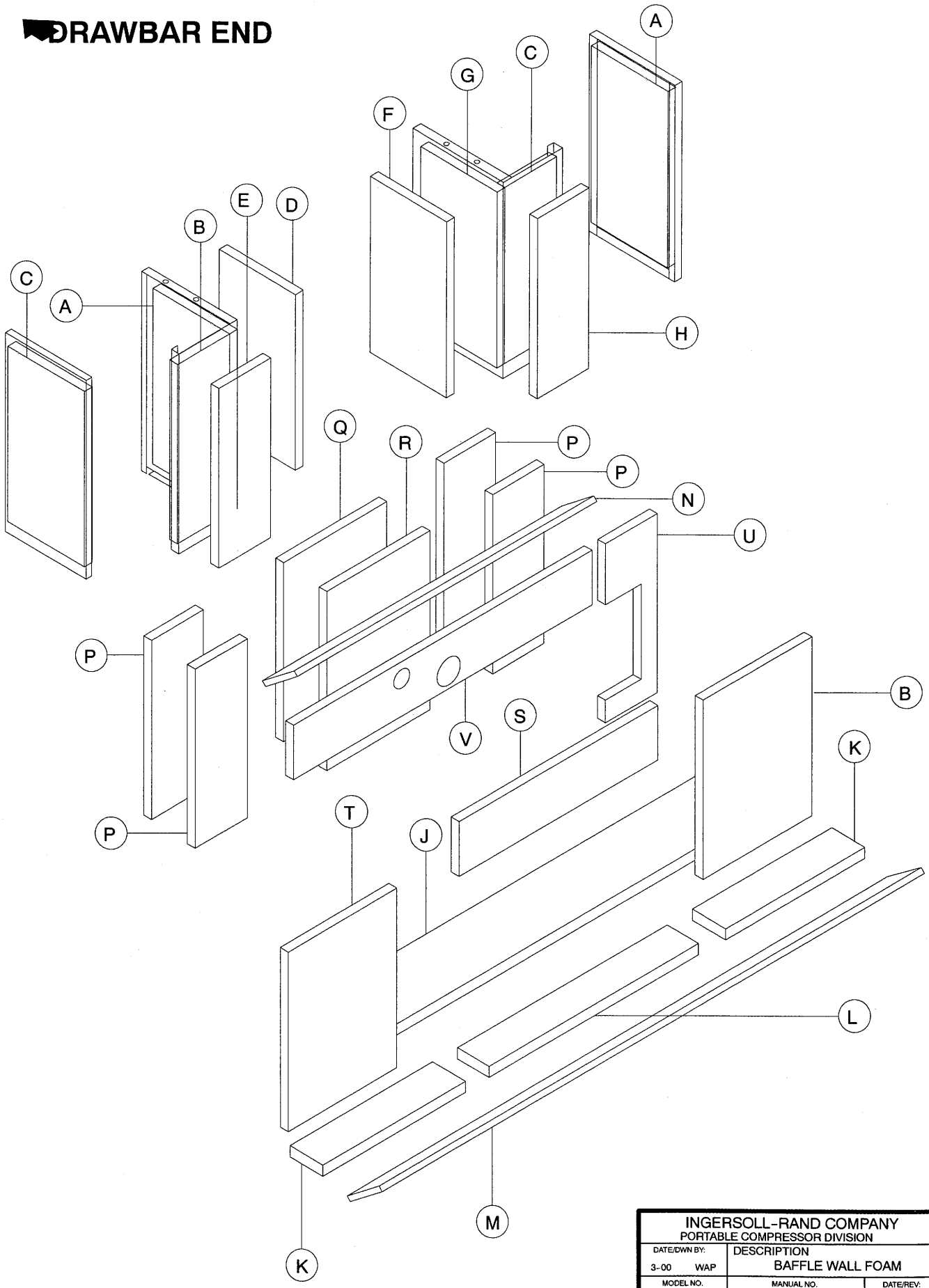


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ACOUSTIC PANELS	
MODEL NO. XHP900	MANUAL NO. 35393925-84	DATE/REV: 3-00/A

ITEM	C.P.N.	DESCRIPTION
A	36882827	FOAM , TOP
B	36882801	PANEL , TOP FIBERGLASS
C	36882835	PANEL , TOP FIBERGLASS
D	36864411	FOAM , TOP PANEL
E	36864437	FOAM , TOP DOOR
F	36864429	FOAM , TOP CENTER PANEL

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION ACOUSTIC PANELS	
MODEL NO. XHP900	MANUAL NO. 35393925-85	DATE/REV: 3-00/A

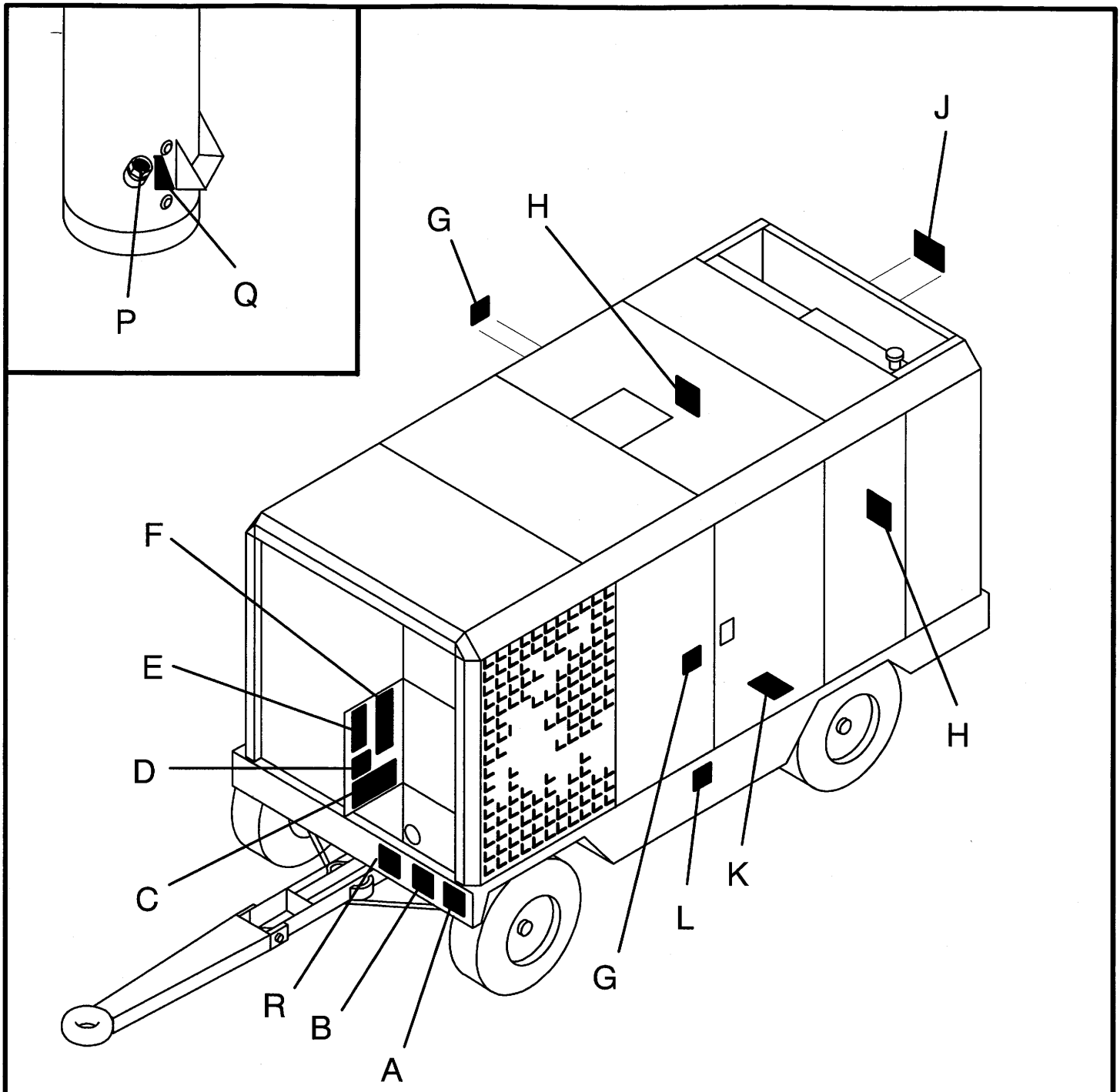
DRAWBAR END

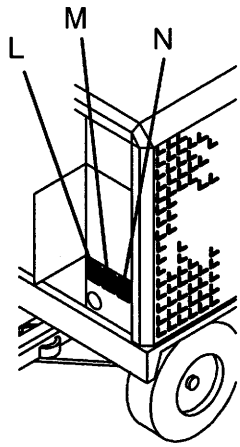


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION BAFFLE WALL FOAM	
MODEL NO. XHP900	MANUAL NO. 35393925-86	DATE/REV: 3-00/A

ITEM	C.P.N.	QTY	DESCRIPTION
A	36757938	2	ACOUSTIC PANEL , L.H. FRONT INLET BAFFLE / R.H. SPLITTER
B	36757920	1	ACOUSTIC PANEL , L.H. FRONT INLET BAFFLE
C	36757946	2	ACOUSTIC PANEL , R.H. FRONT INLET BAFFLE / L.H. SPLITTER
D	36797470	1	ACOUSTIC PANEL , L.H. FRONT INLET BAFFLE
E	36797488	1	ACOUSTIC PANEL , L.H. FRONT INLET BAFFLE
F	36797496	1	ACOUSTIC PANEL , R.H. FRONT INLET BAFFLE
G	36757953	1	ACOUSTIC PANEL , R.H. FRONT INLET BAFFLE
H	36797504	1	ACOUSTIC PANEL , R.H. FRONT INLET BAFFLE
J	36863464	1	ACOUSTIC PANEL , BOTTOM SHROUD
K	36787984	2	ACOUSTIC PANEL , R.H. & L.H. EHAUST PLENUM FLOOR
L	36787992	1	ACOUSTIC PANEL , CENTER EHAUST PLENUM FLOOR
M	36788016	1	ACOUSTIC PANEL , FRAME EXTENSION
N	36787745	1	ACOUSTIC PANEL , REAR TOP BAFFLE
P	36784434	4	ACOUSTIC PANEL , R.H. & L.H. REAR BAFFLE
Q	36784246	1	ACOUSTIC PANEL , INSIDE REAR BAFFLE DOOR
R	36784403	1	ACOUSTIC PANEL , OUTSIDE REAR BAFFLE DOOR
S	36788008	1	ACOUSTIC PANEL , CENTER FRAME
T	36864445	2	ACOUSTIC PANEL , REAR SIDE PANEL
U	36797546	1	ACOUSTIC PANEL , R.H. REAR BAFFLE (COOLER SIDE)
V	36797561	1	ACOUSTIC PANEL , TOP REAR BAFFLE (ENGINE SIDE)

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION BAFFLE WALL FOAM	
MODEL NO. XHP900	MANUAL NO. 35393925-87	DATE/REV: 3-00/A

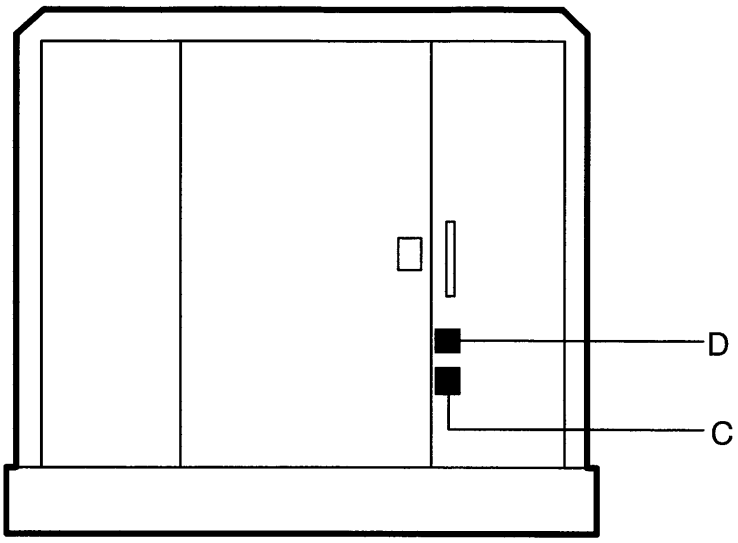


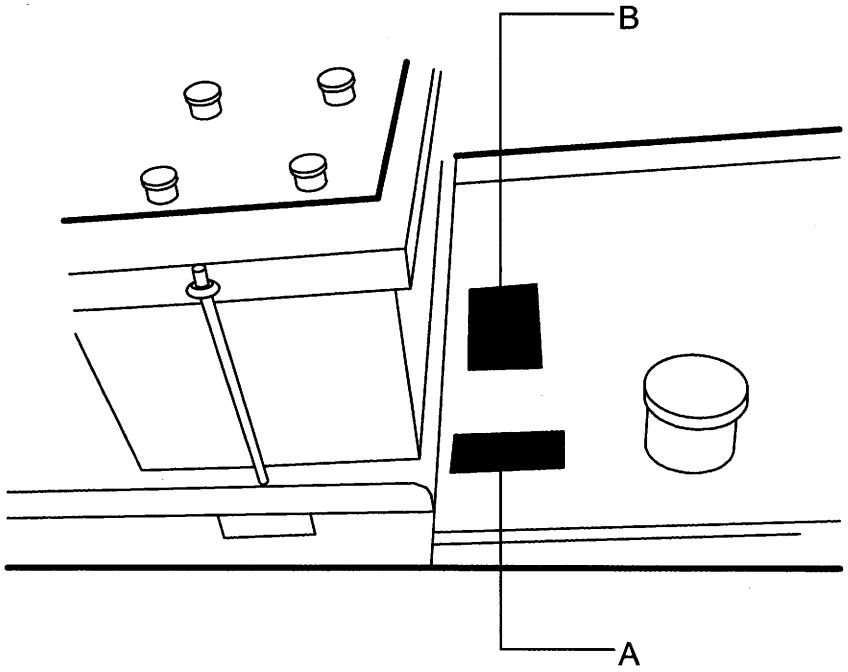


INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION DECAL LOCATION	
MODEL NO. XHP650/900	MANUAL NO. 35393925-88	DATE/REV: 3-00/A

A	36520690		UNRESTRICTED AIR FLOW DECAL
B	36508976		TRAPPED AIR DECAL
C	36522290		SAFETY CARD LAMINATE
D	36522035		IMPROPER OPERATION DECAL
E	36521425	650	GENERAL DATA DECAL
	36521433	750	
	36522431	900	
	36521939	825	
F	36517134		PRESSURE ADJUSTING DECAL
G	36504942		HIGH PRESSURE AIR DECAL
H	36522050		ROTATING FAN DECAL
J	35859339		RADIATOR CAP DECAL
K	36516474		DIESEL FUEL DECAL
L	36508307		ROOF / LIFTING EYE DECAL
M	36522043		BREATHING AIR DECAL
N	36514602		EPA DECAL
P	35810357		OIL FILL DECAL
Q	36512739		OIL LEVEL DECAL
R	36532877		TRAILER SWAY DECAL

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION DECAL LOCATION	
MODEL NO. XHP650/900	MANUAL NO. 35393925-89	DATE/REV: 3-00/A

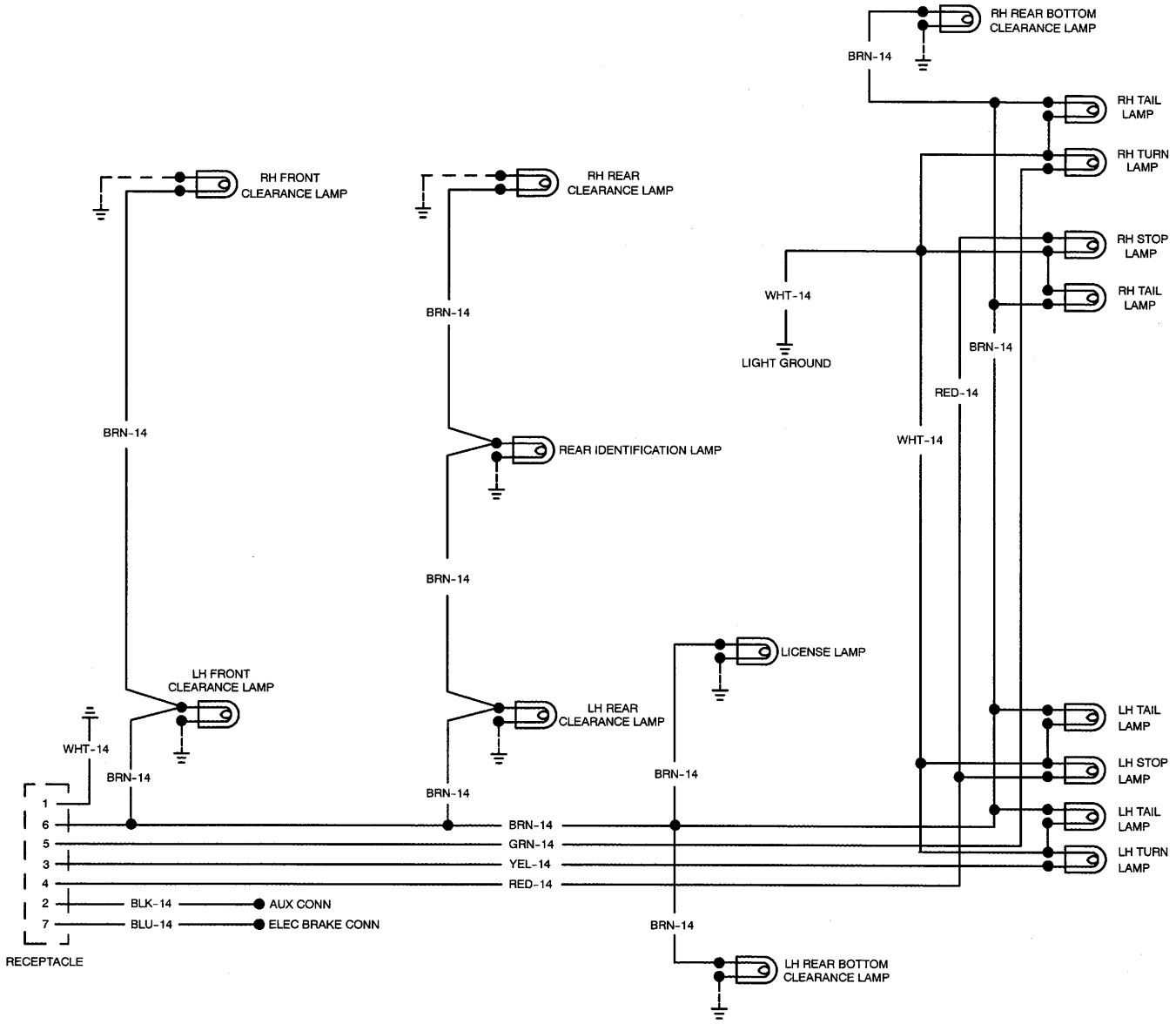




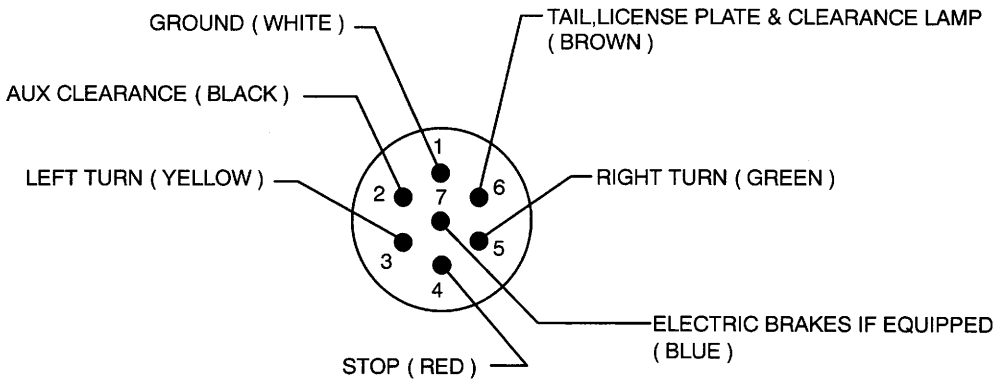
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION DECAL LOCATION	
MODEL NO. XHP650/900	MANUAL NO. 35393925-90	DATE/REV: 3-00/A

A	36516474	DIESEL FUEL DECAL
B	36519445	BATTERY GAS DECAL
C	36508323	DOOR UNDER PRESSURE DECAL
D	36508307	ROOF / LIFTING EYE

INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION DECAL LOCATION	
MODEL NO. XHP650/900	MANUAL NO. 35393925-91	DATE/REV: 3-00/A



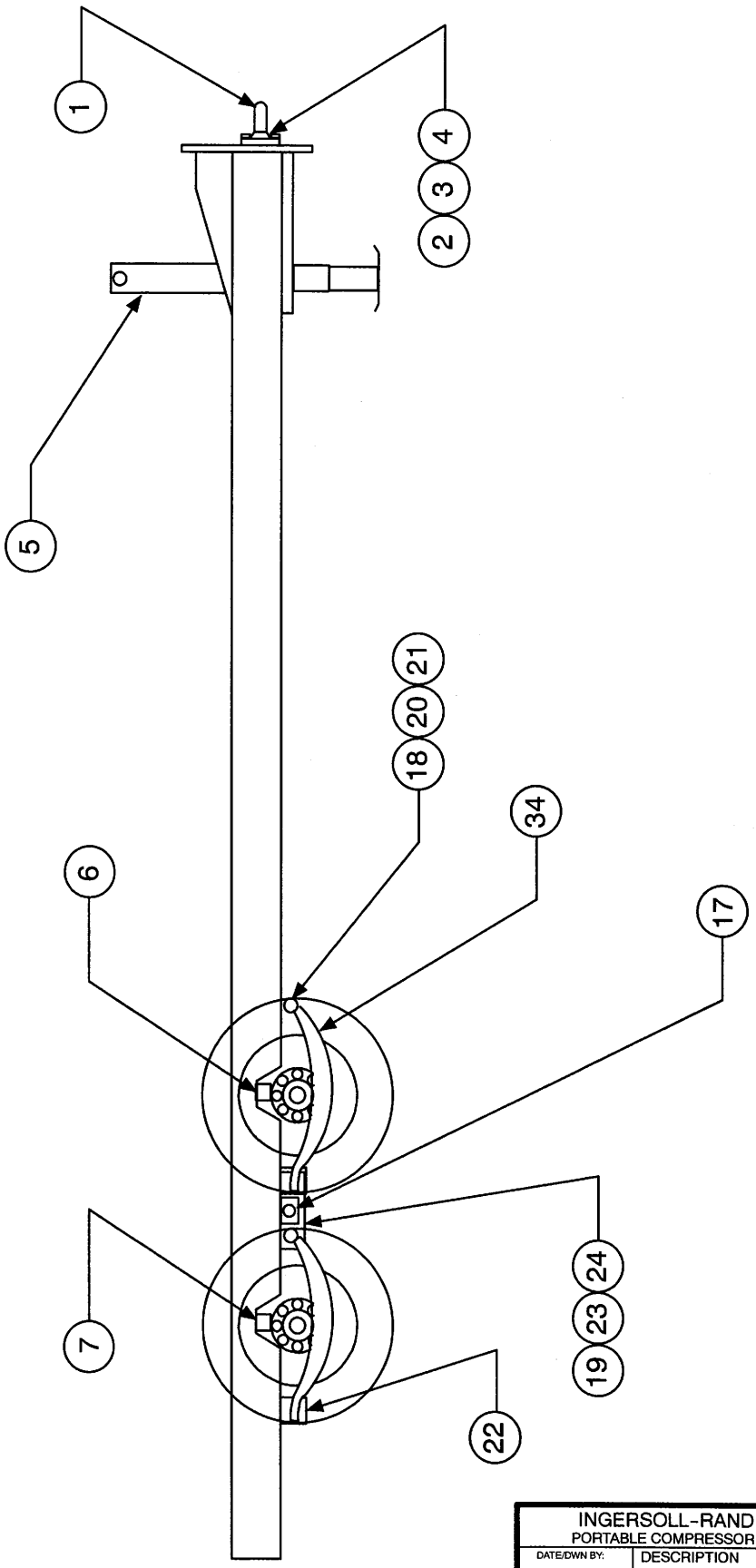
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 2-00 WAP	DESCRIPTION HIGH SPEED RUNNING GEAR	
MODEL NO. XHP650/900	MANUAL NO. 35393925-92	DATE/REV: 8-00/B



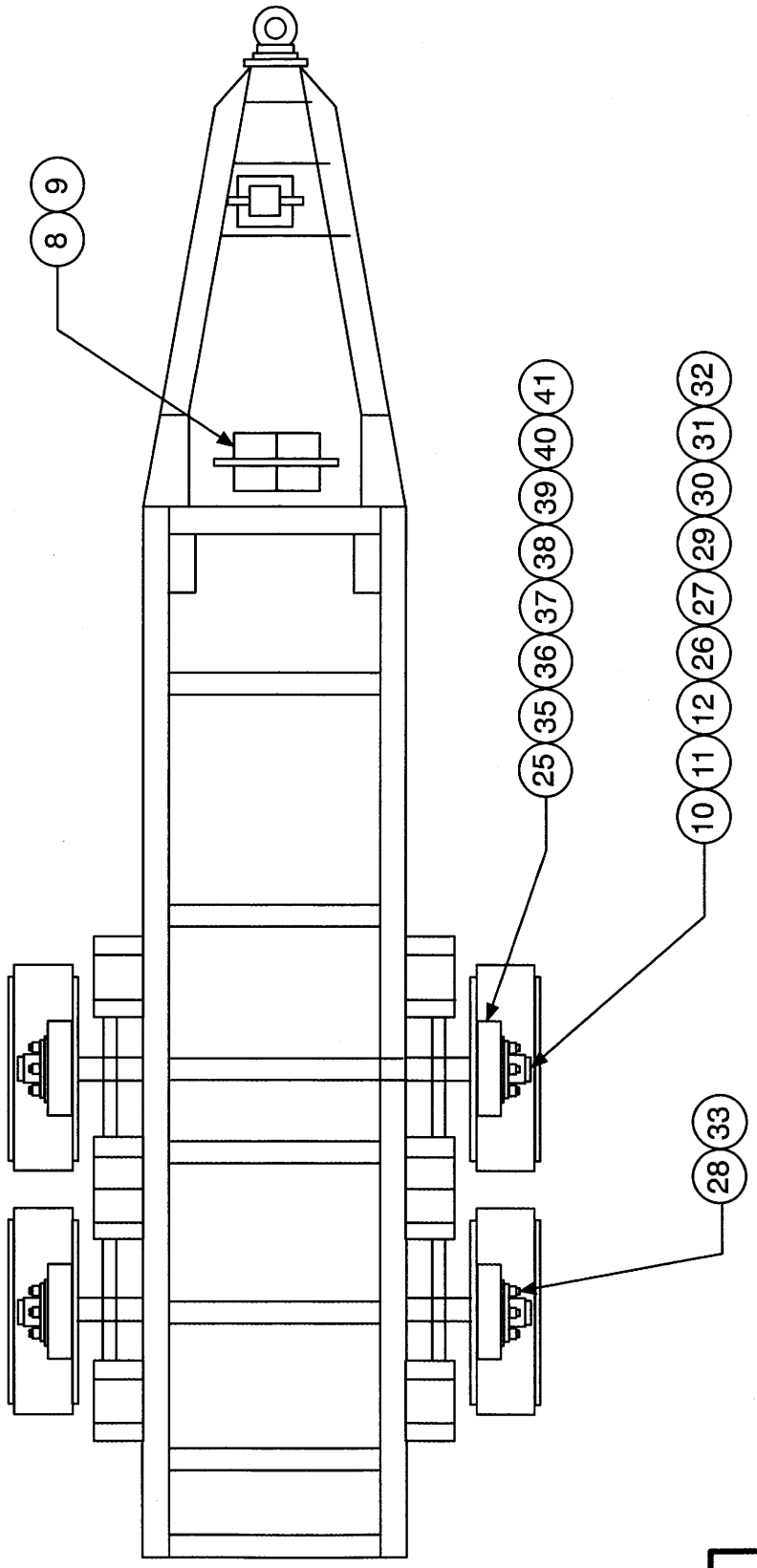
STOP,TAIL & TURN LIGHT OPTION
(AS VIEWED FROM REAR OF SOCKET)

LIST OF MATERIALS									
CKT	TERMINATION A	TYPE	SIZE	TERMINATION B	TYPE	SIZE	GAUGE	LENGTH	COLOR
1	RECEPTACLE 1	E		GROUND	A	1/4	14	46	WHT
2	RECEPTACLE 6	E		SPLICE 1	D		14	24	BRN
3	SPLICE 1			LH FRT CLEARANCE	B		14	95	BRN
4	LH FRT CLEAR W/CKT 3B			RH FRT CLEARANCE	B		14	89	BRN
5	SPLICE 1 W/CKT 3A			SPLICE 2	D		14	218	BRN
6	RECEPTACLE 3	E		RH TURN	G		14	342	YEL
7	RECEPTACLE 5	E		LH TURN	G		14	255	GRN
8									
9									
10	RH TURN/TAIL W/CKT 27B			RH REAR CLEAR BOT	B		14	22	BRN
11									
12	SPLICE 2			LH REAR CLEARANCE	B		14	19	BRN
13	LH REAR CLEAR W/CKT 12B			LH REAR TOP CLEAR	B		14	74	BRN
14	LH REAR TOP CLEAR W/CKT 13B			REAR ID W/CKT 15A	B		14	61	BRN
15	R ID W/CKT 14B			RH REAR TOP CLEAR	B		14	56	BRN
16	SPLICE 2 W/CKT 12A			LICENSE LAMP	B		14	31	BRN
17	SPLICE 2 W/CKT 12A			LH TURN/TAIL	G		14	13	BRN
18	RECEPTACLE 4	E		LH STOP LAMP	G		14	261	RED
19	LIGHT GRD W/CKT 24A			LIGHT GROUND			14	36	WHT
20	LEFT STOP LAMP W/CKT 18B			RIGHT STOP LAMP	G		14	99	RED
21	RECEPTACLE 7	E		ELECTRIC BRAKES			14	29	BLU
22	LEFT TURN GRD			LH ST/GRD W/CKT 23A	G		14	30	WHT
23	LEFT STOP GRD			RT ST/GRD W/CKT 24A	G		14	99	WHT
24	RIGHT STOP GRD			RH TURN GRD	G		14	30	WHT
25	LH TURN/TAIL W/CKT 17B			LEFT STOP/TAIL	G		14	30	BRN
26	LH STOP/TAIL W/CKT 25B			RIGHT STOP/TAIL	G		14	99	BRN
27	RH STOP/TAIL W/CKT 26B			RIGHT TURN/TAIL	G		14	30	BRN
28	RECEPTACLE 2	E		AUX	B		14	29	BLK

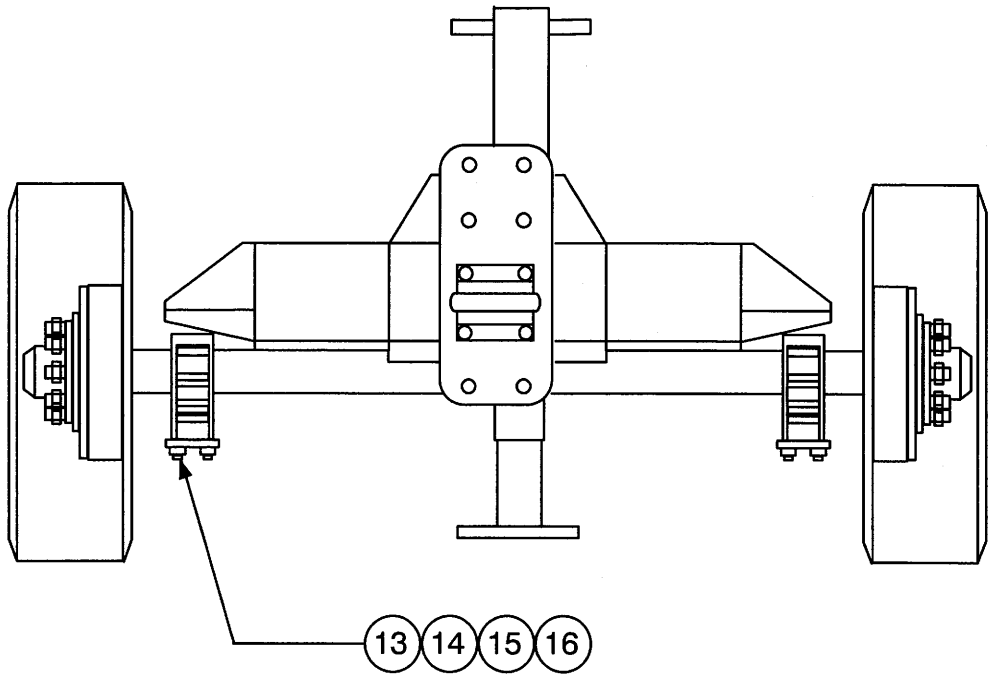
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 2-00 WAP	DESCRIPTION HIGH SPEED RUNNING GEAR	
MODEL NO. XHP650/900	MANUAL NO. 35393925-93	DATE/REV: 8-00/B

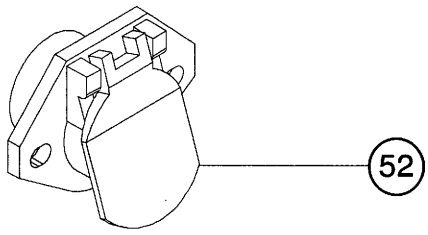


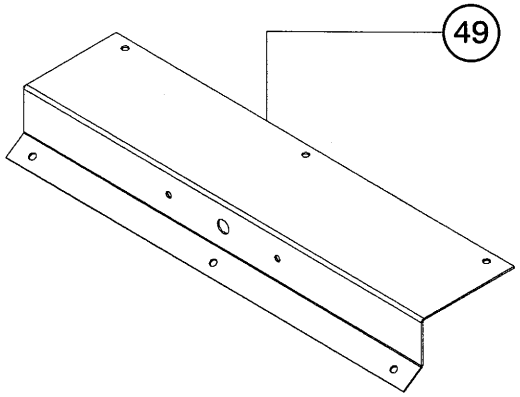
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION HIGH SPEED RUNNING GEAR	
MODEL NO. XHP650/900	MANUAL NO. 35393925-94	DATE/REV: 8-00/B

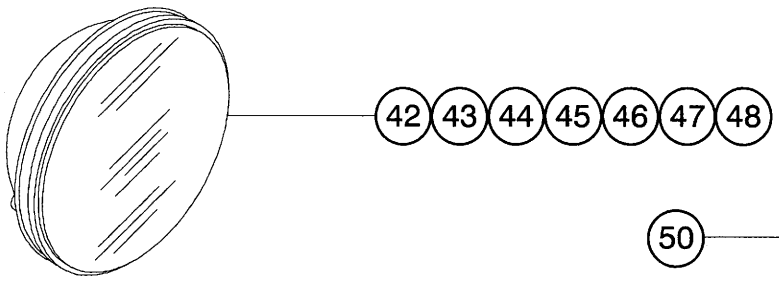


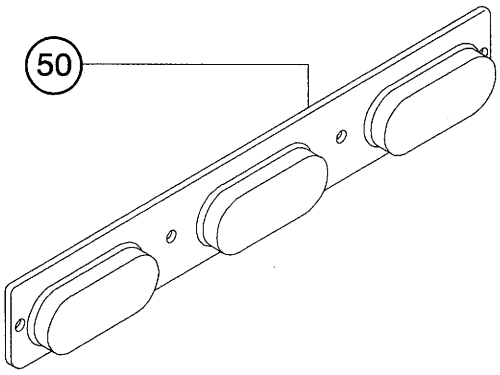
INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION HIGH SPEED RUNNING GEAR	
MODEL NO. XHP650/900	MANUAL NO. 35393925-95	DATE/REV: 8-00/B

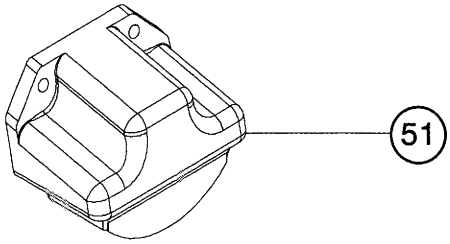












INGERSOLL-RAND COMPANY PORTABLE COMPRESSOR DIVISION		
DATE/DWN BY: 3-00 WAP	DESCRIPTION HIGH SPEED RUNNING GEAR	
MODEL NO. XHP650/900	MANUAL NO. 35393925-96	DATE/REV: 8-00/B

ITEM	QTY.	PART NO.	DESCRIPTION
1	1	36880128	EYE , LUNETTE
2	4	36880136	BOLT
3	4	95935011	FLATWASHER
4	4	95077608	LOCKNUT
5	1	36880144	DROPLEG JACK
6	4	36880151	BUMPER , RUBBER
7	8	35144336	SCREW
8	2	35603190	CHOCK , WHEEL
9	2	35333830	STRAP , RUBBER
10	4	36853091	NUT
11	2	36853109	WASHER
12	2	36853117	WASHER , LOCK
13	2	36880169	PLATE , U-BOLT
14	4	36880177	U-BOLT
15	8	36880185	NUT
16	8	95934741	WASHER , LOCK
17	2	36880193	HANGER , CENTER
18	2	36880201	HANGER , FRONT
19	2	36880219	BAR , EQUALIZER
20	8	36880227	BOLT , SHACKLE
21	8	35336700	NUT , LOCK
22	2	36880235	HANGER , REAR
23	2	36880243	BOLT , EQUALIZER
24	2	36880250	LOCKNUT
25	4	36880268	HUB ASSEMBLY
26	1	36851624	INNER BEARING CUP
27	1	36851616	BEARING , OUTER CUP
28	8	35372150	STUD
29	1	36851608	BEARING , INNER
30	1	36851590	BEARING , OUTER
31	1	36851590	SEAL
32	1	36776813	CAP , DUST
33	8	36880276	NUT , CONE
34	4	36880284	SPRING , LEAF
35	2	36880292	L.H. ELECTRIC BRAKE ASSY.
36	2	36880300	R.H. ELECTRIC BRAKE ASSY.
37	4	36880318	BOTTOM DUST SHIELD
38	4	36880326	TOP DUST SHIELD
39	7	36880334	BOLT , HEX
40	7	95939955	WASHER , LOCK
41	7	36880342	LOCKNUT
42	2	36788081	STOP,TURN AND TAIL LIGHT
43	6	36787968	GROMMET (USE ON 42 & 44)
44	4	36859320	STOP,TURN AND TAIL LIGHT
45	4	35367051	YELLOW LIGHT
46	2	36893642	GROMMET (USE ON 45)
47	2	36893634	GROMMET (USE ON 45)
48	4	35367044	RED CLEARANCE LIGHT
49	1	36896306	ID BRACKET
50	1	36922144	3 LIGHT ASSEMBLY
51	1	36895860	LICENSE PLATE LIGHT
52	1	36894129	7-WAY CONNECTOR
	1	36893774	LIGHT HARNESS

INGERSOLL-RAND COMPANY
PORTABLE COMPRESSOR DIVISION

DATE/DWN BY:	DESCRIPTION	
3-00 WAP	HIGH SPEED RUNNING GEAR	
MODEL NO.	MANUAL NO.	DATE/REV:
XHP650/900	35393925-97	8-00/B

SECTION 12

Caterpillar Engine Operation & Maintenance Manual

Bulletin # SEBU6328

Bulletin # SEBU6993

CATERPILLAR®

SEBU6993
January 1996

Operation & Maintenance Manual

3406C Industrial Diesel Engine

3ER1-UP

Table of Contents

Foreword

Literature Information

This manual contains information and instructions concerning engine safety, operation, lubrication, and maintenance. Read, study, and keep it available with other literature and engine information.

Some photographs or illustrations in this publication show details or attachments that may differ from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this publication.

Whenever a question arises regarding your engine, or this publication, please consult your Caterpillar dealer for the latest available information.

Safety

The safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance and/or repair on this product.

Operation

Engine operation outlined in this publication is basic. Engine operators gain knowledge of the engine through experience, developing operation skills and techniques which enhance efficient and economical engine operation.

The operation section is a reference for operators. Photographs and illustrations guide operators through correct procedures of inspecting, starting, operating and stopping the engine. Discussion of gauges and engine control information is included.

Maintenance

The maintenance section is a guide to engine care. The illustrated instructions are grouped by maintenance service intervals. The actual operating environment of the engine also governs the maintenance schedule. Under extremely severe, dusty, or frigid operating conditions, lubrication and maintenance checks more frequent than those specified in the Maintenance Schedule may be necessary.

Maintenance Intervals

Use the service hour meter to determine service intervals. Calendar intervals shown (daily, weekly, monthly, etc.) can be used instead of service hour meter intervals, if they provide more convenient servicing schedules and approximate the indicated service hour meter reading. Recommended service should always be performed at the interval that occurs first.

We recommend that the maintenance schedules be reproduced for ease of inspection. We also recommend that ongoing maintenance records be kept to document engine service.

See the Maintenance Records section of this publication for information regarding documents that are generally accepted as proof of maintenance or repair. Your Caterpillar dealer can assist you in tailoring your Maintenance Schedule to meet the needs of your operating environment.

Overhaul

Major engine repair details are not covered in this manual. Major repairs are best left to trained personnel or an authorized Caterpillar dealer.

If a major engine failure requiring removal of the engine occurs, numerous after-failure overhaul options available from your Caterpillar dealer. Contact your dealer for information regarding these options.

Engine Storage

For general information, refer to the Engine Lifting & Storage topic. For complete engine storage information refer to Special Instruction SEHS9031, Storage Procedure for Caterpillar Products.

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.

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Safety

Warning Signs and Labels

There may be several specific warning signs on your engine. Please familiarize yourself with all warning signs.

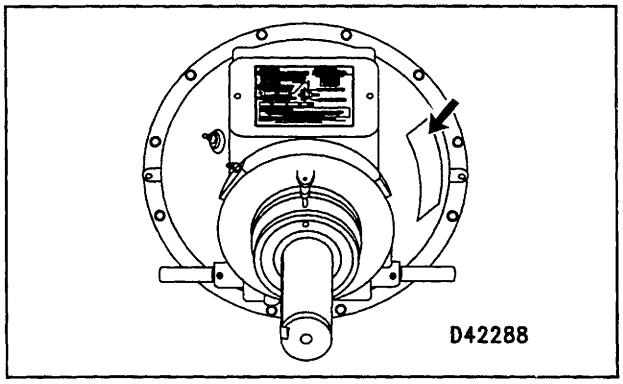
Make sure that you can read all warning signs. Clean or replace warning signs if you cannot read the words or see the pictures. When cleaning the labels use a cloth, water and soap. Do not use solvents, gasoline, etc., to clean warning signs. The use of solvents, gasoline, etc., could loosen the sign's adhesive and cause the sign to fall off.

You must replace a warning sign if it is damaged, missing or cannot be read. If a warning sign is attached to a part, and that part is replaced, make sure a new warning sign is installed on the replaced part. See your Caterpillar dealer for new warning signs.

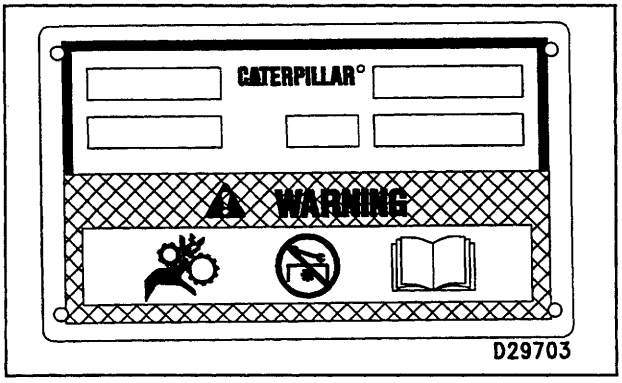
Do not operate or work on the engine unless you have read and understand the instructions and warnings in this Manual. Proper care is your responsibility. Failure to follow the instructions or heed the warnings could result in injury or death.

⚠ WARNING

Rotating gears– finger or hand entanglement. Do not service until reading the operator's manual.



The clutch warning sign is located on the clutch housing (if equipped).



Clutch warning sign.

Located near batteries (if equipped):

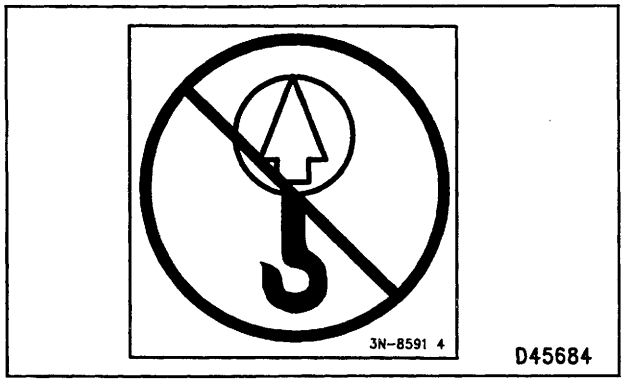
⚠ WARNING

Improper jumper cable connections can cause an explosion resulting in personal injury.
Batteries may be located in separate compartments. When using jumper cables, always connect positive (+) cable to positive (+) terminal of battery connected to starter solenoid and negative (-) cable from external source to starter negative (-) terminal (if machine not equipped with starter negative terminal, connect to engine block.) Follow procedure in the operation manual.

Located on engine lifting eye cover assembly:

⚠ WARNING

Do not use the engine lifting eyes to remove the engine and base together.

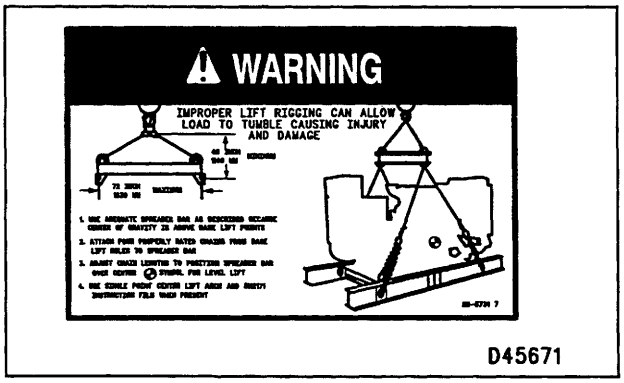


Cover assembly warning sign.

Located on the mounting base (if equipped) near the lifting holes:

⚠ WARNING

Improper lift rigging can allow load to tumble causing injury and damage.
1. Use adequate spreader bar as described because center of gravity is above base lift points.
2. Attach four properly rated chains from base lift holes to spreader bar.
3. Adjust chain lengths to position spreader bar over center symbol for level lift.
4. Use single point center lift arch and 5N2171 Instruction Film when present.



Base lifting warning sign.

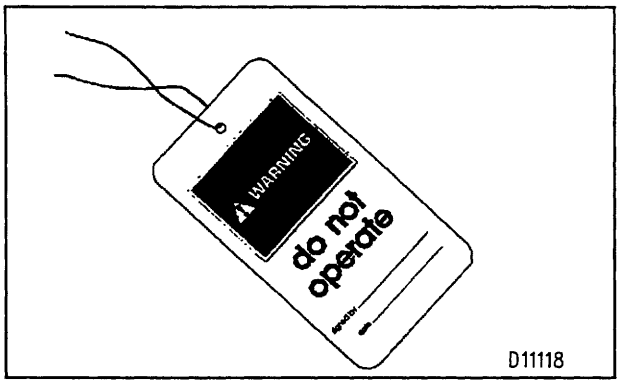
Located on the fuel tank (if equipped):

⚠ WARNING

Drain fuel tank before lifting unit. Lifting this unit when fuel is present in the tank could result in separation of the tank from the base and cause personal injury or death.

General Hazard Information

Attach a **DO NOT OPERATE** or similar warning tag to the start switch or controls before performing maintenance or repairing the engine. These tags, SEHS7332, are available from your Caterpillar dealer. When appropriate, attach the tags at the engine and at each operator's position. Disconnect starting controls when appropriate.



Do not allow unauthorized personnel on, around or in the engine unit when it is being serviced.

Diesel engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Use caution when removing filler cap, grease fittings, pressure taps, breathers or drain plugs. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure.

- Wear a hard hat, protective glasses, hearing protection and other protective equipment as required by job conditions.
- Do not wear loose clothing or jewelry that can catch on controls or other parts of the engine.
- Make certain all protective guards and covers are secured in place.
- Use all cleaning solutions with care.
- Never put maintenance fluids into glass containers since glass containers can break.
- Report all needed repairs.

UNLESS INSTRUCTED DIFFERENTLY, PERFORM ALL MAINTENANCE AS FOLLOWS:

- Stop the engine.
- Ensure the protective locks or controls are in the applied position.
- Disconnect the batteries whenever performing any maintenance or before servicing the electrical system. If the engine has electric starters, disconnect and tape the battery ground leads to prevent accidental starting.
- Do not attempt any repairs or adjustments to the engine or driven equipment while it is running.
- Do not attempt repairs you do not understand. Use proper tools; replace or repair broken or damaged equipment.
- Apply the parking brakes (if equipped).
- Block or restrain the vehicle or machine, if applicable before operating or performing maintenance.
- When starting an engine after repairs have been made to the fuel system or governor, make provisions for shutting off the engine's intake air supply (to stop the engine), in case there is an overspeed on start-up.
- Start the engine only from the operator's station. Never short across the starter terminals or the batteries as this could bypass the engine neutral-start system as well as damage the electrical system.

Pressure Air and Water

Pressure air can cause personal injury. When using pressure air for cleaning, wear a protective face shield, protective clothing and protective shoes.

The maximum air pressure must be below 205 kPa (30 psi) and maximum water pressure must be below 275 kPa (40 psi) for cleaning purposes.

Wear eye protection at all times when cleaning the cooling system. Pressurized water could cause debris and/or hot water to be blown and result in personal injury.

Fluid Penetration

Always use a board or cardboard when checking for a leak. Escaping fluid under pressure, even a pin-hole size leak, can penetrate body tissue, causing serious injury or possible death.

If fluid is injected into your skin, it must be treated by a doctor familiar with this type of injury immediately.

Asbestos Information

This Caterpillar product and replacement parts shipped from the factory are asbestos free. Caterpillar recommends the use of only genuine Caterpillar replacement parts. If any replacement parts containing asbestos fibers are used, the following guidelines should be used in handling these parts and asbestos debris.

Asbestos used in components is usually bound in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust which contains asbestos is not generated.

Caution should be used to avoid breathing dust that may be generated when handling components containing asbestos fibers. If this dust is inhaled, it can be hazardous to your health.

If dust, which may contain asbestos is present, there are several common sense guidelines that should be followed.

- Never use compressed air for cleaning.
- Avoid brushing or grinding of asbestos containing materials.
- For clean up, use wet methods or a vacuum equipped with a high efficiency particulate air (HEPA) filter.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. (For example in the U.S.A., OSHA requirements as set forth in 29 CFR 1910.1001).
- Follow environmental rules and regulations for disposal of asbestos.
- Avoid areas where airborne asbestos particles may be present.

Lines, Tubes and Hoses

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses.

Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires.

Inspect all lines, tubes and hoses carefully. Do not use your bare hands to check for leaks. Tighten all connections to the recommended torque.

Check for the following:

- End fittings damaged, leaking or displaced.
- Outer covering chafed or cut and wire reinforcing exposed.
- Outer covering ballooning locally.
- Evidence of kinking or crushing of the flexible part of the hose.
- Armoring embedded in the outer cover.

Make sure that all clamps, guards and heat shields are installed correctly to prevent vibration, rubbing against other parts and excessive heat during operation.

Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any repair or maintenance is performed on the engine.

Relieve all pressure in air, oil, fuel or cooling systems before any lines, fittings or related items are disconnected or removed.

Coolant

Use caution when removing filler cap, grease fittings, pressure taps, breathers or drain plugs. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure.

To prevent personal injury, do not step up on engine to remove the filler cap, if applicable. Use an adequate ladder.

At operating temperature, the engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot water. When pressure is relieved rapidly, this hot water can turn into steam.

Allow cooling system components to cool before draining. Any contact with hot water or steam can cause severe burns.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to remove with your bare hand.

Remove the cooling system filler cap slowly to relieve pressure.

Cooling system additive (conditioner) contains alkali. To prevent personal injury, avoid contact with the skin and eyes and do not drink.

Oils

Hot oil and components can cause personal injury. Do not allow hot oil or components to contact the skin.

Keep all exhaust manifold and turbocharger shields in place to protect hot exhaust from oil spray in the event of a line, tube or seal failure.

Batteries

Battery electrolyte contains acid and can cause injury. Avoid contact with the skin and eyes.

Wash hands after touching batteries and connectors. Use of gloves is recommended.

Batteries give off flammable fumes which can explode. Ensure there is proper ventilation for batteries which are located in an enclosure.

Always thaw a frozen battery before jump starting. Frozen batteries can explode.

Do not smoke when observing the battery electrolyte levels.

Always wear protective glasses when working with batteries.

Never disconnect any charging unit circuit or battery circuit cable from the battery when charging unit is operating. A spark can cause the flammable vapor mixture of hydrogen and oxygen to explode.

Fire or Explosion Prevention

Fire may result from lubricating oil or fuel sprayed on hot surfaces causing personal injury and property damage. Inspect all lines and tubes for wear or deterioration. They must be routed, supported or clamped securely. Tighten all connections to the recommended torque. Leaks can cause fires.

Determine whether the engine will be operated in an environment in which combustible gases could be drawn through the air inlet system. These gases could cause the engine to overspeed, which in turn could seriously damage the engine and result in bodily injury or property damage.

If your application involves the presence of combustible gases, consult your Caterpillar dealer to obtain additional information concerning protection devices (i.e. air inlet shutoff) suitable for the application involved.

All fuels, most lubricants and some coolant mixtures are flammable.

Diesel fuel is flammable. Gasoline is flammable. The mixture of diesel and gasoline fumes are extremely explosive.

Do not smoke while refueling or in a refueling area.

Do not smoke in areas where batteries are charged, or where flammable materials are stored.

Batteries give off flammable fumes which can explode.

Keep all fuels and lubricants stored in properly marked containers and away from all unauthorized persons.

Store all oily rags or other flammable material in a protective container, in a safe place.

Do not weld or flame cut on pipes or tubes that contain flammable fluids. Clean them thoroughly with nonflammable solvent before welding or flame cutting on them.

Remove all flammable materials such as fuel, oil and other debris before they accumulate on the engine.

Do not expose the engine to flames, burning brush, etc., if at all possible.

Shields (if equipped), which protect hot exhaust components from oil or fuel spray in the event of a line, tube or seal failure, must be installed correctly.

Provide adequate and proper waste oil disposal. Oil and fuel filters must be properly installed and housing covers tightened to proper torque when being changed.

Batteries must be kept clean, covers kept on all cells, recommended cables and connections used and battery box covers kept in place when operating.

When starting from an external source, always connect the positive (+) jumper cable to the POSITIVE (+) terminal of the battery of the engine to be started.

To prevent potential sparks from igniting combustible gases produced by some batteries, attach the negative (–) boost ground cable last, to the starter NEGATIVE (–) terminal (if equipped) or to the engine block. See the Operation Section of this manual for specific starting instructions.

Clean and tighten all electrical connections. Check regularly for loose or frayed electrical wires. Refer to maintenance schedules for interval. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the engine.

Wiring must be kept in good condition, properly routed and firmly attached. Routinely inspect wiring for wear or deterioration. Loose, unattached, or unnecessary wiring must be eliminated. All wires and cables must be of the recommended gauge and fused if necessary. Do not use smaller gauge wire or bypass fuses. Tight connections, recommended wiring and cables properly cared for will help prevent arcing or sparking which could cause a fire.

Fire Extinguisher

Have a fire extinguisher available and know how to use it. Inspect and have it serviced as recommended on its instruction plate.

Crushing or Cutting Prevention

Support equipment and attachments properly when working beneath them.

Never attempt adjustments while the engine is running unless otherwise specified in this manual.

Stay clear of all rotating and moving parts. Guards should be in place whenever maintenance is not being performed.

Keep objects away from moving fan blades. They will throw or cut any object or tool that falls or is pushed into them.

Wear protective glasses when striking objects to avoid injury to your eyes.

Chips or other debris can fly off objects when struck. Make sure no one can be injured by flying debris before striking any object.

Mounting and Dismounting

Do not climb on, or jump off the engine or stand on components which cannot support your weight. Use an adequate ladder. Always use steps and handholds when mounting and dismounting.

Clean steps, handholds and areas of the engine you will be working on or around.

Enclosure Doors

Strong winds may lift the enclosure doors off their hinge pins.

If strong winds threaten to lift the enclosure doors, the doors should be removed from their hinges to prevent damage.

Before Starting the Engine

Inspect engine for potential hazards.

Be sure all protective guards and covers are installed if an engine must be started to make adjustments or checks. To help prevent an accident caused by parts in rotation, work carefully around them.

Do not disable or bypass automatic shutoff circuits. They are provided to prevent personal injury and engine damage.

Never start an engine with the governor linkage disconnected.

Make provisions for shutting off the air or fuel supply to stop the engine if there is an overspeed on start-up after performing repair or maintenance to the engine.

See the Maintenance section of this manual for adjustment, or the Service Manual for repairs.

Engine Starting

DO NOT start the engine or move any of the controls if there is a warning tag attached to the controls. Check with the person who attached the tag before starting.

Make sure no one is working on, or close to the engine or engine driven components before starting it. Always make an inspection of the engine before and after starting.

Start the engine only from the operator's station. Never short across the starter terminals or the batteries as this could bypass the engine neutral-start system as well as damage the electrical system.

Always start the engine according to the required Engine Starting procedure described in this manual to prevent major engine component damage and personal injury.

Check the jacket water and oil temperature gauges frequently during the operation of jacket water and/or lube oil heaters to ensure proper operation.

Diesel engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well-ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Starting Aids (if Used)

Ether and other starting aids are poisonous and flammable. Do not smoke while changing ether cylinders.

Use ether only in well ventilated areas.

Keep ether cylinders out of the reach of unauthorized persons.

Do not store replacement ether cylinders in living areas or in the engine compartment or cab (if equipped).

Do not store ether cylinders in direct sunlight or at temperatures above 39°C (102°F). Discard cylinders in a safe place. Do not puncture or burn cylinders.

Engine Stopping

Stop the engine according to the Engine Stopping instructions in the Operation Section to avoid overheating and accelerated wear of the engine components.

Only use the Emergency Stop button in an emergency situation. DO NOT start the engine until the problem necessitating the emergency stop has been located and corrected.

On initial startup or overhaul, be prepared to STOP the engine should an overspeed condition occur. This may be accomplished by cutting the fuel and air supply to the engine.

Customer Service

North America Only
When a problem arises concerning the sale, operation or service of your engine, it will normally be handled by the dealer in your area. The service facility nearest you can be located twenty-four hours a day by calling the phone number below.

In U.S. and Canada: 1 (800) 447-4986.

Your satisfaction is a primary concern to Caterpillar and its dealers. If you have a problem that has not been handled to your complete satisfaction, we suggest the steps that follow.

Step One
Discuss your problem with a member of management from the dealership.

Step Two
When it appears that your problem cannot be readily resolved at the dealer level without additional assistance, use the above telephone numbers and ask to talk to a Field Service Coordinator. Regular Monday through Friday business hours are from 8:00 a.m. to 4:30 p.m. Central Standard Time (CST).

Step Three
If you are still not satisfied, present the engine matter in writing to: Caterpillar Inc.
Manager, Customer Service, Engine Division
Mossville Bldg. A
P.O. Box 600
Peoria, Illinois 61552-0600

When contacting the Manager, Customer Service, please keep in mind that ultimately your problem will likely be resolved at the dealership, using their facilities, equipment, and personnel. Therefore, it is suggested that you follow the above steps in sequence when experiencing a problem.

Outside North America
If a problem arises outside North America, and cannot be resolved at the dealer level, contact the appropriate Caterpillar subsidiary office.

Central/South America (except Brazil)
Caterpillar Americas Co.
100 NE Adams Street
Peoria, Illinois 61629 U.S.A.
Phone: 309-675-5876
Fax: 309-675-5384

Brazil
Caterpillar Americas Co.
Edificio Brasil Interpart
Rua Guararapes, 2064 5.0 andar, cj.2
04561-004 - Sao Paulo-SP-Brazil
01.000-Sao Paulo-SP-Brazil
Phone: 011-536-3388
Fax: 011-505-1647

Far East (except Japan and Australia)
Caterpillar Far East Limited
28th Floor, Sun Hung Kai Centre
30 Harbour Road
G.P.O. Box 3069
Wanchai, Hong Kong
Cable Address: CATFAREAST HKG
Telex No.: HX73305 CFEL
Phone: 5-8326333

Australia and New Zealand
Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Telex: AA30240
Cable: CATERPILLAR MELB
Phone: (03) 339-9333
Fax: (03) 335-3366

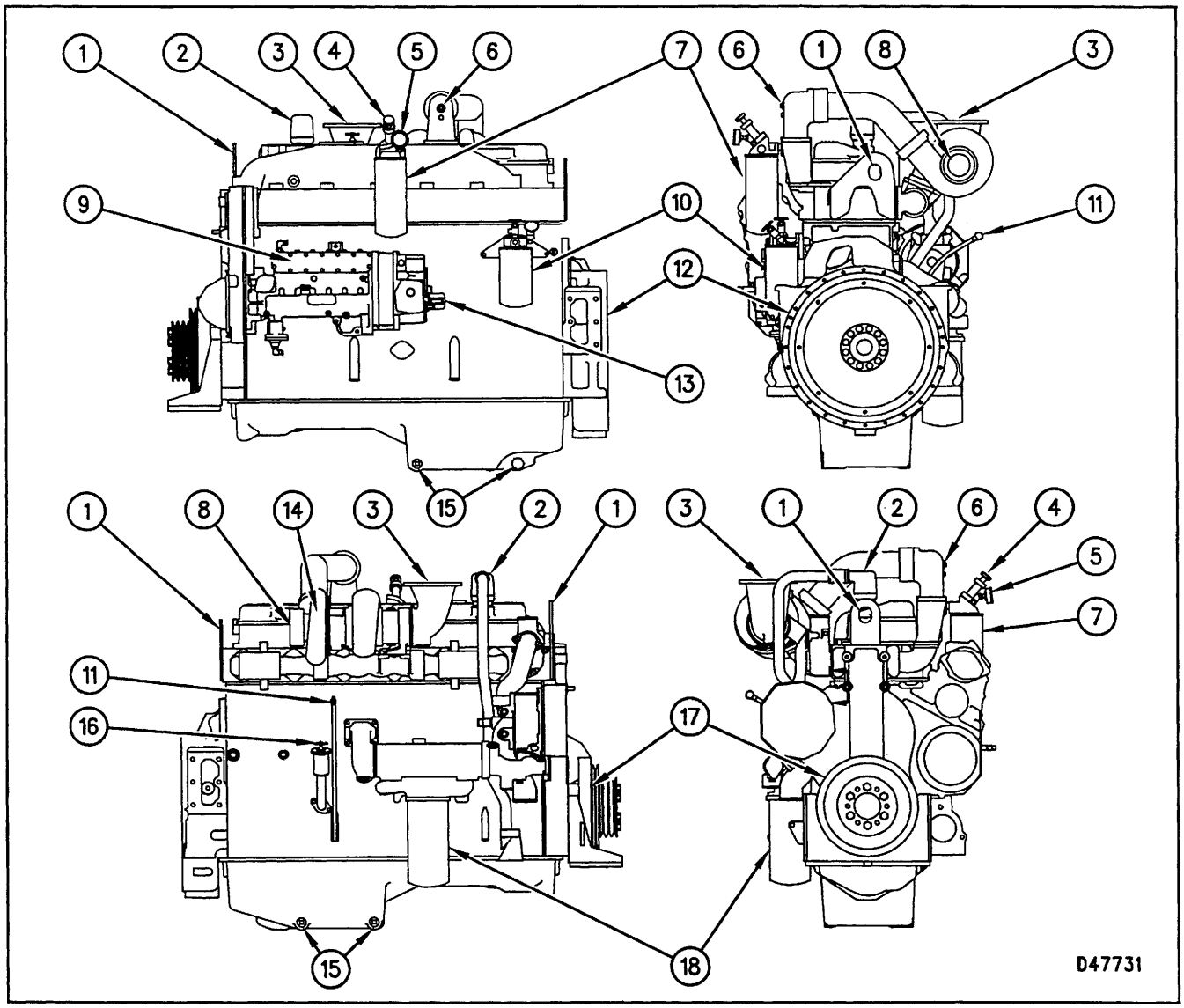
Japan
Caterpillar Mitsubishi Ltd.
3700, Tana, Sagamihara-shi
Kanagawa-ken, 229
Japan
Telex No.: 2872-261CM HAJ
Cable Address: CATERBISHICO SAGAMIHARA
Phone: Sagamihara (0427) 62-1121
Fax: (0427) 62-8542

Europe, Africa, and Middle East
Caterpillar Overseas S.A./Power Systems
YA50 76, Route de Frontenex
P.O. Box 456
1211 Geneva 6
Switzerland
Cable Address: CATOVERSEA
Telex No.: 413323
Phone: (022) 849-4444
Telecopier: (022) 849-4984
Fax: (022) 849-4544

Model Views and Engine Information

Model Views

The sample model view drawings show various typical Caterpillar 3406C Engine features. The drawings are generic and do not reflect all available options. Because of individual applications, your engine may appear different from those illustrated.



Model Views: Lifting Eye (1), Crankcase Breather (2), Exhaust (3), Fuel Priming Pump (4), Fuel Pressure Gauge (5), Ether Starting Aid (if equipped, 6), Fuel Filter (7), Air Inlet (8), Fuel Pump (9), SCA Element (if equipped, 10), Oil Level Gauge (Dipstick, 11), Flywheel Housing (12), Service Hour Meter (13), Turbocharger (14), Oil Drain Plugs (15), Oil Filler Cap (16), Crankshaft Vibration Damper (17), and Oil Filter (18).

Engine Information

Engine Specifications

ENGINE SPECIFICATIONS	
Specification	**3406C Engine**
Cylinders	6 In-line
Bore	137mm (5.4 in)
Stroke	165mm (6.5 in)
Aspiration	T or TA[1]
Displacement	14.6L (893 cu in)
Firing Order	1-5-3-6-2-4
Rotation[2]	Counterclockwise

[1] Turbocharger or Turbocharged and Aftercooled
[2] Viewed from the flywheel.

Engine Descriptions

The engine described in this publication is the 3406C Industrial Diesel Engine. This engine is designed primarily for agricultural, petroleum, and auxiliary industrial applications.

A mechanical governor controls the fuel injection pump output, maintaining the engine rpm selected by the operator. Individual injection pumps (one for each cylinder) meter and pump fuel under high pressure to injection nozzles. Automatic timing advance provides the best fuel injection timing over the full range of engine speed.

The fuel ratio control is located on the governor. The fuel ratio control restricts the fuel rack movement. Only the proper amount of fuel is allowed to be injected into the cylinders during acceleration. This minimizes exhaust smoke.

Inlet air is filtered by an air cleaner. The air is compressed by a turbocharger before the air enters the engine cylinders. The turbocharger is driven by engine exhaust. The engines can have a single or twin turbocharger. The engines can be turbocharged, or turbocharged with jacket water aftercooling.

This engine is a four cycle engine. Each cylinder head has two inlet valves and two exhaust valves. The rocker arms and the valves are actuated by the camshaft. The action is performed by mechanical lifters and push rods.

The cooling system consists of:
- a thermostats to regulate water temperature.
- a gear driven centrifugal pump.
- an oil cooler, and
- a radiator or expansion tank (incorporating a shunt system).

The engine lubricating oil, which is both cooled and filtered, is supplied by a gear-type pump. Bypass valves provide unrestricted flow of lubrication oil to the engine parts if oil viscosity is high, or if the oil cooler or the oil filter elements become plugged.

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to proper operation and maintenance recommendations. Engine performance and efficiency also depend on the use of recommended coolant/antifreeze, fuels, and lubrication oils. Follow the recommended Maintenance Schedule found in this publication, paying attention to emission related components, air cleaner, oil, oil filter, fuel and fuel filter maintenance.

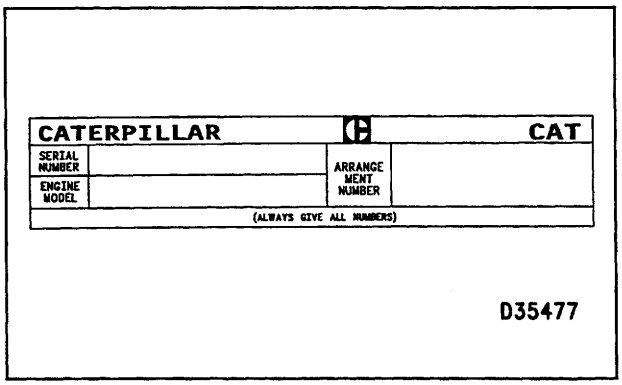
Engine Identification

Caterpillar engines are identified with serial numbers, fuel system setting numbers, and arrangement numbers. In some cases, modification numbers are used. These numbers are shown on the serial number plate mounted on the engine.

Caterpillar dealers need all of these numbers to determine which components were included on the engine when it was assembled at the factory. This permits accurate identification of replacement part numbers.

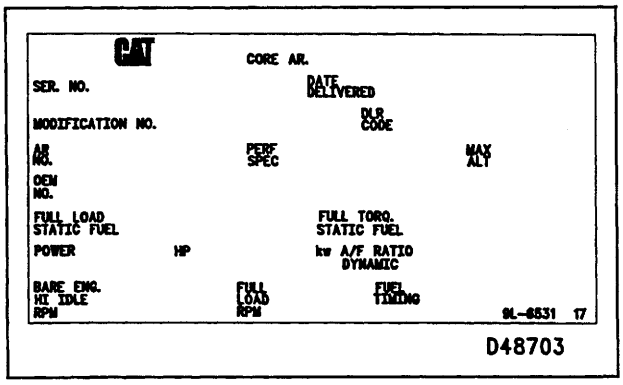
Quality Caterpillar replacement parts are available from Caterpillar dealers throughout North America and the world. Their parts stocks are up to date and include all parts normally required to protect your Caterpillar engine investment.

Serial Number Plate



The Serial Number Plate is located on the left side of the cylinder block. The engine serial number, model, and arrangement number are stamped on the Serial Number Plate.

Information Plate



The Information Plate is located on the right side rear valve cover. The engine's maximum altitude, horsepower, high idle, full load rpm, and other information is stamped on the Information Plate.

Reference Numbers

Fill in the blanks for future reference.

Engine Model_____

Engine Serial No._____

Engine Arrangement No._____

Engine Power_____

Engine Low Idle rpm_____

Engine Full Load rpm_____

Performance Specification No._____

Governor Group No._____

Fuel Filter Element No._____

Lubrication Oil Filter Element No._____

Auxiliary Oil Filter Element No._____

Lubrication Oil System Capacity_____

Supplemental Coolant Additive
Maintenance Element No._____

Supplemental Coolant Additive
Precharge Element (Optional) No._____

Cooling System Capacity_____

Air Cleaner Element No._____

Fan Drive Belt Set No._____

Alternator Belt No._____

Ordering Parts

When ordering parts, your order should specify the quantity, part number, part name and serial number, arrangement number and modification number of the engine for which the parts are needed. If in doubt about the part number, please provide your dealer with a complete description of the needed item.

When service or maintenance is needed for your Caterpillar engine, be prepared to give the dealer all the information that is provided on the Information Plate.

Discuss the problem with the dealer, such as when it occurs, what happens, etc. This will help the dealer in troubleshooting and solving the problem faster.

Engine Ratings

Industrial Rating Definitions

NOTE: The application examples are listed for reference only. Refer to the specific application information and guidelines within the Technical Marketing Information for exact rating determination.

A Rating (Continuous)

- For heavy-duty service when engine is operated at rated load and speed up to 100 percent of the time without interruption or load cycling.
- Time at full load up to 100 percent of the duty cycle.
- Typical examples are: pipeline pumping, ventilation, and customer specifications.

B Rating

- For service where power and/or speed are cyclic.
- Time at full load not to exceed 80 percent of the duty cycle.
- Typical examples are: irrigation where normal pump demand is 85 percent of the duty cycle, oil field mechanical pumping and drilling, and stationary/plant air compressors.

C Rating (Intermittent)

- For service where power and/or speed are cyclic.
- The horsepower and speed capability of the engine can be used for one uninterrupted hour, followed by one hour of operation at or below the A rating.
- Time at full load not to exceed 50 percent of the duty cycle.
- Typical examples are: agricultural tractors, harvesters and combines, off-highway trucks, fire pump application power, blast hole drills, rock crushers and wood chippers with high torque rise, and oil field hoisting.

D Rating

- For service when rated power is required for periodic overloads.
- The maximum horsepower and speed capability of the engine can be used for a maximum of 30 uninterrupted minutes, followed by one hour of followed by one hour of C rating operation.
- Time at full load not to exceed 10 percent of the duty cycle.
- Typical examples are: offshore cranes, runway snow blowers, water well drills, portable air compressors, and fire pump certification power.

E Rating

- For service where rated power is required for a short time for initial starting or sudden overload. For emergency service where standard power is unavailable.
- The maximum horsepower and speed capability of the engine can be utilized for a maximum of 15 uninterrupted minutes, followed by one hour at C rating operation, or for the duration of the emergency.
- Time at full load is not to exceed 5 percent of the duty cycle.
- Typical examples are: standby centrifugal water pumps, oil field well servicing, crash trucks, and gas turbine starters.

Rating Conditions

Unless otherwise specified, all ratings are based on SAE J1349 standard ambient conditions:
- 100 kPa (29.6 inches of Hg) of pressure
- 30 percent relative humidity, and
- a temperature of 26°C (77°F).

Ratings also apply at AS1501, BS5514, DIN6271, and ISO3046/1 standard conditions.

Power for diesel engines is based on:
- API gravity of 35 at 15°C (60°F),
- fuel LHV of 42.780 kJ/g (18390 Btu/lb) at 29°C (84°F), and
- fuel density of 838.9 g/L (7.0001 lb/US gal)

Ratings are gross output ratings– the total output capability of the engine equipped with standard accessories. Standard accessories include pumps for lubrication oil, fuel, and jacket water, and magneto as required. The gross output, minus the power required to drive auxiliary components, equals the net power available for the external (flywheel) load. Typical auxiliary components include cooling fans, air compressors, and charging alternators.

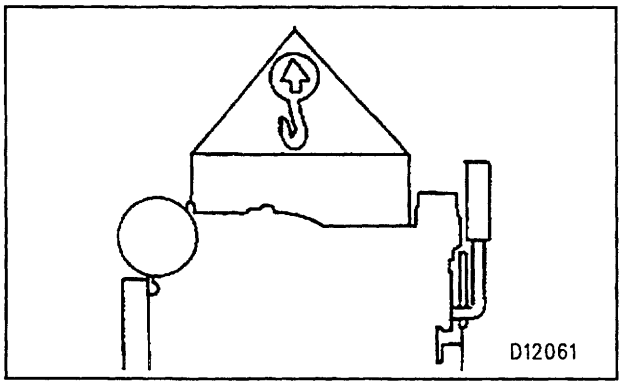
Ratings must be reduced to compensate for altitude conditions, according to the applicable engine test specification derating data at normal ambient temperature.

NOTICE

Operating units above the rating definitions will result in shorter service life before overhaul.

Engine Lifting and Storage

Engine Lifting



NOTICE

When it is necessary to remove a component on an angle, remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees. Eye Bolts and brackets should never be bent, and should only be loaded under tension.

Use a hoist to remove heavy components. Use an adjustable lifting beam to lift the engine. All supporting members (chains and cables) should be parallel to each other, and perpendicular as possible to the top of the object being lifted.

Some removals require the use of lifting fixtures, to obtain proper balance and provide safe handling.

To remove the engine ONLY, use the lifting eyes equipped with the engine.

The lifting eyes are designed for the engine arrangement as sold. Modifying the lifting eyes and/or engine arrangement weight renders the lifting eyes and devices obsolete.

If you modify the lifting eyes and/or engine arrangement weight, you are responsible for providing adequate lifting devices. Contact your Caterpillar dealer for information regarding fixtures for proper engine package lifting.

Engine Lifting With Fuel Tank

Lifting the engine along with a mounted fuel tank requires special equipment and procedures. Do not lift the unit with fuel in the tank. Contact your Caterpillar dealer for information regarding proper engine and fuel tank lifting.

Engine Storage

The following Engine Storage procedures and recommendations minimize the possibility of damage to engines stored for one year or less.

When an engine is not started for several weeks, the lubricating oil drains from the cylinder walls and piston rings. Rust can then form on the cylinder liner surface, increasing engine wear and decreasing engine life.

Special precautions should be used with engines remaining out of service for extended periods.

After one year, a complete protection procedure must be followed if the engine is kept in storage longer.

To prevent excessive engine wear:

- Be sure all lubrication recommendations mentioned in the Maintenance Schedule intervals chart are completed.
- If freezing temperatures are expected, check the cooling system for adequate protection against freezing. A 50/50 solution of Caterpillar (permanent-type) Antifreeze and approved water will give protection to –29°C (–20°F).

If it will be impossible to start the engine periodically, consult your Caterpillar dealer for instructions to prepare your engine for longer storage periods.

Refer to Storage Procedures For Caterpillar Products, SEHS9031, for more detailed information on engine storage.

Torque Specifications

Torque for Standard Bolts, Nuts and Taperlock Studs

NOTICE

The following charts give general torques for bolts, nuts, and taperlock studs. For torque specifications not included in this section, refer to Torque Specifications, SENR3130, available from your Caterpillar dealer.

Torques for Bolts and Nuts With Standard Threads

Thread Size Inch	Standard Bolt & Nut Torque	
	N•m[1]	lb ft
1/4	12 ± 3	9 ± 2
5/16	25 ± 6	18 ± 4.5
3/8	47 ± 9	35 ± 7
7/16	70 ± 15	50 ± 11
1/2	105 ± 20	75 ± 15
9/16	160 ± 30	120 ± 20
5/8	215 ± 40	160 ± 30
3/4	370 ± 50	275 ± 37
7/8	620 ± 80	460 ± 60
1	900 ± 100	660 ± 75
1 1/8	1300 ± 150	950 ± 100
1 1/4	1800 ± 200	1325 ± 150
1 3/8	2400 ± 300	1800 ± 225
1 1/2	3100 ± 350	2300 ± 250

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

Torques for Taperlock Studs

Thread Size Inch	Standard Taperlock Stud Torque	
	N•m[1]	lb ft
1/4	8 ± 3	6 ± 2
5/16	17 ± 5	13 ± 4
3/8	35 ± 5	26 ± 4
7/16	45 ± 10	33 ± 7
1/2	65 ± 10	48 ± 7
5/8	110 ± 20	80 ± 15
3/4	170 ± 30	125 ± 22
7/8	260 ± 40	190 ± 30
1	400 ± 60	300 ± 45
1 1/8	525 ± 60	390 ± 45
1 1/4	750 ± 80	550 ± 60
1 3/8	950 ± 125	700 ± 92
1 1/2	1200 ± 150	890 ± 110

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

NOTE: Use these standard torque values for all fasteners, unless otherwise specified in this manual or in the Service Manual.

Torque for Metric Fasteners

NOTICE

Be very careful never to mix metric with customary (SAE standard) fasteners. Mismatched or incorrect fasteners will cause engine damage or malfunction and may even result in personal injury.

Original fasteners removed from the engine should be saved for reassembly whenever possible. If new fasteners are needed, they must be of the same size and grade as the ones that are being replaced.

Material strength identification is usually shown on the bolt head by numbers (8.8, 10.9, etc.). The following chart gives general torque values for bolts and nuts. Use these standard torque values unless otherwise specified in this publication.

NOTE: Metric hardware must be replaced with metric hardware. Check Parts Manual for proper replacement.

Torques for Bolts and Nuts with Metric Threads

METRIC ISO[2] THREAD		
Thread Size Metric	Standard Torque	
	N•m[1]	lb ft
M6	12 ± 3	9 ± 2
M8	28 ± 7	20 ± 5
M10	55 ± 10	40 ± 7
M12	100 ± 20	75 ± 15
M14	160 ± 30	120 ± 20
M16	240 ± 40	175 ± 30
M20	460 ± 60	340 ± 40
M24	800 ± 100	600 ± 75
M30	1600 ± 200	1200 ± 150
M36	2700 ± 300	2000 ± 225

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.
[2] ISO–International Standard Organization.

Torque for Standard Hose Clamps–Worm Drive Band Type

NOTE: The following chart gives the torques for initial installation of hose clamps on new hose and for reassembly or tightening of hose clamps on existing hose.

	Initial Installation Torque on New Hose	
Clamp Width	N•m[1]	lb in
16 mm (.625 in)	7.5 ± 0.5	65 ± 5
13.5 mm (.531 in)	4.5 ± 0.5	40 ± 5
8 mm (.312 in)	0.9 ± 0.2	8 ± 2
	Reassembly or Retightening Torque	
Clamp Width	N•m[1]	lb in
16 mm (.625 in)	4.5 ± 0.5	40 ± 5
13.5 mm (.531 in)	3.0 ± 0.5	25 ± 5
8 mm (.312 in)	0.7 ± 0.2	6 ± 2

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

Torque for Constant Torque Hose Clamps

NOTICE

Due to extreme temperature changes, hose will heat set. Heat setting causes hose clamps to loosen. Loose hose clamps can result in leaks. There have been reports of component failures caused by hose clamps loosening. The new constant torque hose clamp will help prevent these failures. A constant torque hose clamp can be used in place of any standard hose clamp. Make sure the constant torque hose clamp is the same size as the standard clamp.

Installation

Each installation application can be different depending on the type of hose, fitting material, and anticipated expansion or contraction of the hose and fittings. A torque wrench should be used for proper installation of constant torque hose clamps. Constant torque hose clamps should be installed as follows:

- To allow for maximum expansion, install clamps at 5.7 N•m (50 lb in).
- To allow for equal expansion and contraction, install clamps at 10.2 N•m (90 lb in).
- To allow for maximum contraction, install clamps at 14.1 N•m (125 lb in).

Cooling System Specifications

General Coolant Information

Several industry sources claim that forty percent of all engine failures are due to cooling system problems. Many of these failures could be avoided with proper cooling system maintenance. Cooling system maintenance is as important as fuel and lubricating system maintenance. Coolant quality is as important as the quality of fuel and lubricating oil.

The three main coolant functions provide:

- adequate heat transfer and anti-boil protection,
- cavitation erosion and corrosion protection,
- anti-freeze protection.

Coolant is normally composed of three elements:

- Water
- Additives
- Glycol

A brief discussion of each of these elements follows.

Water

Distilled or deionized water is recommended for use in cooling systems. DO NOT use hard, tap water or salt softened tap water in engine cooling systems. If Distilled or deionized water is NOT available, use water that meets the Minimum Acceptable requirements listed in the following chart.

MINIMUM ACCEPTABLE WATER	
Water Content	**mg/L or ppm[1] (grains/US gal)**
Chlorides	40 (2.4) maximum
Sulfates	100 (5.9) maximum
Total Hardness	170 (10) maximum
Total Solids	340 (20) maximum
pH	5.5 to 9.0

[1]ppm = parts per million

NOTICE

Water that does not meet the Minimum Acceptable limits will reduce engine service life when used in cooling systems.

If you are not sure of your water's contents, contact your Caterpillar dealer, your local water department, agricultural agent, or an independent laboratory to analyze the water.

Additives

Additives must be included in all coolant mixtures. Additives help prevent the formation of rust, scale and mineral deposits. Additives protect metals from corrosion, prevent liner cavitation, and contain anti-foaming agents. Additives deplete during engine operation and need to be replenished. This is done through the addition of supplemental coolant additives (SCAs, with conventional coolants) or Extender (with Caterpillar Long Life Coolant/Antifreeze).

Nitrites or nitrite and molybdate additives protect the cylinder liner from cavitation corrosion. Nitrites deplete, creating the need for SCAs or Extender. SCAs and Extender also contain other inhibitors that deplete from cooling systems.

Under-concentration of additives does not provide the protection required for cooling systems. Over-concentration can cause additives to drop out of solution, deposit inside the cooling system, or form a gel in the radiator. Deposits can be in the form of sludge and scale which accumulate on hot engine surfaces, reducing cooling system effectiveness, or causing water pump leaks.

To maintain conventional cooling system protection, it is necessary to monitor SCA concentration. Incorrect SCA concentration requires action to return proper additive levels to the cooling system.

Glycol

Engine coolant glycol is normally one of two varieties, ethylene or propylene. Glycol raises the boiling point of water to help prevent boil-over, provides freeze protection, helps prevent water pump cavitation, and reduces cylinder liner pitting.

NOTICE

For ambient temperatures requiring lower freeze protection (higher than 50 percent glycol), use ethylene glycol. DO NOT use propylene glycol.

Proper anti-freeze/boil protection requires the proper ratio of glycol and Acceptable Water. Use the following charts to determine glycol concentrations to mix with Acceptable Water.

PROPYLENE GLYCOL		
	Protection	
Concentration % Glycol/% Water	Anti-Freeze °C (°F)	Anti-Boil °C (°F)
30/70	−15° (5°)	102° (216°)
40/60	−23° (−9°)	104° (219°)
50/50	−37° (−34°)	106° (222°)

ETHYLENE GLYCOL		
	Protection	
Concentration % Glycol/% Water	Anti-Freeze °C (°F)	Anti-Boil °C (°F)
30/70	−15° (5°)	104° (219°)
40/60	−24° (−12°)	106° (222°)
50/50	−37° (−34°)	108° (226°)
60/40	−57° (−62°)	111° (231°)

Check the coolant solution periodically to ensure adequate anti-freeze/boil protection. Use the 1U7298 Coolant Tester (°C) or use the 1U7297 Coolant Tester (°F). These Testers give immediate, accurate readings and can be used with ethylene or propylene glycol.

NOTE: For more detailed specifications, refer to: Know Your Cooling System, SEBD0518, and Coolant and Your Engine, SEBD0970, or contact your Caterpillar dealer.

Caterpillar Coolant Recommendations

- Preferred- Caterpillar Long Life Coolant/Antifreeze (LLCA).

Conventional Antifreeze/Coolant

- Recommended- Caterpillar Diesel Engine Antifreeze/Coolant (DEAC).
- Acceptable- Any low silicate coolant that meets Truck Maintenance Council (TMC) Recommended Practice (RP) 329, TMC RP330, or ASTM D4985 requirements when used with SCAs.
- Permitted-A mixture of Acceptable Water and SCA, where freeze protection is not necessary.
- Unacceptable- ANY high silicate coolant that is classified as meeting ASTM D3306.

NOTICE

Most commercial engine coolant/antifreezes are formulated for gasoline engine applications and have high silicate content. High silicates provide conditions favoring cylinder liner cavitation and corrosion. Caterpillar DOES NOT recommend these antifreezes.

NOTE: Due to individual engine applications, engine cooling system maintenance practices may need periodic re-evaluation.

NOTICE

Never operate without thermostats in the cooling system. Thermostats maintain the engine coolant at the proper operating temperature. Cooling system problems can arise without thermostats.

NOTICE

Never add coolant water to an overheated engine–engine damage can result. Allow the engine to cool first. Do not add coolant water too quickly. Filling the cooling system at over 19 L (5 US gal) per minute can create air pockets in the cooling system.

When filling or adding to the coolant to the system, premix the coolant solution prior to pouring it into the cooling system. Pure undiluted glycol will freeze at −23°C (−10°F). Use a mixture in a range which will provide protection to the lowest expected outside (ambient) temperature and provide the required boil-over protection.

Caterpillar Long Life Coolant/Antifreeze (LLCA)

Caterpillar's Long Life Coolant/Antifreeze (LLCA) anti-corrosion package is totally different from the conventional antifreezes that have been in use. Caterpillar LLCA is an ethylene glycol based coolant/antifreeze containing organic corrosion inhibitors and anti-foam agents with fewer nitrites than conventional coolants.

LLCA was specifically designed for cooling systems in diesel and natural gas engines. LLCA may also be used in automotive applications

LLCA extends coolant life to 6,000 service hours or four years, whichever comes first. The only maintenance required for cooling systems filled with LLCA is one addition of Caterpillar Extender.

Major LLCA advantages:

- twice the coolant life.
- considerably less maintenance.
- improved corrosion protection.
- better aluminum protection.
- better liner protection.
- fewer additives (chemicals) and no chemical drop out.
- longer radiator life.
- increased water pump seal life.

LLCA is available premixed 50/50 with deionized water, or in concentrate, in the following quantities.

CATERPILLAR LONG LIFE COOLANT/ANTIFREEZE QUANTITIES AVAILABLE		
Type	**Size**	**Part No.**
Pre-mix[1]	Bulk 208.5 L (55 US gal) 3.8 L (1 US gal)	119-5148 101-2845 101-2844
Concentrate[2]	3.8 L (1 US gal)	119-5150

[1] 50 percent Long Life Coolant/Antifreeze and 50 percent water.
[2] LLCA Concentrate is available ONLY to lower freeze protection. The Concentrate is not intended to be used as a mix.

NOTE: A 50/50 LLCA/water solution provides freeze protection to −37°C (−34°F) and anti-boil protection to 108°C (226°F). DO NOT use LLCA at reduced concentrations (less than 50 percent), since the additives would be reduced along with the antifreeze. LLCA concentrate is available to lower the freeze point for arctic conditions. LLCA concentration can be increased to 60 percent for −52°C (−62°F) freeze protection.

Extender

LLCA Extender is a liquid that is poured into the cooling system halfway through the LLCA service life.

The cooling system should be treated with Extender at the 3,000 service hour interval or two years, whichever comes first. Use the following table to determine the recommended amount of Extender to add to LLCA.

RECOMMENDED AMOUNT OF EXTENDER BY COOLING SYSTEM CAPACITY	
Cooling System Capacity	**Recommended Amount of Extender**
22 to 30 L (6 to 8 US gal)	0.57 L (20 oz)
30 to 38 L (8 to 10 US gal)	0.71 L (24 oz)
38 to 49 L (10 to 13 US gal)	0.95 L (1 qt)
49 to 64 L (13 to 17 US gal)	1.2 L (40 oz)

LLCA Cooling System Maintenance

NOTICE

Use only Caterpillar products or commercial products that have passed the CAT EC-1 specification for pre-mixed or concentrate coolants.
Use only Caterpillar Extender with LLCA.
Mixing LLCA with other products reduces the LLCA service life. Failure to follow the recommendations can reduce cooling system component life unless appropriate corrective action is performed.

Due to the balance of antifreeze and additives, care should be taken to maintain the proper LLCA concentration. Lowering the proportion of antifreeze lowers the proportion of additive, thus lowering the coolant's ability to protect the system from pitting, cavitation, erosion, and deposits.

Make Proper LLCA Additions

NOTE: DO NOT add LLCA Concentrate as a makeup solution for routine cooling system top-off. Adding concentrated LLCA increases the concentration of glycol in the cooling system.

During normal maintenance, use pre-mixed LLCA as a top-off to the system to bring the coolant up to the proper level. Use LLCA or a coolant that meets Caterpillar's EC-1 specification. If a coolant that meets EC-1 is not available, use distilled or de-ionized water as a make-up. Check the system's glycol with the 1U7298 Coolant Tester (°C) or with the 1U7297 Coolant Tester (°F). Use LLCA Concentrate to restore the proper glycol concentration before the engine is exposed to freezing temperatures.

NOTICE

Do not use conventional coolant to top off a cooling system using LLCA.

Do not use supplemental coolant additives (SCA's) in cooling systems filled with LLCA.

If the LLCA cooling system has been topped off with a small amount of conventional coolant or if SCA was added to the system by mistake, the system will not be harmed.

Should the system become contaminated with conventional coolant or SCA exceeding 10 percent of the system's total capacity, either:
- drain the system and refill with LLCA, or
- maintain the system as if the system is filled with conventional coolant.

LLCA Cooling System Cleaning

NOTE: No cleaning agents are to be used when a system ALREADY using LLCA is drained, flushed, and refilled.

CLEAN WATER is the only system cleaning/flushing agent required when LLCA is drained from the cooling system.

LLCA can be recycled. The drained coolant mixture can be "distilled" to remove the ethylene glycol and water for reuse. Contact your Caterpillar dealer for more information.

After draining and refilling the cooling system, operate the engine with the radiator filler cap removed until the coolant reaches normal operating temperature and coolant level stabilizes. Add coolant mixture as necessary to fill the system to the proper level.

Changing the Cooling System From Conventional Coolant To LLCA

NOTE: When the coolant is switched from conventional coolant to LLCA, Caterpillar cleaner should be used. After the use of Caterpillar cooling system cleaners, the system MUST be thoroughly flushed with clean water.

To switch from conventional coolant to LLCA, perform the following steps:

1. Drain the coolant.

2. Flush the system with clean water to remove any debris.

3. Use Caterpillar cleaner to clean the system. Follow the instructions on the label. Caterpillar cleaner is available from your Caterpillar dealer.

4. Drain the cleaner, and flush the cooling system with clean water.

5. Fill the cooling system with clean water. Operate the engine until the cooling system temperature is 49° to 66°C (120° to 150°F).

6. Drain and flush the cooling system with clean water.

7. Repeat steps five and six.

8. Fill the cooling system with LLCA.

9. Attach a label to the cooling system to indicate the system has been switched over to LLCA.

Conventional Antifreeze/Coolant

Recommended– Caterpillar Diesel Engine Antifreeze/Coolant (DEAC)

NOTE: The following information and recommendations are for Caterpillar DEAC only.

Caterpillar DEAC was specifically designed for diesel and natural gas engine cooling systems. Caterpillar DEAC is an alkaline type, ethylene glycol based formula containing inorganic corrosion inhibitors and anti-foam agents. Caterpillar DEAC was formulated with the correct additive levels to protect metal parts in diesel engines. Caterpillar DEAC will furnish adequate corrosion, anti-foam, and cylinder liner/block pitting protection in a 30/70 DEAC/Acceptable Water and SCA solution.

Major advantages of Caterpillar DEAC:

- minimal silicate content. High silicate coolants, used with SCAs, can cause a build-up of solids over a period of time. Build-up of solids can cause plugging, loss of heat transfer, and water pump seal damage. Caterpillar DEAC significantly reduces solid residue buildup that causes inhibitor dropout and water pump seal damage.
- no need to add SCA on initial fill, which must be done with other commercially available coolants.

Caterpillar DEAC is available from your Caterpillar dealer in the following quantities;

CATERPILLAR ANTIFREEZE/COOLANT CONCENTRATE	
Part Number	**Size**
8C3684	3.8 L (1 US gal)
8C3686	208 L (55 US gal)

Proper Antifreeze Concentrations

Use the following chart to determine concentrations of Caterpillar DEAC to mix with Acceptable water and SCA.

ANTIFREEZE CONCENTRATIONS (GLYCOL)	
Protection Temperature	**Concentration**
Protection to −15°C (5°F)	30% antifreeze and 70% water
Protection to −23°C (−9°F)	40% antifreeze and 60% water
Protection to −37°C (−35°F)	50% antifreeze and 50% water
Protection to −51°C (−60°F)	60% antifreeze and 40% water

Acceptable Antifreeze/Coolant

Any low silicate coolant that meets Truck Maintenance Council (TMC) Recommended Practice (RP) 329, TMC RP330, or ASTM D4985 requirements when used with SCAs.

Caterpillar recommends a minimum of 30 percent glycol to 70 percent water and SCA for corrosion protection. All Caterpillar engines with air-to-air after cooling (ATAAC) require a minimum concentration of 30 percent glycol to prevent water pump cavitation.

While 30 percent glycol is the minimum acceptable volume, Caterpillar prefers a 50/50 glycol/water-SCA coolant mixture for optimum performance.

When using Caterpillar DEAC, no SCA is necessary on initial fill because SCA is in the DEAC. SCA must be added with commercial coolants meeting ASTM D4985 at initial fill. SCA must be replenished with both Caterpillar DEAC and other commercial coolants at regular service intervals. Refer to the following chart for quantities of Caterpillar Liquid SCA to mix with ASTM D4985 commercial coolants at initial fill.

LIQUID SUPPLEMENTAL COOLANT ADDITIVE REQUIRED BY CAPACITY		
Cooling System Capacity Liters (US gal)	**Amount At Initial Fill[1] Quantity[2] Or**	**Amount At 250 Hour Maintenance[2]**
22 to 30 (6 to 8)	3P2044 (1)	6V3542 (1)
30 to 38 (8 to 10)	3P2044 (1) 6V3542 (1)	111-2372 (1)
38 to 49 (10 to 13)	3P2044 (1) 8T1589 (1)	111-2372 (1)
49 to 64 (13-17)	3P2044 (2)	8T1589 (1)
64 to 83 (17 to 22)	3P2044 (2) 8T1589 (1)	3P2044 (1)
83 to 114 (22 to 30)	3P2044 (3) 8T1589 (1)	3P2044 (1)
114 to 163 (30 to 44)	3P2044 (5)	3P2044 (1) 6V3542 (1)
163 to 243 (44 to 64)	3P2044 (8)	3P2044 (2)

Number in brackets () indicates quantity required.
[1]Use only when not using Caterpillar DEAC on initial fill or refill.
[2]Do not exceed six percent maximum SCA concentration. Check concentration with SCA test kit.

Supplemental Coolant Additive (SCA)

⚠ WARNING

Supplemental cooling system additive contains alkali. To prevent personal injury, do not drink, avoid contact with the skin and eyes.

NOTICE
The cooling system MUST contain supplemental coolant additive (SCA) for proper engine protection, regardless of antifreeze concentration.

NOTICE
DO NOT mix Caterpillar SCA or coolant additive elements with another manufacturer's products: select a cooling system treatment and use it exclusively.

SCA is necessary for proper conventional coolant maintenance. Most coolant solutions DO NOT contain sufficient SCA for diesel engine application.

NOTICE
Do not exceed the recommended six percent SCA concentration. Excessive SCA concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive SCA concentration could also result in radiator tube blockage, overheating, and/or accelerated water pump seal wear. Never use both liquid SCA and the spin-on element (if equipped) at the same time. The use of those additives together could result in SCA concentration exceeding the recommended six percent maximum.

Use liquid SCA or a SCA element (if equipped) to maintain a three to six percent SCA concentration in the coolant.

NOTE: Caterpillar Test Kits check for concentration of nitrites in the coolant solution. Some manufacturers' SCA are phosphate based. Caterpillar Test Kits provide inaccurate results with phosphate based SCA. Commercial SCA products must contain silicates and a minimum of 1200 mg/L or 1200 ppm (70 grains/US gal) nitrites. If another manufacturer's SCA is used, use that manufacturer's test kit. Follow the manufacturer's recommendations for cooling system treatment and test evaluation.

Test the coolant periodically to monitor SCA levels. Use the 4C9301 Test Kit to check for Caterpillar SCA concentration. The Kit also provides cooling system maintenance recommendations. This kit is specifically for use with Caterpillar SCA's. The 8T5296 Test Kit can also to check for Caterpillar SCA concentration.

The following charts lists the part numbers and quantities of SCA (liquid and solid) available from your Caterpillar dealer. Follow the instructions on the label.

LIQUID SUPPLEMENTAL COOLANT ADDITIVE REQUIRED BY CAPACITY	
Cooling System Capacity Liters (US gal)	**Amount At 250 Hour Maintenance[1]**
22 to 30 (6 to 8)	6V3542 (1)
30 to 38 (8 to 10)	111-2372 (1)
38 to 49 (10 to 13)	111-2372 (1)
49 to 64 (13 to 17)	8T1589 (1)
64 to 83 (17 to 22)	111-2372 (1) 6V3542 (1)
83 to 114 (22 to 30)	3P2044 (1)
114 to 163 (30 to 44)	3P2044 (1) 6V3542 (1)
163 to 242 (44 to 64)	3P2044 (2)

[1] Numbers in brackets () are quantities required. Do not exceed six percent maximum concentration. Check concentration with SCA test kit.

SUPPLEMENTAL COOLANT ADDITIVE ELEMENTS REQUIRED BY CAPACITY	
Cooling System Capacity Liters (US gal)	**Amount At 250 Hour Maintenance[1]**
22 to 30 (6 to 8)	111-2370 (1)
30 to 49 (8 to 13)	111-2369 (1)
49 to 64 (13 to 17)	9N3368 (1)
64 to 83 (17 to 22)	111-2371 (1)
83 to 114 (22 to 30)	9N3718 (1)
114 to 163 (30 to 44)	111-2371 (2)
163 to 242 (44 to 64)	9N3718 (2)

[1] Do not use SCA element and SCA liquid at the same time.

Permitted-Water/SCA Coolant

NOTICE
Never use water alone without SCA or inhibited coolant. Water alone is corrosive at engine operating temperatures.

NOTICE
A mixture of water and SCA does not protect against freezing or boiling.

NOTICE
A coolant mixture of water and SCA will cool and provide some protection to engine components, but it will NOT provide normal engine service life.

NOTICE
Caterpillar's recommendation for proper coolant is a minimum concentration of 30 percent glycol and 70 percent Acceptable Water and SCA (3 percent of the total mixture). This recommendation will maintain cooling system corrosion protection.

In applications where freeze protection is not required, or where antifreeze is not available, a coolant mixture of Acceptable Water and SCA can be used. A Water/SCA system should maintain a six to eight percent SCA concentration. DO NOT exceed eight percent maximum SCA concentration. SCA concentration levels must be monitored.

The 8T5296 Test Kit can be used to evaluate the SCA concentration in Water/SCA coolant, with the following modifications to label instruction Step 3 and Step 5.

STEP 3. - Add tap water to the vial up to the 20 ml mark.

STEP 5. - With the defined procedure, the six to eight percent concentration will yield a 20 to 27 drop range. Fewer drops indicate under-concentration of SCA and more drops indicate over-concentration. Adjust the concentration appropriately.

If the SCA concentration is greater than the maximum of eight percent: drain some of the coolant, refill the system with Acceptable Water, and re-test the concentration level.

Conventional Cooling System Maintenance

Check the antifreeze solution frequently in cold weather to ensure adequate freeze protection. Test the concentration or a submit a coolant sample to your Caterpillar dealer to monitor the SCA concentration in your engine's coolant mixture Every 250 Service Hours. SCA or a maintenance additive element (if equipped) may be needed Every 250 Service Hours.

NOTICE

To prevent over-inhibiting the engine's cooling system, NEVER use both SCA liquid AND an SCA element (if equipped) at the same time. Use one method or the other exclusively.

When using Caterpillar DEAC and SCA, the cooling system should be drained, cleaned, flushed, and filled with new coolant Every Two Years. Refer to the Maintenance Schedule in this manual.

When NOT using Caterpillar DEAC and SCA, the drain/flush period must be performed at least Every Year.

After draining and refilling the cooling system, operate the engine with the radiator filler cap removed until the coolant reaches normal operating temperature and the coolant level stabilizes. Add coolant mixture as necessary to fill the system to the proper level.

Cooling System Cleaning

Draining, cleaning and flushing the cooling system removes small particles, undesirable chemicals, scale, and other deposit formations. Not performing maintenance on the cooling system can eventually cause engine overheating problems that could result in severe damage to engine and components.

Clean the cooling system if the system becomes contaminated, the engine overheats, or foaming is observed.

Caterpillar Fast Acting Cooling System Cleaner is designed to clean the system of harmful scale and corrosion. The Cleaner dissolves mineral scale, corrosion products, light oil contamination, and sludge.

Caterpillar Fast Acting Cooling System Cleaner is available from your Caterpillar dealer in the quantities listed below. Follow the product label directions for proper use.

CATERPILLAR COOLING SYSTEM FAST ACTING CLEANER	
Part No.	**Size**
4C4609	0.47 L (1 pt)
4C4610	0.95 L (1 qt)
4C4611	3.8 L (1 US gal)
4C4612	19 L (5 US gal)
4C4613	208.5 L (55 US gal)

Fuel Specifications

Fuel Recommendations

NOTICE

Fill the fuel tank at the end of each day of operation to drive out moist air and prevent condensation. Maintain a fairly constant level in the day tank (near the top) to avoid drawing moisture into the tank as the level decreases.

Do not fill the tank to the top. Fuel expands as it warms, and may overflow.

Do not fill fuel filters with fuel before installing them. Contaminated fuel causes accelerated wear to fuel system parts.

Use fuel only as recommended in this section. Fuel grades recommended for use in Caterpillar diesel engines are: No.2-D diesel fuel with low sulfur (0.05 percent maximum), or regular sulfur (0.5 percent maximum). No.1 grades are acceptable.

The following chart lists worldwide fuel standards which meet Caterpillar requirements.

WORLDWIDE FUEL SPECIFICATIONS-DIESEL ENGINES	
Specifications	**Fuel Designation**
U.S. STANDARDS	
ASTM D975	No.1-D, No.2-D & No.4 Diesel Fuel
ASTM D396	Low Sulfur No.1 & No.2 Diesel Fuel
ASTM D2880	No.1-GT & No.2-GT Gas Turbine Fuels
BRITISH STANDARDS	
BS 2869	Classes A1, A2 & B1 Engine Fuels Classes C2 & D Burner Fuels
GERMAN STANDARDS	
DIN 51601	Diesel Fuel
DIN 51603	Heating Oil El
AUSTRALIAN STANDARD	
AS 3570	Automotive Diesel Fuel
JAPANESE STANDARD	
JIS K2204	Types 1 (spl), 1, 2, 3 & 3 (spl) Gas Oil
U.S. GOVERNMENT	
VV-F-800C	DF-1,DF-2 & DF-20 Con. U.S. Diesel Fuel
VV-F-815C	FS1 & FS2 Burner Fuel Oil
U.S. MILITARY	
MIL-F-16884G	Marine Oil

Aviation kerosene-type fuels meeting acceptable limits may also be used as an engine fuel. The following chart lists some of the acceptable kerosene-type fuels.

Acceptable Kerosene-type Fuels	
Standard	**Description**
ASTM D 1655-80	Aviation Turbine Fuel (JET A-1)
MIL-T-5624L	Aviation Turbine Fuel (JP-5) (NATO Code No.F-44)
MIL-T-83133B	Aviation Turbine Fuel (JP-8) (NATO Code No.F-34)
VV-F-800F1	Grade DF-A (Arctic)

Fuel viscosity is a major concern with aviation fuels. A minimum viscosity of 1.4 cSt at 38°C (100°F) is required to properly lubricate Caterpillar fuel system components. These kerosene-type fuels have a lower viscosity for low temperature operation.

The kerosene-type fuels have less energy per unit volume than diesel fuels, producing less peak power. More kerosene-type fuel is needed than diesel fuel to do the same amount of work.

Caterpillar Diesel Engines are capable of burning a wide range of distillate fuels. Burning clean, stable blends of distillate fuel meeting the following requirements will provide quality engine service life.

DISTILLATE FUEL RECOMMENDATIONS–DIESEL ENGINES	
Specifications	**Requirements[1]**
Aromatics (ASTM D1319)	35% Max.
Ash (ASTM D482)	0.02% Weight Max.
Cetane Number (ASTM D613)	40 Minimum
Cloud Point (ASTM D97)	Not Above Lowest Expected Ambient Temperature
Gravity API (ASTM D287)	30 Min. and 45 Max.
Pour Point (ASTM D97)	6°C (10°F) Below Ambient Minimun
Sulfur (ASTM D2788, D3605 or D1552)	0.5% Max. (See Sulfur Topic)
Viscosity, Kinematic @ 38°C (100°F) (ASTM D445)	20.0 cSt Max. 1.4 cSt Min.
Water & Sediment (ASTM D1796)	0.01% Max.

[1] As delivered to fuel system

NOTE: When economics or fuel availability dictate, other fuel types may be burned in the engine. Consult your Caterpillar dealer for more information and advice on any specific fuel.

Cetane Number

Under average starting conditions, direct injection engines require a minimum cetane number of 40. A higher cetane value may be required for high altitude or cold weather operation.

Filterability

Clean fuels should have no more than 0.1 percent of sediment and water. Fuel stored for extended periods of time may oxidize and form solids, causing filtering problems.

Pour Point

Fuel pour point should be at least 6°C (10°F) below the lowest ambient temperature at which the engines must start and operate. Lower pour points of No.1 or No.1-D fuel may be necessary in extremely cold weather.

Cloud Point

The cloud point should be below the lowest ambient temperature at which the engines must start and operate, to prevent the fuel filter elements from plugging with wax crystals. Refer to Fuel Problems in Cold Weather Operation for additional information.

Viscosity

Fluid viscosity is a measure of resistance to flow. Fuel viscosity is important because it effects lubrication of fuel system components, and fuel atomization. The provided viscosity limits address both of those effects.

Additives

Fuel additives are generally not recommended or needed for the specified fuels listed. Cetane improvers can be used as necessary for direct injection engine requirements. Biocides may be needed to eliminate microorganism growth in storage tanks. In cold conditions, treatment for entrained water may also be necessary.

Consult your fuel supplier about the use of additives to prevent incompatibility among additives already in the fuel and the additives to be used.

Fuel Sulfur

The percentage of sulfur in fuel affects engine oil recommendations. Fuel sulfur can change chemically during combustion, forming both sulfurous and sulfuric acids. The acids attack metal surfaces and cause corrosive wear. Sulfur oxides formed during combustion also produce particulate exhaust emissions.

Some lubricating oil additives contain alkaline compounds to neutralize acids in combustion gases and minimize corrosive wear. Reserve alkalinity in lubricating oil is measured and defined with a Total Base Number (TBN).

Periodically request fuel sulfur content information from your fuel supplier. Fuel sulfur content can change with each bulk delivery.

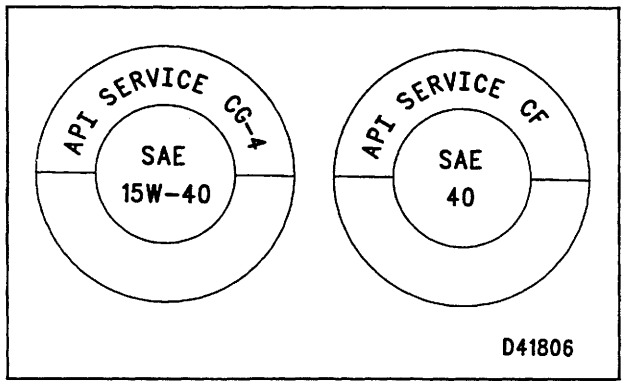
More information concerning fuel sulfur and lubrication can be found in the Lubricant Specifications section of this manual.

Refer to Diesel Fuels and Your Engine, SEBD0717, or contact your Caterpillar dealer for more information on fuel selection and fuel properties.

Lubricant Specifications

General Information

Caterpillar recognizes and supports the American Petroleum Institute (API) "Engine Oil Licensing and Certification System" for engine oils. The API publication No. 1509, 13th edition, contains the detailed information concerning this system. Engine oils bearing the API symbol are licensed by the API.



Examples of the API symbol.

Diesel engine oil classifications CD, CD-2 and CE will not be API licensed categories after January 1, 1996. Caterpillar will only reference those categories that are licensed by the API. The following chart summarizes the status of the categories.

OIL CLASSIFICATION STATUS	
Obsolete	**Current**
CC, CD	CF
CD-2[1]	CF-2[1]
CE	CF-4, CG-4

[1] CD-2 and CF-2 are oil categories for two cycle diesel engines. These oils are NOT recommended for Caterpillar engines.

Engine Lubricant Specifications

Caterpillar Oil

Caterpillar Oils have been developed, tested, and approved by Caterpillar to provide the performance and life that has been designed and built into Caterpillar diesel engines. Caterpillar Oils are used for engine development and factory fill. They are available from Caterpillar dealers. Due to significant variations in the quality and performance of commercially available oils, Caterpillar recommends the following.

Caterpillar Diesel Engine Oil (DEO) (multi-grade)

Caterpillar DEO multi-grade oils are formulated with detergents, dispersants, and sufficient alkalinity to provide superior performance in Caterpillar diesel engines. DEO multi-grade oils are blended in two viscosity grades: SAE 10W30 and SAE 15W40. Refer to the lubricant viscosity chart to choose the correct viscosity grade based on ambient temperatures. Multi-grade oils provide the correct viscosity for a broad range of operating temperatures and for cold engine starts. Multi-grade oils are also effective in maintaining low oil consumption and low levels of piston deposits.

Caterpillar DEO multi-grade oils are also qualified for use in other diesel engines and in gasoline engines. Consult the engine manufacturer's guide for the recommended specifications, and compare to the specifications of Caterpillar DEO multi-grade. The current Caterpillar DEO industry specifications are listed on the label and on the product data sheets.

Commercial Diesel Engine Oils

The performance of commercial diesel engine oils are based on API categories. These API categories are developed to provide commercial lubricants for a wide variety of diesel engines that operate at various conditions.

If Caterpillar DEO (multi-grade) is not used, the following commercial oils are recommended.

- API CG-4 Preferred
- API CF-4 Allowed

API CG-4 oils are preferred for Caterpillar engines because of the fuel sulfur level. API CG-4 is the only oil category that evaluates oils with engine tests utilizing 0.05 percent sulfur fuel.

The following explanations of these API categories can be used to make the proper choice of a commercial oil.

CG-4: This is the newest oil category. CG-4 oils were primarily developed for diesel engines that are operating on 0.05 percent sulfur diesel fuel. All of the laboratory engine tests for this category were run with 0.05 percent sulfur diesel fuel. This category also defines oils that have superior soot dispersancy. CG-4 oils will provide improved viscosity control and improved crankcase cleanliness in applications where oil soot is a problem. CG-4 oils should also be used in engines that contain hydraulically actuated fuel injection pumps; these are the first oils to pass industry tests for foam control and viscosity shear loss. CG-4 oils must also pass recently developed tests for metals corrosion, and wear. CG-4 oils can be used in all Caterpillar engines where CF-4 oils are recommended.

CF-4 oils service a wide variety of modern diesel engines. This oil classification was developed with 0.40 percent sulfur diesel fuel. The fuel used in the CF-4 tests represents the type of diesel fuels commonly available world wide. CF-4 oils provide improved piston deposit control and improved oil control when compared to the CE category oils. CF-4 oils also provide improved soot dispersancy compared to CD or CF category oils.

Some commercial oils meeting these API specifications may require shortened oil change intervals as determined by close monitoring of oil condition and wear metals (Caterpillar's S•O•S Oil Analysis Program preferred).

Consult with your Caterpillar dealer for the latest oil recommendations or refer to the following Caterpillar Supplements: SEBU6250, SEBU6251, and SEBU6385.

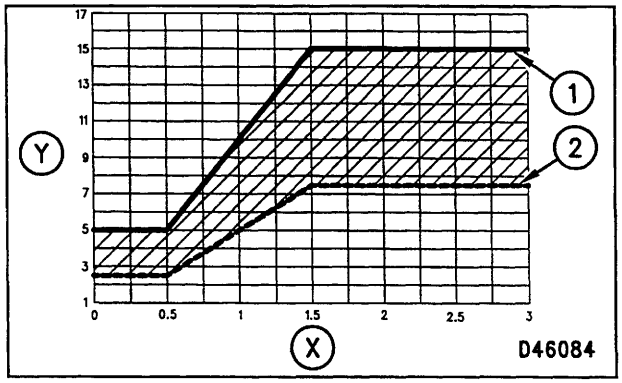
NOTICE

Failure to follow these oil recommendations can cause shortened engine life due to deposits and or excessive wear.

Total Base Number (TBN) and Fuel Sulfur Levels For Caterpillar Direct Injection (DI) Diesel Engines

The TBN for a new oil is dependent on the sulfur level of the fuel used. For direct injection engines running on distillate diesel fuel, the minimum new oil TBN (by ASTM D 2896) must be 10 times the fuel sulfur level, and the minimum TBN is 5 regardless of sulfur level, see the chart below.

TBN vs Fuel Sulfur for Caterpillar DI Diesel Engines



Y = oil TBN shown by ASTM D2896.
X = percent of fuel sulfur by weight.
New oil TBN (1).
Change oil when the used oil TBN limit (2) is reached.

In areas where the fuel sulfur exceeds 1.5 percent, choose an oil with the highest TBN that is within the API CF-4 or CG-4 categories, and shorten the oil change period based on oil analysis. The oil analysis should evaluate oil condition and wear metals. High TBN oils that are not within the API CF-4 or CG-4 categories can produce excessive piston deposits leading to a loss of oil control and bore polishing.

NOTICE

Operation at fuel sulfur levels over 1.5 percent may require shortened oil change periods to maintain adequate wear protection.

Lubricant Viscosity Recommendations

The proper SAE viscosity grade oil is determined by the minimum outside temperature at cold engine start up, and the maximum outside temperature during engine operation. Use the minimum temperature column on the chart to determine the oil viscosity required for starting a "cold soaked" engine. Use the maximum temperature column on the chart to select the viscosity for operation at the highest temperature anticipated. In general, use the highest viscosity oil available that still meets the start up temperature requirements.

ENGINE OIL VISCOSITY PROTECTION		
	Ambient Temperature	
Engine Oil Viscosity Grade	Minimum °C (°F)	Maximum °C (°F)
SAE 0W20	−40° (−40°)	10° (50°)
SAE 5W30	−30° (−22°)	30° (86°)
SAE5W40	−30° (−22°)	40° (104°)
SAE 10W30	−20° (−4°)	40° (104°)
SAE 15W40	−15° (5°)	50° (122°)

Synthetic Base Stock Oils

Synthetic base stock oils are acceptable for use in Caterpillar engines and machines if these oils meet the performance requirements specified by Caterpillar for a particular compartment.

Synthetic base stock oils generally outperform non-synthetics in two areas:
1. Improved low temperature viscosity characteristics, especially in Arctic conditions.
2. Improved oxidation stability, especially at high operating temperatures.

Some synthetic base stock oils have performance characteristics that enhance the useful life of the oil. However, Caterpillar does NOT recommend the automatic extension of oil drain intervals for any oil, including synthetic base stock oils. For Caterpillar diesel engines, oil drain intervals can only be adjusted through an oil analysis program that contains the following elements: oil condition and wear metals (Caterpillar's S•O•S Oil Analysis preferred), trend analysis, fuel consumption, and oil consumption.

Re-Refined Base Stock Oils

Re-refined base stock oils are acceptable for use in Caterpillar engines and machines if these oils meet the performance requirements specified by Caterpillar for a particular compartment. Re-refined oils can be used exclusively in a finished oil or in combination with new base stocks. The US Military and other heavy equipment manufacturers have also accepted the use of re-refined base stock oils with the same criteria.

The re-refining process should be adequate to remove all wear metals and oil additives that were present in the used oil. This type of re-refining is generally accomplished by vacuum distillation and hydrotreating the used oil. Filtering alone is inadequate for producing a high quality re-refined base stock from used oil.

After-Market Oil Additives

Caterpillar does NOT recommend the use of after-market oil additives. After-market oil additives are not necessary to achieve life predictions or to achieve rated performance. Fully formulated finished oils are made up of base stocks and commercial additive packages. These additive packages are blended into the base stocks at precise percentages to provide finished oils with performance characteristics that meet lubricant industry standards.

Lubricant industry standard tests do not exist to evaluate the performance of after-market oil additives. There are also no lubricant industry standard tests to evaluate the compatibility of these after-market additives in a finished oil. After-market additives could be incompatible with the finished oil additive package, and lower the performance of the finished oil. The after-market additive could fail to mix with the finished oil, and produce a sludge in the crankcase. Caterpillar discourages the use of after-market additives in finished oils.

To achieve all the performance that was built into a Caterpillar engine, follow these guidelines:

- Select the proper Caterpillar oil or commercial oil that meets the compartment specifications.
- Select the proper oil viscosity based on the Engine Oil Viscosity Chart in this manual.
- Service the engine at the specified interval with new oil and oil filter.
- Perform maintenance at the intervals specified by the Operation and Maintenance Manual.

Caterpillar Lubricating Grease

The National Lubricating Grease Institute (NLGI) classifies grease, based on ASTM D217-68 Worked Penetration characteristics. Grease characteristics are given a defined consistency number.

Caterpillar has grease and lubricants for all applications. Your Caterpillar dealer can provide you with complete information regarding all of the different types and sizes of Caterpillar lubrication and special application products.

CATERPILLAR LUBRICATING GREASE		
Part No.	**Item**	**Size**
2S3230	Bearing Lubricant[1]	411 g (14.5 oz)
5P0960	Molybdenum Grease[2]	411 g (14.5 oz)
1P0808	All-Purpose Lubricant[3]	411 g (14.5 oz)
4C4774	Water & Temperature Resistant Grease[4]	454 g (16 oz)

[1] NLGI No.2 Grade, services heavily loaded ball and roller bearings operating at high speeds, extreme pressure, and temperatures from −34 to 163°C (−18 to 300°F). Use for bearings in electric motors, fan drives, starting motors, alternators/generators and to pack similar bearings in many other applications.

[2] NGLI No.2 Grade, three to five percent molybdenum disulfide, multi-purpose grease with an operating temperature range from −28 to 149°C (−18 to 300°F).

[3] NGLI No.2 Grade lithium grease has mechanical stability, resists oxidation, protects from rust, excellent breakaway torque. For light-duty automotive-type applications and temperatures up to 175°C (350°F).

[4] This NLGI No.2 Grade has exceptional water resistance, meets ASTM D-1264 Water Washout Test. This low and high temperature resistant grease has a starting torque at −40°C (−40°F), and is still not fluid at 316°C (600°F).

Caterpillar Specialty Lubricants

CATERPILLAR SPECIALTY LUBRICANTS		
Part No.	**Item**	**Size**
6V4876	Molykote Paste Lubricant[1]	500 g (17.6 oz)
5P3931	High Temperature Anti-Seize[2]	150 g (5.3 oz)

[1] Recommended for typical uses such as on head bolt threads and washers.

[2] Recommended for connectors such as exhaust manifold studs and nuts.

Gauges

Gauges provide indications of engine performance. Be sure they are in good working order. You can determine what is the "normal" operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings indicate potential gauge or engine problems. This also applies to gauge readings that have changed significantly, but are still within specifications. The cause of any sudden or significant change in gauge readings should be determined and corrected. Contact your Caterpillar dealer for assistance as needed.

Oil Pressure – Indicates engine oil pressure. The oil pressure should be greatest after starting a cold engine. Oil pressure should read between 275 and 606 kPa (40 and 88 psi) when: the engine is running at rated engine speed with SAE 10W30 oil, with an oil temperature no more than 110°C (230°F). A lower pressure is normal at low idling speed.

If the oil pressure readings fluctuate after the load has stabilized:
1. Remove the load.
2. Reduce the engine speed to low idle.
3. Check the oil level, and add oil if necessary.

The minimum recommended oil pressure at 600 rpm is 103 kPa (15 psi). If low oil pressure or no oil pressure is indicated, stop the engine and determine the cause of the problem. Refer to the Troubleshooting section of the Service Manual, or consult with your Cater[pillar dealer.

NOTICE

Engine damage can result if the engine is operated with no oil pressure gauge reading. If no pressure is indicated, stop the engine.

Jacket Water Temperature – Indicates engine coolant temperature. It should normally indicate between 87 to 98°C (189 to 209°F). Higher temperatures may occur under certain conditions. Maximum allowable temperature is 104°C (220°F) with the cooling system pressurized.

If the engine is operating with a jacket water temperature above this range:
1. Reduce the load and rpm.
2. Look for coolant leaks.
3. Determine if the engine must be shut down immediately, or if the engine can be cooled by reducing the load.

Ammeter – Indicates the amount of charge or discharge in the battery charging circuit. Normal operation of the indicator should be slightly to the positive (right) side of "0" (zero).

Check the charging system for malfunction if, during operation, the indicator is constantly to the negative (left) side of "0" (zero) or shows excessive charge.

Tachometer – Indicates engine rpm (speed). The engine can be operated at high idle without damage, but should not be allowed to overspeed. Overspeeding can seriously damage your engine.

NOTICE

Do not exceed "bare engine high idle" rpm in any situation.

Fuel Level – Indicates fuel level in the fuel tank. The electrically operated fuel level gauge registers only when the START/STOP (ignition key) switch is ON.

Fuel Pressure – Indicates fuel pressure to the injection pump. The indicator should register in the NORMAL (green) range.

If the indicator moves to the OUT position or registers below 160 kPa (23 psi) when equipped with a numerical gauge, the engine will not operate properly. In most cases this is caused by a plugged fuel filter.

Service Hour Meter – Indicates the total number of service meter units or clock hours the engine has operated.

Engine Protection Devices

Shutoff and Alarm Systems

Shutoff and alarm systems are either electrically or mechanically operated. The operation of all electric shutoffs and alarms utilize components which actuate switches in a sensing unit.

Shutoff switches are set at a more critical operating temperature, pressure, level or speed than the alarm components. A shutoff switch opens or closes the circuit to the fuel shutoff solenoid. Opening the circuit to the fuel shutoff solenoid moves the fuel rack to the FUEL OFF position. The particular shutoff may require resetting before the engine will start.

When any sensing switch shuts the engine down, the problem causing the shutdown must be corrected before attempting to restart the engine.

Familiarize yourself with the:
- types and locations of the shutoff controls
- conditions which cause each control to function
- resetting procedure required to restart your engine

Alarm switches consist of a sensor and contactor. Examples of sensors are the magnetic pickup for detecting speed, and the pressure and temperature sensors. Sensors are wired to contactors. The contactors activate alarm circuits in the Annunciator Panel.

Alarm switches are set at a less critical operating temperature, pressure, level, or speed than the shutoff components. The purpose of the alarm switches is to warn the operator that an unsafe operating condition is beginning to occur.

When an alarm is activated, corrective measures must be taken, **before the situation becomes an emergency,** to avoid possible engine damage.

If corrective measures are not taken within a reasonable time, engine damage could result. Alternatively, a corresponding shutdown device (if equipped) will stop the engine.

The alarm will continue until the condition is corrected or the alarm is reset by the operator. The alarm circuits merely warn the operator, they do not shut the engine down to protect it from damage.

A switch may be installed in the alarm circuit for silencing the alarm while the engine is stopped for repairs. Before starting, be sure the switch is moved to the closed (ON) position and the warning lights are illuminated.

If the switch is left in the open (OFF) position when the engine is started, the engine will not be protected.

NOTICE

Always determine the cause of the engine shutdown. Make necessary repairs before attempting restarting the engine.

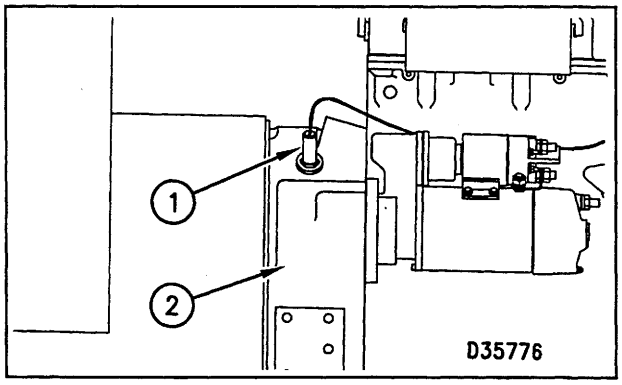
Air Shutoff Solenoid (If Equipped)

This optional solenoid is located on top of the engine in the air inlet system. When the solenoid is activated, the solenoid mechanically shuts off inlet air to the engine. The solenoid can only be activated by the overspeed switch or the emergency stop switch.

Fuel Shutoff Solenoid

This solenoid is located on the governor or on the fuel injection pump. When the solenoid is activated, the solenoid moves the fuel rack (either directly or through the governor) to the FUEL OFF position.

Overspeed Shutoffs

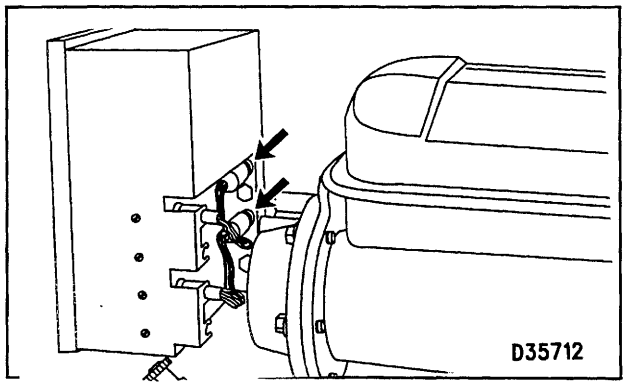


Magnetic pickup (1), mounted in the flywheel housing (2).

A magnetic pickup mounted in the flywheel housing senses the passage of the flywheel ring gear teeth. Should the engine speed increase above the overspeed setting of the Electronic Speed Switch (118 percent of rated engine speed), the magnetic pickup will sense the overspeed. The overspeed condition activates both the air (if equipped) and fuel shutoff solenoids.

The shutoffs must be reset before the engine will restart. A reset button on the Electronic Speed Switch (in the junction box) must be pushed to open the overspeed switch. The air shutoff lever (at the top of the air inlet housing) must be manually reset.

Oil Pressure Switches



Typical example of oil pressure switches, mounted in the rear of the junction box.

An oil pressure switch has wires connected to the electrical system for alarm or shutoff functions. The oil pressure switch senses oil pressure at the bearing oil gallery. If sufficient oil pressure is not achieved after engine starting, or if the engine has been running normally and then loses oil pressure, the fuel shutoff solenoid is energized to shut the engine off. No resetting procedure is required.

Engine Step Oil Pressure

This is an adjustable engine speed setting that protects the engine from a failure caused by too little oil pressure for a specified speed range. This option requires two different oil pressure switches. One switch has a high pressure rating– when the engine is running above the speed setting, the engine must maintain oil pressure higher than the switch rating. The other switch has a low pressure rating– an engine running below the speed setting must maintain oil pressure above the low switch rating.

In an automatic start/stop system, an automatic reset switch is used. Manually operated systems require the switch to be reset before the engine will start.

NOTICE

If the RESET button does not move to the extended position after the engine starts, the engine will NOT be protected by this particular switch.

If the RESET button remains in the reset position, the engine oil pump will not develop normal oil pressure. An inspection should be made to correct the problem.

In order to reset the switch, push the RESET button until the button latches. After the engine starts and develops oil pressure, the button will move to the extended (running) position.

NOTICE

The button must be in the RUN position to protect the engine. If the button remains in the OFF position, the engine oil pump may not be developing normal oil pressure and proper checks should be made.

Water Temperature Contactor Switch

The water temperature contactor switch is located in the cylinder head. High water temperature closes the switch to activate an alarm or fuel shutoff. No resetting is required. The switch opens as the coolant cools.

NOTICE

The sensing element must be submerged in the coolant to operate. Be sure to have an adequate water supply in the jacket water system, or engine damage could result.

Shutoff and Alarm System Testing

Most alarm panels are equipped with a test switch. Turn the switch to ON position to check indicator lights for proper operation. Replace defective or burnt bulbs immediately.

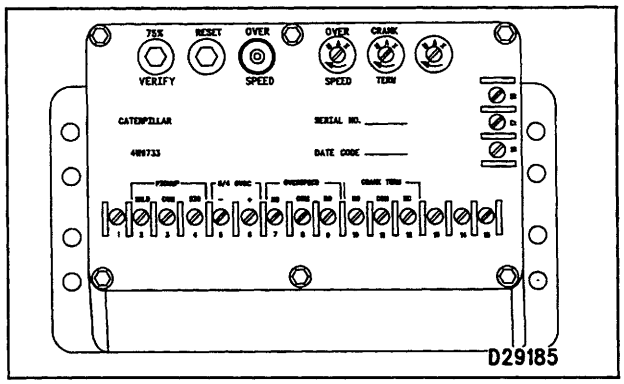
The Engine Protective Devices shutdown controls and alarms on the engine should be tested every 1000 service hours or twice a year for proper operation by authorized Caterpillar service personnel.

NOTICE

During testing, abnormal operating conditions must be simulated. Perform the tests correctly to prevent possible damage to the engine.

Abnormal operating conditions must be simulated which could cause engine damage if the tests are performed incorrectly. Refer to the Service Manual for the testing procedures.

Overspeed Switch Testing



The Electronic Overspeed Switch (if equipped) is located inside the junction box.

The Electronic Overspeed Switch with Cranking Termination has a 75 percent VERIFY button, a RESET button, and an OVERSPEED indicator light.

The Electronic Overspeed Shutoff Switch with Crank Termination has a sensing circuit which prevents the starter pinion from remaining engaged in the flywheel at excessive rpm. Crank Termination has an adjustable engine speed setting, and signals the starter motor when the engine is firing and cranking must be terminated. When the speed setting is reached, a switch opens to start the engine hour meter.

After the starting motor cranks the engine, the pinion gear can remain engaged with the flywheel as the engine speed increases. The magnetic pickup opens the circuit to the starting motor at 400 rpm and allows the pinion gear to disengage.

The circuit will remain open until the flywheel stops. This prevents energizing the starting motor circuit again while the flywheel is turning.

Your engine may be equipped with either an Overspeed Shutoff Switch or an Electronic Overspeed Switch with Cranking Termination. Both switches can be checked for proper operation at 75 percent of overspeed condition. Use the following procedure:

1. Determine full load rpm from the Engine Information Plate.

2. Operate the engine at or slightly above the corresponding speed shown for your engine on the INDUSTRIAL ENGINE OVERSPEED TEST RPM chart.

INDUSTRIAL ENGINE OVERSPEED TEST RPM		
Full Load RPM	**Test RPM For Overspeed[1]**	**Actual RPM Of Overspeed[2]**
1500	1328	1770
1800	1593	2124
2000	1770	2360
2100	1859	2478

[1] The Test RPM for Overspeed is slower than the Full Load RPM: multiply the Full Load RPM by 0.885. The product is the Test RPM.

[2] Multiply the Full Load RPM by 1.18. The product is the Actual RPM of Overspeed.

3. Maintain the test rpm, push and hold the VERIFY button. The engine should stop. If the engine does not stop at the specified test rpm, contact your Caterpillar dealer.

NOTE: As the engine stops, the OVERSPEED light will illuminate and the RESET button must be pushed before restarting the engine.

Engine Starting

Prestart Checks

Walk-Around Inspection

Perform required Daily and other periodic maintenance before starting the engine. Make a walk-around inspection of the installation. It only takes a few minutes to make minor corrections. This can prevent major repairs at a later date.

- For maximum service life of your engine, make a thorough inspection before starting the engine. Look for items such as oil or coolant leaks, loose bolts, and trash build-up. Remove trash build-up and have repairs made as needed.
- Inspect the radiator hoses for cracks and loose clamps.
- Inspect the fan belts and accessory drive belts for cracks, breaks, and other damage.
- Inspect the wiring for loose connections and for worn or frayed wires.
- Check the fuel supply. Drain water from the water separator (if equipped). Open the fuel supply valve.

NOTICE

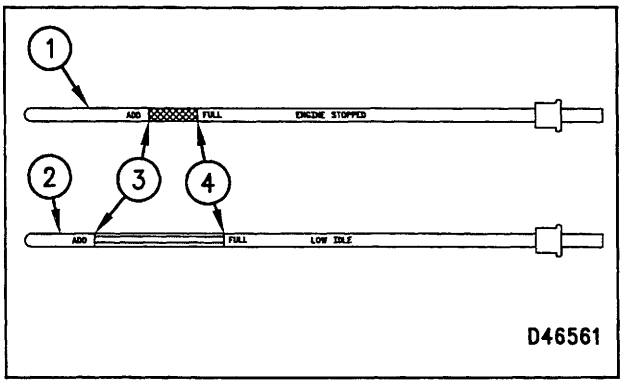
All valves in fuel return line must be open before and during engine operation to prevent high fuel pressure. High fuel pressure may cause filter housing failure or other damage.

If the engine has not been run for several weeks, fuel may have drained and allowed air into the filter housing. Also, when fuel filters have been changed, some air space will be left in the housing. In these instances, prime the fuel system. Refer to Priming the Fuel System in this publication for more information.

⚠ WARNING

Diesel engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well-ventilated area and, if in an enclosed area, vent the exhaust to the outside.

- Do not start the engine or move any of the controls if there is a DO NOT OPERATE or similar warning tag attached to the start switch or controls.
- The operator must be satisfied that no one will be endangered before starting the engine.
- Disconnect the battery charger (if equipped).
- Reset any shutoff or alarm components (if equipped): Low Oil Pressure, Overspeed, Air Shutoff.
- Check for damaged or missing guards. Repair or replace any damaged or missing guards.



Oil Level Gauge (Dipstick): ENGINE STOPPED side (1), LOW IDLE side (2), ADD mark, and FULL mark.

- Check the oil level. The ENGINE STOPPED side of the dipstick is marked to read when the engine is stopped. The LOW IDLE side of the dipstick is marked to read when the engine is at low idle. Maintain the oil level between the ADD and FULL marks.

- Check the coolant level. Make sure the engine is cool. Remove the radiator or expansion tank filler cap slowly to relieve any pressure. Maintain the coolant to within 13 mm (½ inch) of the bottom of the fill pipe.
- Observe the air cleaner service indicator (if equipped). Service the air cleaner when the yellow diaphragm enters the red zone, or the red piston locks in the visible position.

Electric Starting

NOTE: Startability will be improved at temperatures below 12°C (55°F) by the use of a starting aid. A jacket water (coolant) heater or other means can be used to heat the crankcase oil.

NOTICE

Do not crank the engine for more than 30 seconds. Allow the starter motor to cool for two minutes before cranking again.

If the engine does not start within ten seconds, move the governor control lever to the FUEL OFF position. Crank the engine for another ten seconds to clear the cylinders of unburned fuel.

Start the engine using the following procedure:

1. Perform all prestart checks.

2. Place the transmission in NEUTRAL. Disengage the flywheel clutch (if equipped).

3. Move throttle to approximately half engine speed to get the fuel rack to move to the FUEL ON position.

4. Depending on your type of starting controls:
- turn the battery disconnect switch to the ON position, or
- Turn the starter switch to START position.

Release the start switch immediately after the engine starts.

5. Reduce speed to low idle. Allow the engine to idle for 3 to 5 minutes, or until the water temperature gauge indicator has begun to rise. The engine should run at low idle smoothly until speed is gradually increased to high idle.

6. Allow white smoke to clear up and proceed with normal operation. Do not apply load to the engine or increase engine speed until the oil pressure gauge indicates normal. Oil pressure should raise within 15 seconds after the engine starts.

For starting in cold weather, to minimize white smoke: start the engine and allow the engine to idle for 30 seconds. Increase rpm until engine speed reaches 1200 rpm. Then allow the engine to return to low idle.

7. Operate the engine at low load until all systems reach operating temperature. Check all gauges during the warm-up period.

Starting From An External Power Source

⚠ WARNING

Batteries give off flammable fumes that can explode.

Improper jumper cable connections can cause an explosion resulting in personal injury. Do not allow jump start cable ends to contact each other or the engine.

Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jumper cable ends to contact each other or the engine.

Do not smoke when observing the battery electrolyte levels.

Always wear protective glasses when working with batteries.

Electrolyte is an acid and can cause personal injury if it contacts skin or eyes.

First, determine the reason it is necessary to start with power from an external source. Refer to SEHS7668 for information on using the 6V2150 Starting/Charging Analyzer Group.

If the installation is not equipped with a backup battery system, an external electrical source may be required for starting.

Many batteries which are considered unusable are still rechargeable. Severely discharged maintenance free batteries might not fully recharge from the alternator alone after jump starting. The batteries must be charged to the proper voltage with a battery charger. For complete information on testing and charging, refer to SEHS7633, the Battery Test Procedure. The Special Instruction is available from your Caterpillar dealer.

Engines installed without engine-to-frame ground straps can be damaged by electrical discharge.

In order to prevent electrical discharge damage, make sure the engine's electrical system has an engine-to-frame ground strap.

For engines which have the alternator connected to an engine component, the ground strap must connect that component to the frame.

Some engines have starter-to-frame ground straps. Many of these starters have electrical insulation systems and are not electrically grounded to the engine. For this reason, the starter-to-frame ground strap may not be an acceptable engine ground.

If the engine is not electrically connected directly to the rails through mounting bolts, install a separate ground strap. Refer to the Electrical Schematic for your engine, or consult with your Caterpillar dealer.

Your engine has a 24 volt starting system. Use only the same voltage for boost starting. Use of a welder or higher voltage will damage the electrical system and is not recommended.

Refer to the following instructions to properly jump start the engine.

NOTICE

When using an external electrical source to start your engine: turn the START switch off, remove the key, and turn off all electrical accessories before attaching cables.

When using jumper cables always connect the POSITIVE (+) cable to the POSITIVE (+) terminal of the battery connected to the starter solenoid. Connect the NEGATIVE (–) cable from the external source to the starter NEGATIVE (–) terminal. If not equipped with a starter NEGATIVE terminal, connect to the engine block.

Do not reverse the battery cables. The alternator can be damaged. Attach the ground cable last and remove first.

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1. Connect one end of the cable to the POSITIVE (+) terminal of the battery being started. Connect the other end to the POSITIVE (+) terminal of the power source.

2. Connect one end of the other cable to the NEGATIVE (–) terminal of the power source. Connect the other end to the starter NEGATIVE (–) terminal or to the engine block. This prevents potential sparks from igniting combustible gases produced by some batteries.

3. Start the engine.

4. After the engine starts, disconnect the cable from the starter NEGATIVE (–) terminal or engine block. Disconnect the other end from the NEGATIVE (–) terminal of the power source.

5. Disconnect the cable from the POSITIVE (+) terminal of the battery on the engine being started. Disconnect the cable from the POSITIVE (+) terminal of the power source.

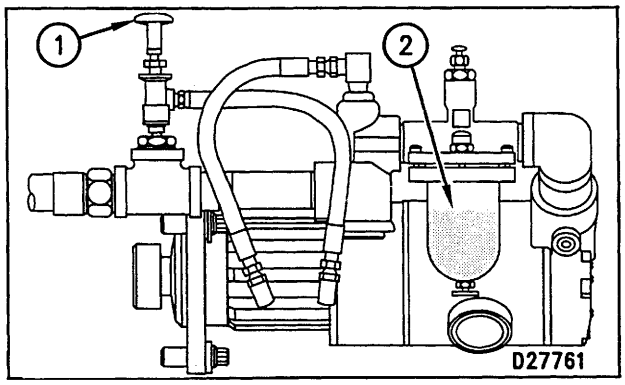
Air Starting

For good life of the air starting motor, the air supply must be free of dirt and water. A lubricator must be used with the starting system. Use non detergent 10W engine oil for temperatures that are greater than 0°C (32°F) or use air tool oil for lower temperatures.

Perform all prestart checks before starting the engine.

1. Open and close the drain valve on the bottom of the air tank to drain condensation and oil carryover.

2. Check the air supply pressure. The air starting motor requires a minimum of 690 kPa (100 psi) air pressure to operate properly. The maximum air pressure must not exceed 1550 kPa (225 psi). The normal air pressure will be 758 to 965 kPa (110 to 140 psi).



Air Starter showing Air Valve (1) and Lubricator Bowl (2)

3. Check the oil level in the lubricator bowl (2). Keep the bowl at least half full and add lubricant if necessary.

4. Push the air valve (1) or the engine start button to crank the engine. Release the valve or button as soon as the engine starts.

Cold Weather Starting Aids

⚠ WARNING

Personal injury or death can result from using ether.

Personal injury or property damage can result from alcohol or starting fluids. Alcohol or starting fluids are highly flammable and toxic and if improperly stored could result in injury or property damage.

When using starting fluid, follow the manufacturer's instructions carefully. Use ether sparingly and spray it only while cranking the engine.

Failure to follow these instructions could result in an explosion and/or fire and possible personal injury.

NOTICE
Excessive ether can cause piston and ring damage. Use ether for cold starting purposes only. Do not use excessive starting fluid during starting or after the engine is running.

Caterpillar engines are designed to start without starting aids at temperatures greater than 12°C (55°F). At least one of the following conditions may be necessary in order to start the engine at colder temperatures:

- the use of a jacket water and/or crankcase oil heater.
- additional volume in the air tank for air starting systems.
- greater pressure for air starting systems.
- extra battery capacity for electric starting.
- spraying starting fluid into the air inlet.
- injecting ether into the air inlet.

To start engines equipped with an ether injector:

1. Press the ether aid switch for three seconds.

2. Release the switch before performing Step 3 in the Electric Starting procedure.

Additional ether injections may be required to achieve low idle speed. Allow the engine to run at low idle until the engine runs smoothly. Allow the white smoke to disperse before proceeding with normal operation.

Optional jacket water heaters can be provided to maintain the minimum temperature when the engine is not running. Immersion heaters are not recommended for crankcase oil heating.

Consult with your Caterpillar dealer about starting at temperatures below −18°C (0°F).

After Starting The Engine

NOTICE

If the oil pressure does not rise within ten seconds after starting, stop the engine and make necessary repairs.

Warm-up

1. Run the engine at low idle for three to five minutes, or until the jacket water temperature starts to rise.

2. Check all gauges during the warm up period. The warm up requires approximately:

- five minutes when the temperature is over 0°C (32°F).
- fifteen minutes when the temperature is below 0°C (32°F).

More time may be necessary when the temperature is below −18°C (0°F).

3. Make another walk-around inspection. Check the engine for fluid and air leaks. Measure the crankcase oil level on the LOW IDLE side of the dipstick. Maintain the oil level between the ADD and FULL marks.

4. Increase the rpm to ½ rated speed. Check for fluid and air leaks. The engine may be operated at full rated speed and full load when the jacket water temperature reaches 66°C (150°F).

Applying the Load

To engage driven equipment before applying the load:

1. Operate the engine at ½ rated speed.

2. Engage the driven equipment without a load on the equipment.

Interrupted starts put excessive stress on the drive train and waste fuel. To get the driven equipment in motion, engage the clutch smoothly, with no load on the equipment. This should result in a smooth, easy start without increasing the engine speed or slipping the clutch.

To apply the load:

1. Make sure the engine gauges register in normal ranges with the engine operating at ½ rated speed. If the driven equipment is already engaged without load, make sure any equipment gauges register in normal ranges.

2. Increase the engine rpm to rated speed. Always increase engine speed to rated speed before applying the load.

3. Apply the load. Begin operating the engine at low load. Check the gauges and equipment for proper operation. After normal oil pressure is reached and the temperature gauge begins to move, the engine may be operated at full load.

If the load varies, or is cyclic, the governor will adjust the engine speed as required.

Extended operation at low idle or reduced load may cause increased oil consumption and carbon build-up in the cylinders. This carbon build-up results in loss of power and/or poor performance. When operating at reduced load, the engine should be fully loaded to burn excess carbon from the cylinders at least every four hours. Check the gauges and equipment frequently while operating under load.

Engine Stopping

NOTICE

Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of the engine components. Allow the engine to engine cool down before stopping. Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

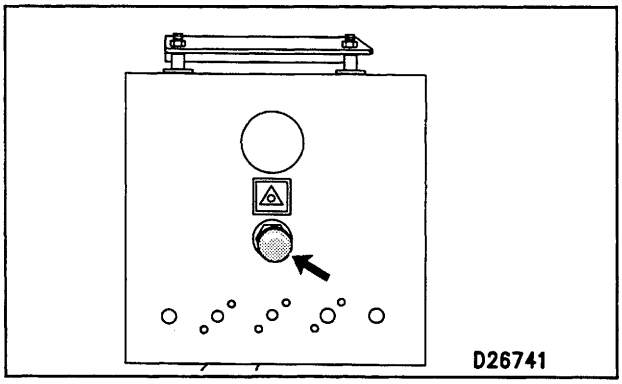
Emergency Stopping

NOTICE

Emergency shutoff controls are for EMERGENCY use ONLY. DO NOT use Emergency shutoff devices or controls for normal stopping procedure.

Make sure that any external system components that have been operating to support engine operation are secured after any stop.

Emergency Stop Buttons

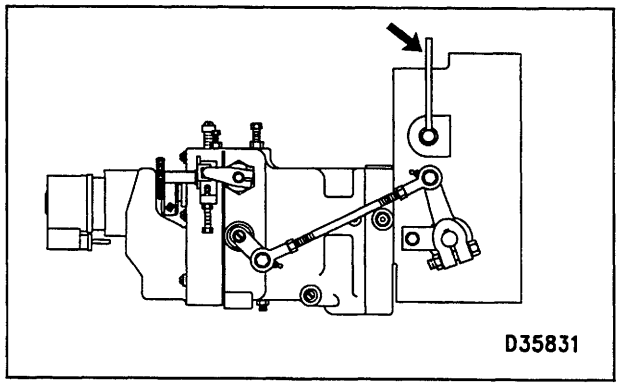


Emergency Stop Button, shown mounted on a junction box.

Emergency stops may be made by pushing the Emergency Stop Button located on the junction box (if equipped). Both the button and the air inlet shutoff (if equipped) require resetting before the engine will start.

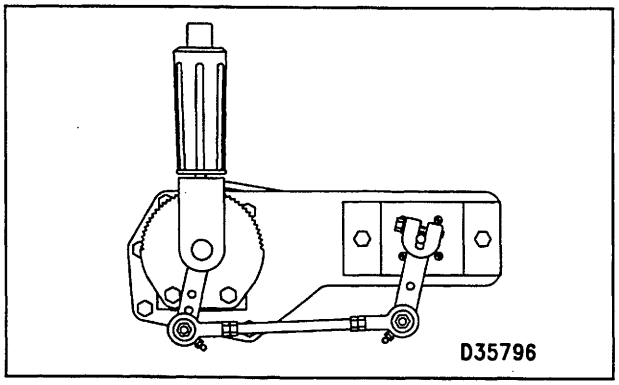
Manual Stopping

A manual shutoff shaft is provided to override the governor control. The shaft will move the fuel control linkage to the FUEL OFF position. Refer to the Model Views for the engine location of the shaft. The engine may be stopped by using the shaft and the Woodward Actuator (if equipped) or the Mechanical Governor (if equipped).



Typical Woodward Actuator Control Lever.

If equipped with a Woodward Actuator, move the control lever to the FUEL OFF position.



Typical Mechanical Governor Control

If equipped with a Mechanical Governor Control, move the control to the FUEL OFF position.

Hold the lever at the FUEL OFF position until the engine stops.

Air Shutoff (If Equipped)

Some engines are equipped with an air shutoff, located between the aftercooler and the turbocharger. If equipped with an air shutoff lever, move the lever to the OFF position.

Manual Stop Procedure

There may be several ways to shut off your engine. Make sure the shutoff procedures are understood. Use the following general guidelines for stopping the engine.

1. Disengage any driven equipment or remove the load from engine.

2. Allow the engine to run at rated speed for five minutes.

3. Run the engine at ½ rated speed for two to three minutes.

4. Reduce the engine speed to low idle for 30 seconds.

Check the crankcase oil level during the engine idle. Read the LOW IDLE side of the dipstick. Maintain the oil level between the ADD and FULL marks.

5. Shut the engine off by turning the start/stop switch to the stop or off position.

After Stopping the Engine

- Check the crankcase oil level. Maintain the oil level between the ADD and FULL marks in the FULL RANGE zone on the dipstick.
- Repair any leaks, perform minor adjustments, tighten loose bolts, etc.
- Note the service hour meter reading. Perform periodic maintenance as instructed in the Maintenance Schedule.
- Fill the fuel tank to prevent accumulation of moisture in the fuel. Do not overfill.

NOTICE

Only use antifreeze/coolant mixtures recommended in the Cooling System Specifications of this manual. Failure to do so can cause engine damage.

- Allow the radiator and engine jacket water system to cool. Check the coolant level. Maintain the cooling system to 13 mm (½ inch) from bottom of the fill pipe.

If freezing temperatures are expected, check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected ambient (outside) temperature. Add the proper coolant and water mixture if necessary.

Engine Operation

Proper operation and maintenance are key factors in obtaining the maximum life and economy of the engine. Following the directions in this manual will lower operating costs.

The time needed for the engine to reach the normal mode of operation is usually less than the time taken for a walk-around-inspection of the engine.

After the engine is started and the cold low idle operation is completed, the engine can be operated at rated speed and low power. The engine will reach normal operating temperature faster when operated at rated speed and low power demand than when idled at no load. Typically the engine should be up to operating temperature in a few minutes.

Gauges readings should be observed and the data recorded frequently while the engine is operating. Comparing the data over time will help determine normal readings for each gauge, and help detect abnormal operating developments. Significant changes in the readings should be investigated.

Fuel Conservation Practices

The efficiency of your engine can affect the fuel economy. Caterpillar's state-of-the-art design and manufacturing technology provides maximum fuel efficiency in all applications. Follow the recommended operating and maintenance procedures to attain optimum performance for the life of your engine.

- Avoid fuel spillage. Fuel expands when warmed, and may overflow from a too-full fuel tank. Inspect fuel lines for leaks, and repair immediately.
- Be aware of the heat values of different fuels. Use only recommended fuels.
- Avoid unnecessary idling. Shut the engine off rather than idle for long periods of time (unless the temperature is extremely cold).
- Observe the air service indicator frequently, and keep the air cleaner elements clean.
- Make sure that turbochargers are operating correctly so that the proper air/fuel ratio is maintained. Clean exhaust indicates proper functioning.
- Maintain a good electrical system. One bad battery cell will overwork the alternator, consuming excess power and fuel.
- Make sure that belts are properly adjusted and in good condition.
- Make sure that all air hose connections are tight and do not leak.
- Cold engines consume excess fuel. Utilize jacket water and exhaust system heat when possible. Keep radiator fins and water pumps clean and in good repair. Never operate without thermostats. All of these items will help maintain operating temperatures.
- Fuel system settings and altitude limits are stamped on the engine Information Plate. If an engine is moved to a higher altitude, settings must be changed by a Caterpillar dealer in order to prevent turbocharger damage and provide maximum engine efficiency. Engines can be operated safely at lower altitudes, but will deliver less horsepower. The fuel settings should be changed by a Caterpillar dealer to obtain the rated horsepower.

Cold Weather Operation

Caterpillar Diesel Engines can operate effectively in cold weather. However, engine operation in cold weather is dependent on the type of fuel used and how well the fuel moves through fuel related components. The purpose of this section is to explain some of the problems and steps that can be taken to minimize fuel problems during cold weather operation, when the engine area is colder than 5°C (40°F).

Radiator Restrictions

Caterpillar discourages the use of air flow restriction devices mounted in front of radiators with air-to-air aftercooled engines. Air flow restriction can cause higher exhaust temperatures, power loss, excessive fan usage, and a reduction in fuel economy.

If an air flow restriction device must be used, the device should have a permanent opening directly in line with the fan hub. The device must have a minimum opening dimension of at least 770 cm^2 (120 in^2).

A centered opening, directly in line with the fan hub, is specified to provide sensing when viscous fan drives are used and/or to prevent an interrupted air flow on the fan blades. Interrupted air flow on the fan blades could cause a fan failure.

Caterpillar recommends that a package include an intake manifold temperature device, such as a light indicator, buzzer, etc., set at 65°C (150°F) and/or installation of an inlet air temperature gauge. For the ATAAC engines, air temperature in the intake manifold should not exceed 65°C (150°F). Temperatures exceeding this limit can cause power loss and potential engine damage.

This temperature provides engine protection for full restriction device closure. This temperature can also serve as a diagnostic tool for a malfunction of the charge air cooling system. It is not anticipated that a temperature of 65°C (150°F) will be encountered under normal operating conditions.

Fuel and the Effect from Cold Weather

The two types of diesel fuel available for your engine are typically grades No.1 and No.2. No.2 diesel fuel is the most commonly used fuel. No.1 diesel fuel, or a blend of No.1 and No.2, is best suited for cold weather operation.

Quantities of No.1 diesel fuel are limited, and generally only available during the winter months in the colder climates. During cold weather operation, if No.1 fuel is unavailable, it may be necessary to use No.2 diesel fuel.

There are three major differences between No.1 and No.2 diesel fuel. No.1 diesel fuel has:
- a lower cloud point
- a lower pour point
- a lower BTU (kJ) (heat content) rating per unit volume of fuel than the average No.2 diesel fuel.

When using No.1 diesel fuel, you may notice a drop in power and fuel efficiency. You should not experience any other operating effects.

The cloud point is the temperature at which a cloud or haze of wax crystals begins to form in the fuel and cause fuel filters to plug. The pour point is the temperature which diesel fuel begins to thicken and be more resistant to flow through fuel pumps and lines.

Be aware of these fuel values when purchasing your diesel fuel. Anticipate the average outside (ambient) temperature for the area your engine will be operating. Engines fueled in one climate may not operate satisfactorily if moved to another because of problems that result from cold weather.

Before troubleshooting for low power or poor performance in winter months, check the type of fuel being used.

When No.2 diesel fuel is used: starting aids, engine oil pan heaters, engine coolant heaters, fuel heaters, and fuel line insulation also provide a means of minimizing starting and fuel problems in cold weather .

Fuel Related Components in Cold Weather

Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off fuel tanks before leaving overnight.

Fuel tanks should contain some provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe.

Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If equipped with this system, regular maintenance of the fuel system filter(s) is important.

Check the fuel level in the day tank daily by observing the sight gauge. Drain the water and sediment from any fuel storage tank weekly, at the oil change period, and before the fuel tank is refilled. This will help prevent water and/or sediment from being pumped from the fuel storage tank into the engine fuel tank.

Fuel Filters

A primary fuel filter is installed between the fuel tank and the engine fuel inlet. After changing the fuel filter(s), always prime the fuel system (if equipped with a priming pump) to remove air bubbles from the system.

The micron rating and location of a primary fuel filter is important in cold weather operation. The primary filter and the fuel supply line to the primary filter are the most common components affected by cold fuel.

The micron rating of the primary fuel filter should only be fine (low) enough to protect the fuel transfer pump. A very fine (low micron rating) primary filter, can be more easily plugged by wax in cold weather.

NOTE: Refer to the Parts Manual for this engine to determine the part numbers required for the fuel filters.

Fuel Heaters

Fuel heaters prevent fuel filters from plugging in cold weather due to waxing. A fuel heater should be installed so that the fuel is heated before it enters the first (primary) fuel filter.

Select a fuel heater that is mechanically simple, yet adequate for the application. The fuel heater should also prevent overheating of the fuel. High fuel temperatures reduce engine performance and power availability. Choose a fuel heater with as large a heating surface as practical. Small heaters can be too hot in their limited surface area.

Disconnect or deactivate the fuel heater in warm weather.

NOTE: Only thermostatically controlled or self-regulating fuel heaters should be used with this engine. Non-thermostatically controlled fuel heaters can heat the fuel in excess of 65°C (149°F). A loss of engine power can occur if the fuel supply temperature exceeds 37°C (100°F).

NOTE: Heat exchanger-type fuel heaters should have a bypass provision to prevent overheating of the fuel in warm weather operation.

The following fuel heaters are recommended for use with Caterpillar engines.

7C3557 Fuel Filter Heater
7C3558 Heater Kit

For further information on fuel heaters, contact your Caterpillar dealer.

Scheduled Oil Sampling S•O•S Analysis

Caterpillar's Scheduled Oil Sampling S•O•S analysis is the best indicator for determining what is happening inside your engine.

S•O•S analysis is a diagnostic tool used to determine oil performance and component wear rates. S•O•S analysis uses a series of tests designed to identify and measure contamination such as:
- soot, sulfur, etc.
- degradation such as the presence of fuel, water and antifreeze in a sample of oil.
- the amount of wear metals present in the oil sample.

Wear metals present in the oil sample are compared to established Caterpillar norms to determine acceptability. S•O•S analysis must be performed on a continuing basis to be effective as an indicator. Intermittent sampling does not allow wear rate trend lines to be established.

Obtain S•O•S samples at regularly scheduled intervals to monitor the condition and maintenance requirements of your engine. Each oil sample should be taken when the oil is warm and well mixed to ensure that the sample is representative of the oil in the engine crankcase.

Consult your Caterpillar dealer for complete information and assistance in establishing an S•O•S analysis program for your engine(s).

S•O•S Analysis

S•O•S analysis is composed of three basic tests:

- Wear Analysis
- Chemical and Physical Tests
- Oil Condition Analysis

Wear analysis is performed with an atomic absorption spectrophotometer to monitor component wear by identifying and measuring concentrations, in parts per million, of wear elements present in the oil. Based on known normal concentration data, maximum limits of wear elements are established. Impending failures can be identified when test results deviate from concentration levels established as acceptable, based on normal wear.

Chemical and physical tests detect the presence of water, fuel and glycol (antifreeze) in the oil and determine whether or not their concentrations exceed established maximum limits.

Oil condition is evaluated with infrared analysis. This test determines the presence and measures the amount of contaminants such as soot, sulfur products, oxidation, and nitration products in the oil. Infrared analysis can also assist in customizing (reducing, maintaining or extending) oil change intervals for particular conditions and applications.

Infrared analysis should always be accompanied by wear element analysis and chemical and physical tests to assure accurate diagnosis.

NOTE: Infrared analysis must be used to determine oil change intervals. S•O•S analysis must include Infrared (IR) in the analysis.

The test results of the oil samples will then be used as a basis for determining the oil change interval for your engine, giving you the ultimate time between oil changes without the risk of engine damage.

Refer to Caterpillar pamphlet Listen To Your Oil, PEDP1129, for information and benefits of S•O•S analysis.

Maintenance Terminology

Adjust – to conform and correspond to specifications.

Check – to observe for satisfactory conditions, accuracy, safety or performance.

Exchange – to trade a worn or failing component for a remanufactured or rebuilt component.

Inspect – to examine closely, in critical appraisal, while testing or evaluating components or systems.

Inspect/Rebuild or Exchange – to examine closely, then making the decision on repair option (i.e. Rebuild or Exchange).

Lubricate – to apply a lubricant (oil, grease, etc.) as specified for reducing friction, heat and wear between solid surfaces.

Protective Devices – indicators such as gauges, lights, emergency shutoffs, etc., that alert an operator that a potential problem may exist. Failure to respond to these indicators in a timely manner could result in serious engine damage.

Rebuild – to repair a worn or failing component with new parts, components and/or remanufactured components.

Replace – to install something new, remanufactured or rebuilt in place of an existing worn or failing component.

Service Hours (Electrical) – records the time (clock hours) the engine is actually running but does not reflect variations in speed, load, etc.

NOTE: Some engines are equipped with mechanical service meters reading in Service Meter Units (SMU). The Maintenance Schedules are developed for clock hours or fuel consumption. For most users, clock hours are the standard interval for maintenance and SMU's can be roughly equal to clock hours. However, Caterpillar recommends that fuel consumption be used as the preferred method of determining intervals rather than SMU's or clock hours.

Interval Categories

Engine components can generally be grouped into speed sensitive and load sensitive categories. The maintenance interval for each item listed in the Maintenance Schedule is based on either engine speed or load.

Speed sensitive items such as water pumps and air compressors are not primarily affected by the operating load on your engine. The load on an engine will not significantly accelerate the repair or replacement cycle for speed sensitive items.

The maintenance intervals established for speed sensitive items are based on service hours.

Load sensitive items such as piston rings and cylinder liners are affected by the operating load on your engine. Generally speaking, the lower the load, the longer the engine life. Conversely, the higher the load, the shorter the engine life. A heavy load on an engine will accelerate the repair or replacement cycle for load sensitive items.

Load sensitive items are normally internal engine components. The amount of fuel consumed is directly related to the load on your engine.

The maintenance interval for load sensitive items includes fuel consumption, since the amount of fuel consumed is directly related to the load on your engine.

Caterpillar recommends performing maintenance on load sensitive items at maintenance intervals based on the quantity of fuel consumed.

Refill Capacities

Lubrication System

The Engine Crankcase REFILL CAPACITIES reflect the approximate crankcase/sump capacity plus standard oil filter(s). Auxiliary oil filter systems will require additional oil. Refer to the OEM specifications for auxiliary oil filter capacity. Refer to the Lubricant Specifications section in this manual for lubricant recommendations.

Cooling System

In order to properly maintain the cooling system, Total Cooling System capacity must be known. The approximate Engine Only cooling system capacity is listed in the REFILL CAPACITIES chart. External System capacities will vary among applications. This capacity information will be needed to determine the amount of antifreeze/coolant required for the cooling system. Refer to the Cooling System Specifications section in this manual for the proper antifreeze/coolant mixtures to use.

REFILL CAPACITIES (APPROXIMATE)		
Compartment or System	**Liters**	**US Quarts**
Engine Crankcase[1]	34.1	36.0
COOLING SYSTEM		
Engine Only	22.7	24.0
External System[2]		
Total Cooling System[3]		

[1] Approximate crankcase/sump capacity including standard oil filter(s). Auxiliary oil filter systems will require additional oil. Refer to the OEM specifications for auxiliary oil filter capacity.

[2] The External System consists of either a radiator or an expansion tank and piping. Refer to the Caterpillar or the OEM specifications for your engine's External System capacity. Enter the capacity in this row.

[3] The Engine Only plus the External System capacity equals the Total Cooling System capacity. Enter the Total in this row.

Maintenance Schedule

3406C Industrial Engine

Use fuel consumption, service hours, or calendar time, whichever occurs first, to determine maintenance intervals.

NOTE: Experience has shown that maintenance intervals are most accurately scheduled on the basis of fuel consumed rather than service hours.

Daily

First 250 Hours or 9500 L (2500 gal) of Fuel*

Every 250 Hours or 9500 L (2500 gal) of Fuel*

Every 1000 Hours or 28,500 L (10,000 gal) of Fuel*

Every 3000 Hours or Two Years or 114,000 L (30,000 gal) of Fuel*

Every 5000 Hours or 190,000 L (50,000 gal) of Fuel*

Every 6000 Hours or 228,000 L (60,000 gal) of Fuel or Four Years

Overhaul Every 10,000 Hours or 380,000 L (100,000 gal) of Fuel*

*Perform previous maintenance interval items before performing this maintenance.

Daily

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Walk-Around Inspection

Inspect Engine for Leaks and Loose Connections

A walk-around inspection should only take a few minutes of your time. By taking the time to make these checks, costly repairs and accidents can be avoided and your equipment will be ready to run should the need arise.

For maximum engine service life, make a thorough inspection before starting the engine. Look for items such as oil or coolant leaks, loose bolts, worn fan belts, loose electrical and mechanical connections, and trash build-up. Remove trash build-up and make repairs as needed.

Keep a close watch for leaks. If leaking is observed, find the source and correct the leak. If leaking is suspected: check the fluid levels more frequently than the recommended maintenance intervals and continue to monitor fluid levels until any leak is found and fixed.

- Wipe all fittings, caps and plugs before servicing to reduce the chance of system contamination.

Inspect:

- Radiator and ATAAC cores for leaks and trash build-up.
- Radiator and ATAAC air intake system hoses and elbows for cracks and loose clamps.
- Fan and accessory drive belts for cracks, breaks or other damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt of a two or three belt set is replaced, it will carry more of a load than the belts not replaced since the older belts are stretched. The additional load on the new belt could cause it to break.

Inspect:

- Water pump for coolant leaks at weep hole. Check the weep hole for water pump breather filter blockage. Replace the filter if necessary.

NOTE: The water pump seal is lubricated by coolant. It is normal for a small amount of leakage to occur as the engine cools down and parts contract. Excessive coolant leakage may indicate the need to replace the water pump seal. If excessive leakage occurs, check the coolant level frequently and continue to monitor the level until the water pump is repaired.

Inspect:

- Lube system components (such as front and rear crankshaft seals, oil pan, oil filters and valve covers) for leaks.
- Fuel system for leaks, loose fuel line clamps and fittings and loose or worn hoses.
- Air intake system hoses and elbows for cracks and loose clamps.
- Engine wiring and electronic wiring harnesses for loose connections and worn or frayed wires.
- Engine electrical grounding system for good connections and condition.
- Machine guards- all guards must be in place. Repair or replace missing or damaged guards.
- Batteries and the level of electrolyte, unless equipped with a maintenance free battery. Disconnect any battery chargers that are not protected against current drain. Refer to the OEM recommendations for battery maintenance.
- Gauges- observe gauge readings frequently and keep a log of gauge readings. Check for loose or damaged components, and make repairs as needed.
- Air service indicator. Service the air cleaner element if the yellow diaphragm enters the red zone, or if the red piston locks in position.
- Listen to the engine during operation, and investigate the cause of any unusual noises.

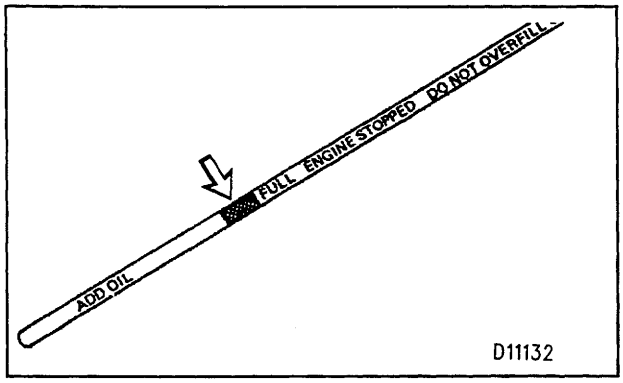
Make sure that the engine is shut off and will not start before you make necessary repairs.

Engine Crankcase

NOTICE
Make sure you read and understand the information in the Safety and Lubricant Specifications sections of this manual before you proceed with maintenance of the crankcase lube oil system.

Check Oil Level

Make sure that you read the correct side of the dipstick. One side of the dipstick is marked for checking the oil level when the engine is stopped. The other side of the dipstick is marked for checking the oil level when the engine is running at low idle.



Maintain the oil level between the ADD and FULL marks on the ENGINE STOPPED side of the dipstick. Remove the oil filler cap and pour oil into the filler tube, if necessary. Do not fill the crankcase above the FULL mark.

NOTICE
Operating your engine when the oil level is above the FULL mark may reduce the lubricating characteristics of your oil and cause engine damage.

Cooling System

NOTICE
Make sure you read and understand the information in the Safety and Cooling System Specifications sections of this manual before you proceed with maintenance of the cooling system.

Check Coolant Level

1. Check the coolant level with the engine stopped and cool.

2. Remove the radiator or expansion tank filler cap slowly to relieve any pressure.

3. Maintain the coolant level within 13 mm (½ inch) below the bottom of the fill pipe or to the proper level on the sight glass (if equipped).

4. Inspect the radiator filler cap. Replace the cap if gaskets are damaged. Install the filler cap.

Air Cleaner

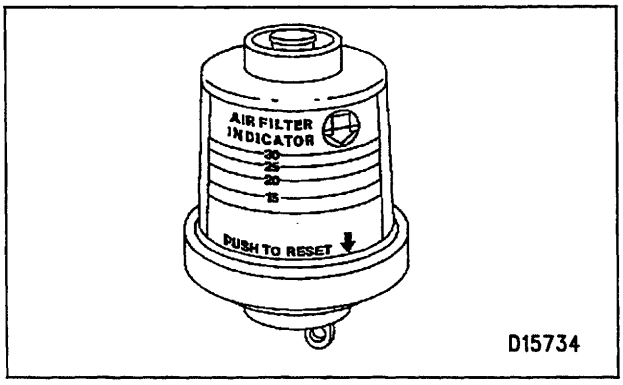
Check Service Indicator

NOTICE
Never run the engine without an air cleaner installed. Never run the engine with a damaged air cleaner. Do not use filter elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaners prevent airborne debris from entering the engine through the air inlet.

NOTICE
Service the air cleaners with the engine stopped. Never service the air cleaner with the engine running since this will allow dirt to enter the engine.

If your air cleaner element becomes plugged, the air can split the element filter material. This allows unfiltered air into the engine which would drastically accelerate internal engine wear.

An air cleaner differential pressure gauge may be located in the engine compartment or on the gauge panel. The air cleaner differential pressure gauge indicates the difference of air pressure between the inlet (dirty) side and the engine (clean) side of the filter element. The pressure difference between the two sides increases as the filter becomes plugged.



Typical air cleaner service indicator.

This engine may be equipped with an air cleaner mounted service indicator. The engine may be equipped with a different indicator or a gauge. If the engine is equipped with an intake restriction gauge or some other system, follow the OEM recommendations.

A colored piston showing in the window indicates the need for servicing the air cleaner element. Clean or replace the air cleaner element when the yellow diaphragm enters the red zone or the red piston locks in the visible position. After servicing the air cleaner, reset the service indicator by pushing on the piston plunger.

Test Service Indicator

Air cleaner service indicators are inexpensive but important instruments.

- Check for ease of resetting. The indicator should reset in less than three pushes.
- Check the movement of the yellow core when the engine is accelerated to rated speed. The yellow core should latch approximately at the greatest vacuum that is attained.

If the indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the indicator should be replaced. If the new indicator will not reset, the indicator sensor hole may be plugged.

Severely dusty environments may require frequent indicator replacements. Replace the indicator yearly, regardless of operating conditions. Replace the indicator at Overhaul, and whenever major engine components are replaced.

NOTE: When you install a new indicator, excessive force may crack the top of the indicator. Tighten the indicator to a torque of 2 N•m (18 lb in).

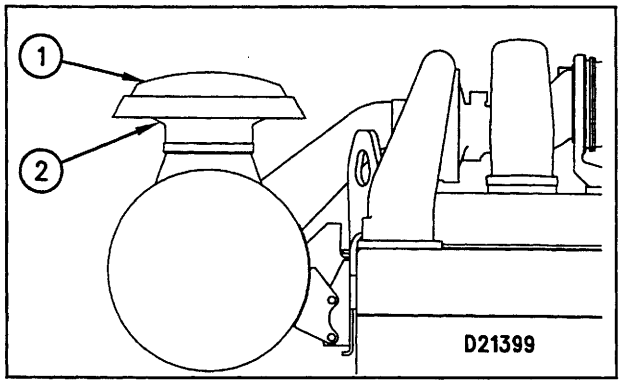
Service Air Cleaner

- Replace air cleaner elements at intervals recommended by the air cleaner OEM.
- Operating conditions (dust, dirt and debris) may require more frequent air cleaner element maintenance.
- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris as needed.

Replace dirty paper elements with new ones. Keep spare filter elements on hand for replacement. The element should be thoroughly checked for rips or tears in the filter material, seal/gasket damage, and replaced at least every year. Maintain a replacement supply of suitable air filter elements.

Dust Collector (If Equipped)

Clean



Typical two stage air cleaner. Individual applications may be different.

1. Remove the air cleaner cap (1). Remove the dust collector cup (2).

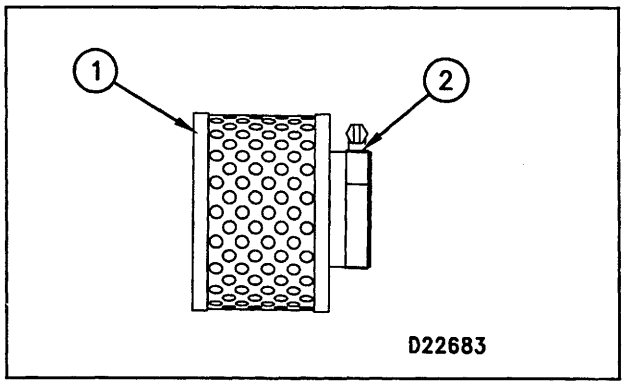
2. Wipe dust collector cup with a clean, dry cloth.

3. Install the cup. Install and secure the cap.

Light Duty Air Cleaner (If Equipped)

Light duty air cleaners are not serviceable (washable). Light duty air cleaners are intended for a 50 service hours of maximum use, or one year, whichever occurs first. However, engines operating in a severe environment may require more frequent air cleaner replacement.

Replace



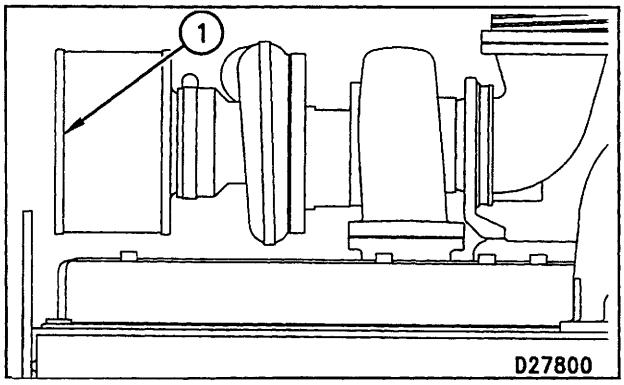
1. Loosen the clamp (2) fastening the air cleaner element (1) to the air intake, and remove the dirty element and clamp.

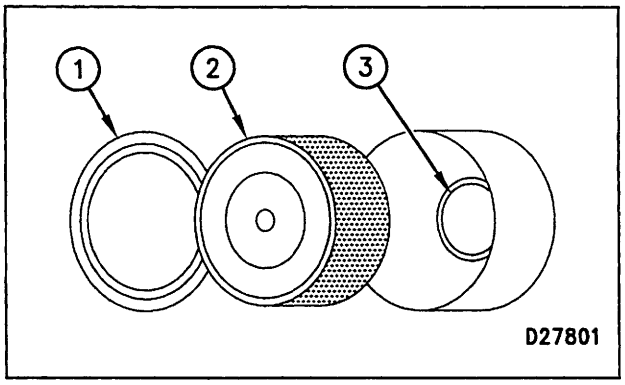
2. Install the clamp on a new element.

3. Install the new element to the air intake and tighten the clamp.

Single Stage Air Cleaner Elements

Remove and Install Air Cleaner Elements





1. Remove the air cleaner cover (1) and element (2).

2. Seal the turbocharger air inlet (3) so that debris can not enter the inlet. Use tape, or secure a clean cloth over the opening.

3. Clean the inside of the air cleaner cover and body. 003796Inspect the replacement element for damage, dirt or debris.

5. Remove the seal from the turbocharger inlet.

6. Install a clean, undamaged element.

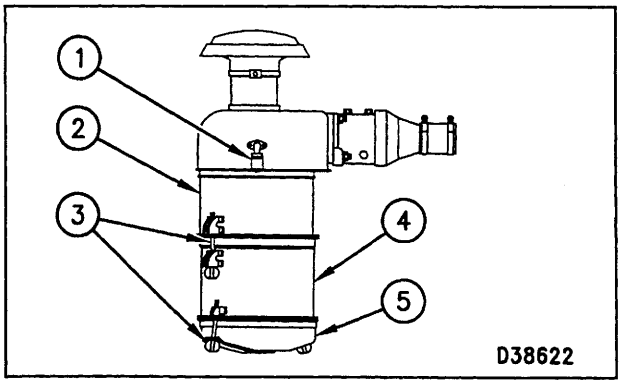
7. Install the air cleaner cover.

8. Reset the service indicator.

Heavy Duty Air Cleaners

Engines equipped with heavy duty air cleaners have a serviceable air cleaner element. The element may be cleaned up to six times, but must be replaced Every Year.

Remove and Install Air Cleaner Elements



Heavy duty air cleaner: service indicator (1), upper body (air filter element housing) (2), clamps (3), lower body (tube element) (4), and dust collector cup (5).

1. Loosen clamps (3) between lower body (4) and dust collector cup (5). Remove the cup.

2. Loosen the clamps between the lower body and the upper body (2). Remove the tube element.

3. Clean the tubes from both sides with water or air.

4. Remove the air filter element from the upper body (2). Wipe the inside of the upper body clean.

5. Inspect a clean air filter element. Install a clean or new element.

6. Inspect the gasket between the upper body and lower body. Inspect the seal between the lower body and the dust collector cup. Install a new gasket and seal if necessary.

7. Install the cleaned, dry tube element. Tighten the retaining clamps attaching the lower body to the upper body.

8. Wipe the dust collector cup clean. Install the cup and tighten the retaining clamps.

9. Reset the service indicator (1).

Cleaning Air Filter Elements

The primary element (Caterpillar air filters) can be cleaned several times before replacement. The element, when cleaned, should be thoroughly checked for rips or tears in the filter material.

Replace the primary element at least Every Year regardless of operating hours it has accumulated.

NOTICE

Do not clean filter elements by bumping or tapping.

Do not use filter elements with damaged pleats, gaskets or seals. Engine damage could result.

Filter elements can be cleaned with air pressure, 205 kPa (30 psi) maximum, or water pressure, 280 kPa (40 psi) maximum, or detergent washing. Have spare elements on hand to use while cleaning used elements.

- Direct air or water along the length of the pleats inside and outside of filter element.

The element can be washed in warm water and nonsudsing household detergent, such as automatic dishwasher detergent. Rinse inside and outside the pleats. The filter should then be thoroughly air dried and inspected.

- Inspect the filter elements after cleaning for any rips, tears or damage. Insert a light inside of the clean, dry element. Do not use a filter element with damaged pleats, gaskets or seals. Discard the element if damaged.

- Wrap and store the clean filter elements in a clean, dry place.

- Reset the service indicator by pushing the piston plunger in.

For more information on air cleaner element cleaning, refer to Guideline for Reusable Parts-Cleaning and Inspection of Air Filters, SEBF8062.

Air Starter & Air Tank (If Equipped)

Check Lubricator Level

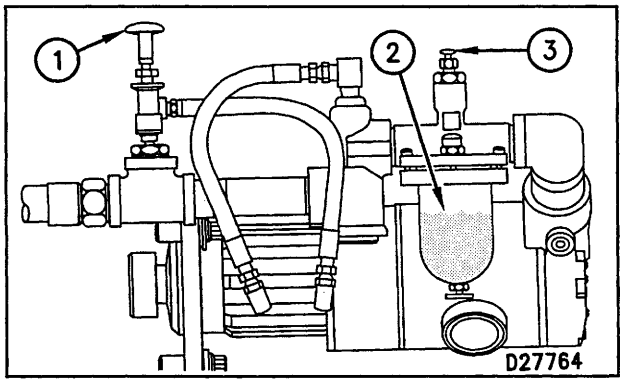
NOTICE

Never allow the lubricator bowl (if equipped) to become empty. The starting motor will be damaged by lack of proper lubrication.

The vanes of the starting motor are lubricated with a fine mist of oil from the motor lubricator. Check the level of oil in the lubricator bowl. If the bowl is less than half full, add lubricant. Use non detergent 10W engine oil for temperatures that are greater than 0°C (32°F). Use air tool oil for temperatures below 0°C (32°F).

Oiler Feed Adjustment

If necessary, adjust the lubricator to release approximately two drops of fluid per 30 seconds into the starting motor air stream.



Air Start Valve (1), Lubricator Bowl (2), and Adjustment Knob (3).

Be sure there is NO fuel supply to the engine.

1. Turn the adjustment knob CW until the knob locks.
2. Turn the adjustment knob CCW ¼ turn.

3. Crank the starter motor for ten seconds and observe the exhaust air from the starter motor mufflers. Look for oil mist. You should see a slight oil mist. The mist should be barely visible.

If no mist is observed, or if the mist is excessive: rotate the adjustment knob in 1/16 turn increments to increase or decrease the oil mist. Repeat the starter cranking and observation until the mist is satisfactory.

NOTE: Drip rates should only be made under an average steady flow condition. Once established, the lubricator will automatically adjust the drip rate proportionally to variations in air flow.

Air Tank (If Equipped)

For good life of the air starting motor, the air supply must be free of dirt and water. The air starter requires adequate air pressure in order to operate.

- Drain water from the air tank (if equipped). Open the drain valve on the bottom of the air tank to drain the condensation and oil carryover.
- Check the air supply pressure. The air starting motor requires a minimum of 620 kPa (90 psi) of air pressure to operate properly. The maximum air pressure must not exceed 1723 kPa (250 psi). The normal air pressure will be 758 to 965 kPa (110 to 140 psi).

Clutch

Check/Adjust/Lubricate

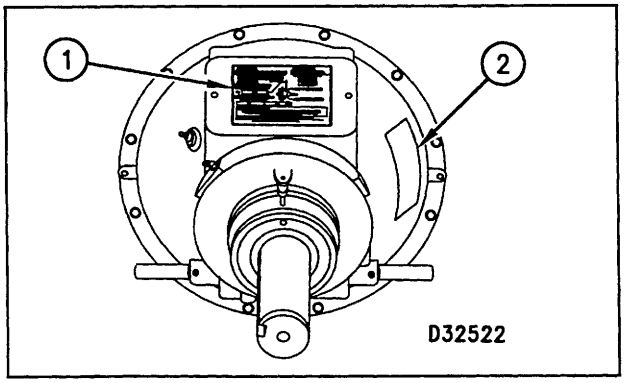
Check/Adjust

NOTICE

New power take-offs should have clutch adjustment checked before being placed in service. Clutch adjustment should be checked again after the first ten hours of operation. New clutch plates have a "wear in" period, and the clutch may require several adjustments until the new plates are "worn in."

Clutch adjustment should be checked regularly after "wear in." Heavy duty applications which have frequent engagements and relatively long periods of clutch slip require more frequent adjustment than light duty applications. Operating torque should be measured to determine if clutch adjustment is required.

Refer to the clutch OEM service instructions and the clutch instruction plate for adjustment and other service recommendations. Perform the maintenance specified on the instruction plate.



Typical clutch Instruction Plate (1) and Serial Number Plate (2) locations.

⚠ WARNING

Do Not operate the engine with Instruction Plate cover removed from the clutch. Personal injury may result.

If the clutch is damaged to the point of burst failure, expelled pieces can cause personal injury to anyone in the immediate area. Proper safeguards must be followed to prevent accidents.

Lubricate

Refer to the clutch OEM service recommendations and the clutch instruction plate for lubrication instructions. Perform the maintenance specified on the instruction plate.

Every 250 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

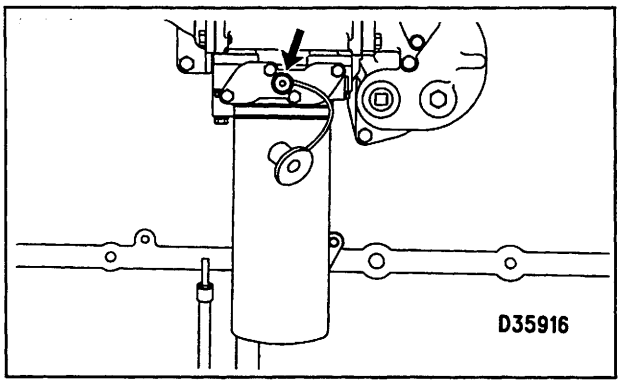
Engine Oil and Filter(s)

Scheduled Oil Sampling (S•O•S) Analysis

To compliment a good preventive maintenance program, Caterpillar recommends using S•O•S analysis at regular scheduled intervals to monitor the condition of the engine oil and maintenance requirements of your engine.

Obtain Sample

Each oil sample should be taken when the oil is warm and well mixed to ensure that the sample is representative of the oil in the crankcase. There are two methods recommended to obtain oil samples from the engine crankcase.



Typical oil sampling valve.

- Use the sampling valve (if equipped).
- Use a sampling gun inserted into the sump.

NOTE: Refer to How to Take a Good Oil Sample, PEHP6001 for a step-by-step explanation if using this method of sampling crankcase oil.

Caterpillar recommends using one of the above methods. If either of these methods are not possible, then use a drain stream method when changing oil.

NOTE: When using the drain stream to obtain the oil sample, do not sample from the beginning or end of drain stream. The oil at the beginning or end of the drain stream is not mixed well enough to be representative of the oil in the crankcase.

Oil Change Intervals

Many conditions exist that can affect the selection of an optimum oil change period. The fundamental requirement in this decision must be to maintain the lube oil in an acceptable condition that provides continual engine protection. The quality and amount of oil available is balanced against the oil's ability to absorb combustion by-products.

Due to manufacturing tolerances, engine application and maintenance variations, all engines do not consume fuel and oil at the same rate. The amount of fuel consumed is in direct relation to the **maximum** oil change interval selected.

All oils do not perform equally. Lower quality lube oil requires reduced oil change intervals. Oil analysis provides the best indication of when to change oil.

Consult your Caterpillar dealer for complete information and assistance in establishing an S•O•S oil analysis program for your engine.

Replace Oil and Filter(s)

NOTE: Refer to the Model Views for the crankcase drain plug, oil filter, and oil filler locations.

Drain Oil

As oil cools, suspended waste particles settle on the bottom of the crankcase or oil pan. The waste particles are not removed with the draining cold oil. Drain the crankcase with the engine stopped and the oil warm. This allows for the draining of the waste particles that are suspended in the oil.

Failure to follow this recommended procedure would result in these waste particles being recirculated through your engine lubrication system with the new oil.

1. Remove the crankcase drain plugs. Plugs from both the deep and shallow portions of the oil pan should be removed to allow the oil to drain. An oil sample can be obtained for S•O•S (Scheduled Oil Sampling) analysis at this time.

2. Wipe clean and install both crankcase drain plugs.

Replace Filter(s)

NOTE: Change oil filter(s) at every oil change. Make sure to use the correct Caterpillar oil filter(s) for your engine arrangement.

NOTICE

Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe damage to your engine bearings, crankshaft, etc., as a result of the larger debris particles from unfiltered oil entering your engine lubricating system.

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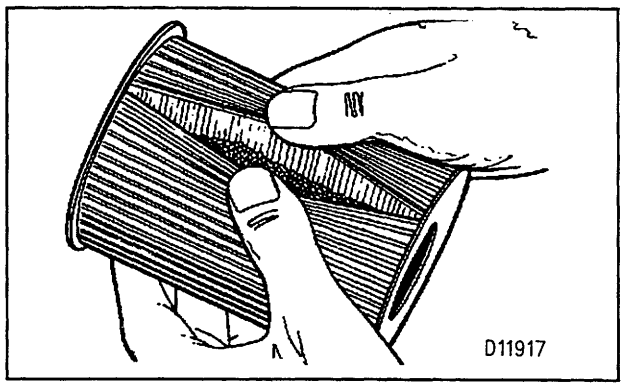
1. Remove the oil filter(s) with a 2P8250 Filter Wrench.

2. Cut the oil filter case open with a 4C5084 Oil Filter Cutter Service Tool. Spread the pleats apart and inspect the element for metal debris. An excessive amount of debris in the oil filter element may be indicative of early wear or a pending failure.



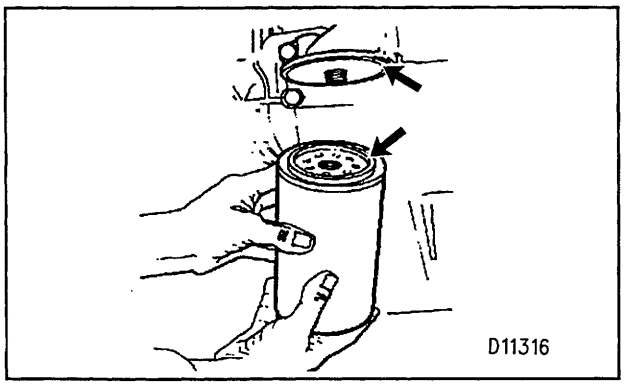
Element with debris.

Use a magnet to differentiate between the ferrous and non-ferrous metals found in your oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of your engine.

Non-ferrous metals may indicate wear on the aluminum, brass or bronze parts of your engine, such as main and rod bearings, turbocharger bearings and cylinder head wear.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter element. Consult your Caterpillar dealer to arrange for further analysis if an excessive amount of debris is found in your oil filter element.

3. Wipe the sealing surface of the filter mounting base. Make sure all of the old gasket is removed.



Filter mounting base and gasket.

4. Apply a small amount of clean engine oil to the new filter gasket.

NOTICE

Do NOT fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil will cause accelerated wear to engine components.

5. Install the new filter(s) until the gasket contacts the base. Tighten the filter ¾ of a turn more by hand. Do not over tighten. Use the rotation index marks, on the filters, as a guide for proper tightening.

Fill Crankcase

NOTE: Refer to Lubricant Specifications, Lubricant Viscosities and Refill Capacities for the proper oil and quantity to use.

NOTICE

If equipped with an auxiliary (or remote mounted oil filter) system, follow the OEM or filter manufacturer's recommendations. Either under filling or overfilling of engine crankcase oil can cause engine damage.

1. Remove the oil filler cap to fill the crankcase with new oil.

2. Fill the crankcase. Refer to the Lubricant Specifications section of this manual for the correct oil grade and viscosity. Refer to the Refill Capacities chart for the recommended quantity of oil. Allow enough time for the oil to drain into the sump.

3. Check the oil level on the ENGINE STOPPED side of the dipstick before starting the engine. Maintain the oil level between the ADD and FULL marks.

NOTICE

to prevent crankshaft bearing damage, crank the engine with the fuel OFF to fill the oil filters before starting the engine. Do not crank the engine for more than 30 seconds.

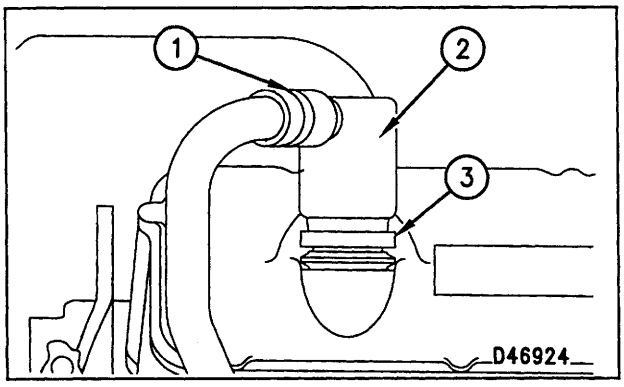
4. Start the engine. Allow the engine to run at low idle. Inspect for oil leaks.

5. Check the oil level on the LOW IDLE side of the dipstick. If necessary, add oil to maintain oil level between the ADD and FULL marks.

Crankcase Breather

Clean

NOTICE
If the crankcase breather is not maintained on a regular basis, it will become plugged. A plugged crankcase breather would result in excessive crankcase pressure that may cause crankshaft seal leakage.



Hose clamp (1), breather assembly (2), and retaining clamp (3).

1. Loosen hose clamp (1). Slide the hose from breather assembly (2).

2. Loosen retaining clamp (3). Remove breather assembly (2) and seal.

3. Wash the breather element in clean, nonflammable solvent. Allow the breather element to dry before installation.

4. Inspect the seal for cracks or damage. Replace the seal as necessary. Install the seal. Apply clean engine oil or petroleum jelly on the rubber parts to make installation easier.

5. Install the clean, dry breather assembly (2) in the same position as before removal. Secure the breather assembly with retaining clamp (3). Slide the hose onto the breather assembly. Secure the hose with hose clamp (1). Tighten the clamps to 4.5 ± 0.5 N•m (40 ± 5 lb in).

Cooling System

NOTICE
Make sure you read and understand the information in the Safety and Cooling System Specifications sections of this manual before you proceed with cooling system maintenance.

Test for SCA Or Obtain Level I Analysis (Conventional Coolant/Antifreeze Only)

The use of Caterpillar SCA will prevent internal damage to the engine, such as liner or block pitting. If the concentration level is too low, pitting of the cylinder wall may occur, which can lead to costly engine damage.

If the concentration level is too high, sludge and mud-like deposits may form in the cooling system. This adversely affects engine performance and can also lead to costly repairs of the engine and cooling system.

NOTICE
The over concentration of a supplemental coolant additive will result in deposits on the higher temperature surfaces of the cooling system and create a barrier that reduces the engine's heat transfer characteristics.

Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive concentrations of additive could also accelerate water pump seal wear.

Use the 8T5296 Test Kit to check for SCA concentration. Add SCA if the concentration is too low. If the SCA concentration is excessive, drain half the coolant, and replace with the proper water/antifreeze mixture.

NOTE: You may test your coolant SCA concentration **OR** have the SCA concentration tested as part of a S•O•S Coolant Analysis (Level I).

Obtain Level I Analysis

S•O•S Coolant Analysis is the best way to monitor the condition of your coolant and your cooling system.

Level I: Basic Coolant Maintenance Check

Checks for correct chemical balance for proper heat and corrosion control. Tests for:

- glycol
- SCA concentrations
- pH
- conductivity

Caterpillar's S•O•S Coolant Analysis reports results and makes recommendations, usually within 24 hours. Consult with your Caterpillar dealer for more information.

Add Liquid Supplemental Coolant Additive (SCA)

NOTICE
ONLY add SCA if required by the SCA test results.

1. Loosen the radiator or expansion tank filler cap slowly to relieve pressure and remove the cap.

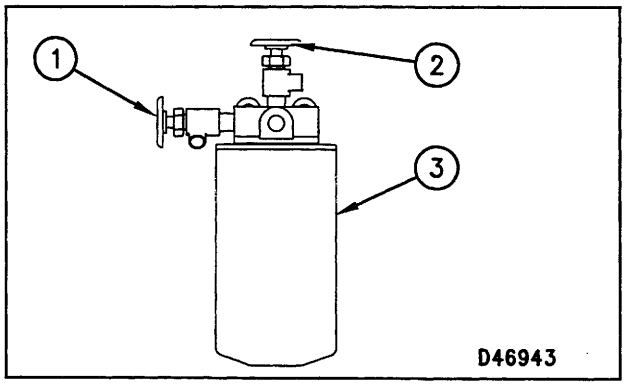
2. It may be necessary to drain enough coolant from the radiator to allow for the addition of the liquid SCA.

3. Add liquid SCA according to the requirements for your cooling system capacity. Refer to the Cooling System Specifications section of this manual for the necessary amount of liquid SCA to add.

4. Inspect the radiator filler cap gaskets. Replace the cap if the gaskets are damaged. Install the filler cap.

Replace SCA Element (If Equipped)

NOTICE
ONLY replace the SCA element if required by the SCA test results.



1. Close coolant additive element inlet valve (1) and outlet valve (2). Remove and discard coolant additive element (3).

2. Clean the element mounting base. Make sure all of the old gasket is removed.

3. Refer to the Cooling System Specifications in this manual for the proper SCA element for your system. Coat the gasket of the new SCA element with a thin film of engine oil. Install the SCA element. Spin the element until the gasket contacts the base, then tighten ¾ turn more by hand. DO NOT over tighten.

4. Open inlet and outlet valves (1) and (2).

5. Remove the radiator filler cap. Start the engine and check for leaks. Allow the coolant level to stabilize.

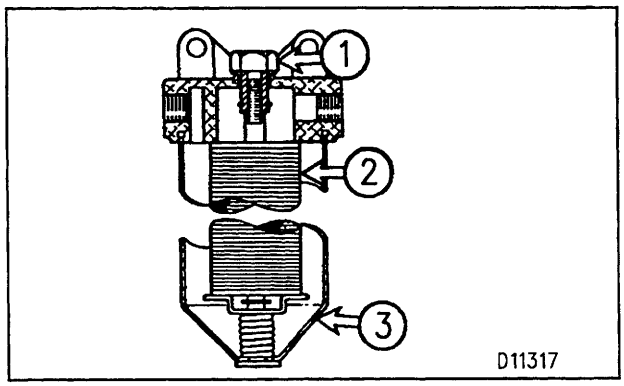
6. Add the proper premixed coolant/water, if necessary, to bring the coolant to within 13 mm (½ inch) below the bottom of the fill pipe or to the proper level on the sight glass, if equipped.

7. Inspect the filler cap. Replace the cap if the gasket is damaged. Install the filler cap.

Fuel System

Clean Primary Filter

- Stop the engine.
- Turn the start switch OFF or disconnect the battery and shut off fuel tank supply valve (if equipped) when performing maintenance on fuel filters.



1. Loosen bolt (1) on the filter housing and remove filter case (3).

2. Remove element (2) and wash it in clean, nonflammable solvent.

3. Install element (2) and filter case (3). Tighten bolt (1) to a torque of 24 ± 4 N•m (18 ± 3 lb ft).

Replace Final Fuel Filter

NOTE: Refer to the Model Views for the fuel filter and fuel priming pump locations

1. Remove and discard the used fuel filter.

2. Clean the gasket sealing surface of the fuel filter base. Make sure all of the old gasket is removed.

3. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE

Do NOT fill the fuel filters with fuel before installing them. The fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

4. Install the new fuel filter. Spin the fuel filter onto the base until the gasket contacts the base. Tighten the filter ¾ turn more by hand. Do not over tighten. Use the rotation index marks on the filters as a guide for proper tightening.

5. Prime the fuel system.

Priming the Fuel System

Prime the fuel system to fill dry fuel filters and purge trapped air. The fuel system requires priming after:

- being run dry.
- storage.
- fuel filter cleaning/replacement.

NOTE: If the engine does not have a fuel priming pump, go to step 4.

1. Unlock and operate the priming pump plunger until a resistance is felt. A considerable number of pump strokes may be required.

2. Push in and hand-tighten the plunger.

3. Crank the engine. If the engine starts, but runs rough, continue running the engine at low idle until the engine runs smoothly.

NOTICE

Do not crank the engine for more than 30 seconds. If the engine does not start, allow the starter motor to cool for two minutes before cranking again.

NOTE: If the engine will not start, or once started, continues to misfire or smoke, further priming is necessary. Repeat steps 1 through 3. If operating problems persist after repeating steps one through three, further priming is necessary.

4. Open the vent valve (if equipped) on the fuel injection pump housing.

NOTICE
DO NOT remove the plug in the fuel filter base (for the fuel pressure sending unit [if equipped]) to purge air from the fuel system. Periodic removal of the plug will result in increased wear of the threads in the fuel filter base and lead to fuel leakage.

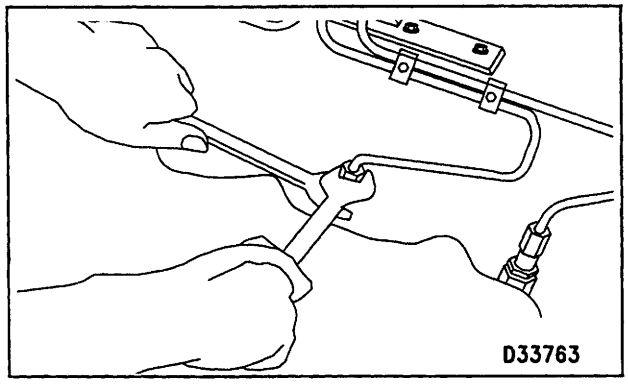
5. Operate the priming pump until the flow of fuel from the vent valve is continuous and free of air bubbles. If the engine does not have a fuel priming pump, crank the engine. Do not crank the engine for more than 30 seconds. Allow the starter to cool for two minutes before cranking again.

6. Close the vent valve. Push in and hand-tighten the plunger.

7. Crank the engine. If the engine starts, but runs rough, continue running the engine at low idle until the engine runs smoothly.

NOTE: If the engine will not start, or once started, continues to misfire or smoke, further priming is necessary.

8. Loosen the fuel line nuts, one at a time, at the valve cover base.



NOTICE
A fuel injection nozzle will be damaged if the top of the nozzle turns in the body. The engine will be damaged if a defective fuel injection nozzle is used because the fuel spray pattern that comes out of the nozzle will be incorrect. Fuel injection nozzles can be permanently damaged by twisting if only one wrench is used to loosen or tighten the fuel line nuts. Do NOT let the tops of the fuel nozzles turn when the fuel lines are loosened. Use one wrench to hold the nozzle and another to loosen the fuel line nut.

Operate the priming pump plunger until the flow of fuel from the fuel line is continuous and free of air bubbles. Push the plunger in and tighten by hand. If the engine does not have a fuel priming pump, crank the engine.

Tighten each fuel line nut before the next fuel line nut is loosened. Tighten the fuel line nuts to 40 ± 7 N•m (30 ± 5 lb ft). Continue the procedure until all of the fuel lines have been cleared of air. Make sure the fuel line nuts are tightened and the priming pump is locked before starting the engine.

Fuel Tank

Drain Water and Sediment

Water is an engine's worst enemy and most diesel fuel contains a slight amount. Condensation also occurs as fuel is heated when passing through the fuel system and cools when returned to the fuel tank. This causes water to accumulate in fuel storage tanks.

Fuel tanks should contain some provision for draining water and sediment from the bottom of the tanks.

Drain water and sediment from the fuel storage tank weekly, and before the tank is refilled. This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

Open the drain valve on the fuel tank and drain the water and sediment. Close the valve.

NOTE: Fill the fuel tank at the end of each day of operation to drive out moist air and to prevent condensation. Do not fill the tank to the top. Fuel expands as it gets warm and may overflow.

Belts, Hoses and Clamps

Inspect/Replace

Alternator and Fan Drive Belts

Inspect the condition and adjustment of alternator and accessory drive belts. Examine all drive belts for wear and replace if they show any signs of wear. Loose or worn pulley grooves cause belt slippage and low accessory drive speed. If belts are too loose, they vibrate enough to cause unnecessary wear on the belts and pulleys and possibly slip enough to cause overheating.

If belts are too tight, unnecessary stresses are placed upon the pulley bearings and belts which might shorten the life of both.

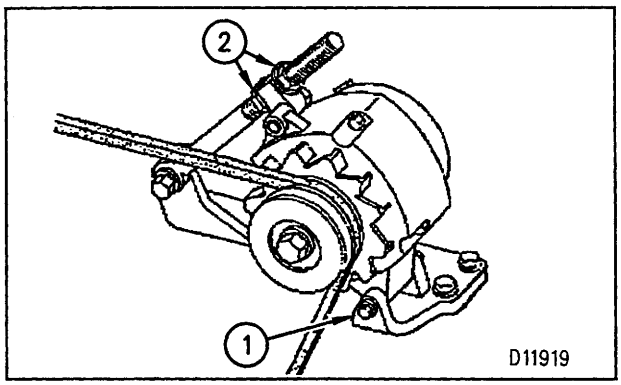
If one belt in a set requires replacement, always install a new matched set of belts. Never replace just the worn belt. If only the worn belt is replaced, the new belt will carry all the load, as it will not be stretched as much as the older belts. All the belts will fail in rapid succession.

Adjust

1. Remove belt guard. Inspect the condition and adjustment of alternator belts and accessory drive belts, if equipped.

2. To check the belt tension, apply 110 Newton (25 lb) force, perpendicular to the belt, midway between the driving and driven pulley. Measure the belt deflection. Correctly adjusted belts will deflect 15 to 20 mm (9/16 to 7/8 inch).

If the belt does not require replacement or adjustment, install the belt guard. If the belt requires adjustment or replacement, do not install the belt guard. Perform the following procedure to adjust the belt tension.



Typical belt assembly mounting bolt (1) and adjusting nuts (2).

3. Loosen the mounting bolt (1) and the locknut on the adjusting bolt.

4. Turn the adjusting nuts (2) to increase or decrease the belt tension.

5. Tighten the adjusting bolt locknut. Tighten the mounting bolts.

6. Install the belt guard.

If new belts are installed, check the belt adjustment again after 30 minutes of engine operation.

Hoses and Clamps

- Inspect all hoses for leaks due to cracking, softness and loose clamps. Replace hoses that are cracked or soft and tighten loose clamps.

NOTICE

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque.

Check for the following:

- End fittings damaged, leaking or displaced.
- Outer covering chafed or cut and wire reinforcing exposed.
- Outer covering ballooning locally.
- Evidence of kinking or crushing of the flexible part of the hose.
- Armoring embedded in the outer cover.

A constant torque hose clamp can be used in place of any standard hose clamp. Make sure the constant torque hose clamp is the same size as the standard clamp. Due to extreme temperature changes, hose will heat set. Heat setting causes hose clamps to loosen. Loose hose clamps can result in leaks. There have been reports of component failures caused by hose clamps loosening. The new, constant torque hose clamp will help prevent these failures.

Each installation application can be different depending on the type of hose, fitting material and anticipated expansion or contraction of the hose and fittings. A torque wrench should be used for proper installation of the new, constant torque hose clamps.

Hose Replacement

1. Loosen the cooling system filler cap slowly to relieve any pressure and remove the cap.

2. Drain the coolant from the cooling system to a level below the hose being replaced.

3. Remove the hose clamps, disconnect the old hose and replace with a new hose.

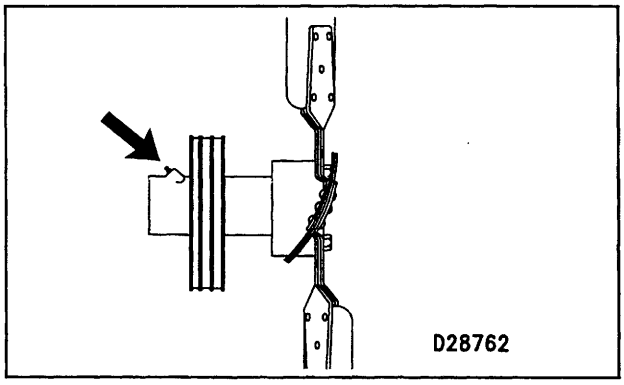
4. Install hose clamps. See the Torque for Standard Hose Clamps chart in the Torque Specifications section of this publication for the appropriate torque.

5. Add the proper coolant mixture to the cooling system. Refer to the Cooling System Specifications section in this publication for information about cooling system requirements. Fill the system to the proper level.

6. Inspect the filler cap. Replace the cap if the gasket is damaged. Install the filler cap. Start the engine and inspect for cooling system leaks.

Fan Drive

Lubricate Bearing



Lubricate one fitting.

Use 2S3230 Bearing Lubricant Special Purpose Grease to service ball and roller bearings which operate at high speeds and temperatures. NLGI No.2 Grade is acceptable for temperatures from –34 to 163°C (–20 to 325°F).

Batteries

Clean/Check Electrolyte Level (if required)

BATTERY ELECTROLYTE CHART	
Battery	**Interval**
Conventional	125 Hour
Low Maintenance	250 Hours
Maintenance Free	None Required

1. Remove filler caps. Maintain electrolyte level to bottom on fill plug openings.

If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

At proper charging rate, batteries should not require more than 30 cc (1 oz) water per cell per week.

2. Keep batteries clean.

3. Loosen and remove cable clamps from all battery terminals.

4. Clean all battery terminals.

5. Clean all cable clamps.

6. Install and tighten cable clamps to battery terminals.

7. Coat cable clamps and terminals with 5N5561 Silicone Lubricant, petroleum jelly or MPGM grease.

Check Battery Charger (if equipped)

- Check the battery charger for proper operation. If batteries are properly charged, ammeter reading should be very near zero. All batteries should be kept charged to a corrected specific gravity of 1.250 or above.

- The batteries should be kept warm, if possible. The battery temperature affects the cranking power. If the battery is too cold, it will not crank the engine, even if the engine is warm.

- When the engine is not run for long periods of time or is run for short periods, the batteries may not fully recharge. Ensure a full charge to help prevent the battery from freezing.

Battery or Battery Cable Replacement

NOTE: When replacing batteries or battery cables, use the following procedure.

1. Turn off the START switch. Turn off (open) the ignition switch (if equipped) and remove the key and all electrical loads.

2. Disconnect the cable from ground (one cable connects to frame and one to battery negative). Be sure the cable cannot contact where it was just removed.

3. Disconnect the negative battery cable terminal at the battery(s) that goes to the start switch. Where four 12 volt batteries are involved, the negative side of two batteries must be disconnected.

4. Proceed with necessary system repairs. Reverse steps to reconnect all cables.

Radiator Fins, Aftercooler

Inspect/Check

Check the radiator fins for debris. High pressure water is an excellent way to clean the debris out of the radiator fins. If necessary, use a light bulb behind the radiator fins to see if they are completely clean.

Refer to Know Your Cooling System, SEBD0518, for more detailed information on cleaning your radiator fins.

Inspect/Check Aftercooler System

Inspect the front of the air-to-air aftercooler. Examine core fins for external damage, insects, dirt, debris, salt, corrosion, etc. Use a firm stainless steel brush and soapy water to remove dirt, debris, salt, etc. Depending on your findings and operating environment, the maintenance interval for cleaning the air-to-air aftercooler may be more frequent.

A slight reduction in power or response, or a small increase in exhaust temperature, may indicate a small air leak in the charge air cooler core or piping. Inspect all air ducting and gasket connections at each oil change. Constant torque hose clamps should be secure. Tighten these clamps until the spring is at least partially compressed.

Inspect all welds for cracks. Check the mounting brackets to ensure they are secure and in good condition.

NOTE: Whenever air-to-air aftercooler parts are repaired and/or replaced, a leak test is highly recommended. Refer to the service manual or consult your Caterpillar dealer for the correct procedure to use when performing a leak test.

Every 1000 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Engine Protection Devices

Inspect/Check

The alarm and shutoff controls should be checked for proper operation in order to ensure engine protection. The manual shutoff devices should be tested for proper operation.

All checks and tests should be made by Caterpillar authorized service personnel or other qualified mechanics. Consult with your Caterpillar dealer for assistance.

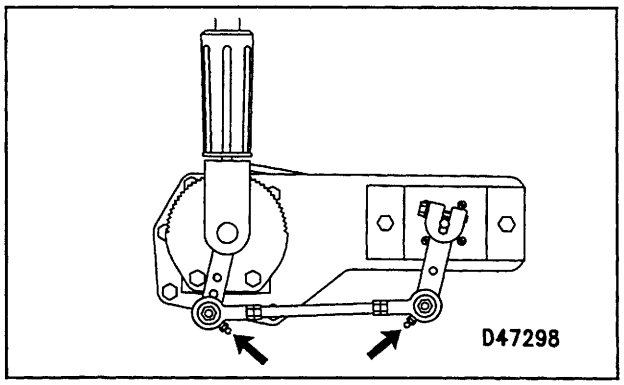
Visual Inspection

Visually check the condition of all sensors and wiring. Look for loose, broken, or damaged wiring and components. Repair or replace any damaged wiring or components immediately.

Fuel Control Linkage

Check/Lubricate

Check the fuel control linkage for proper operation and make adjustments if necessary. Refer to the Service Manual for adjustment procedures.



Fuel control linkage grease fittings.

Some engines are equipped with fuel control linkage which requires lubrication. Lubricate the grease fittings with 1P0808 Multipurpose Lithium Grease, or equivalent.

Every 3000 Hours

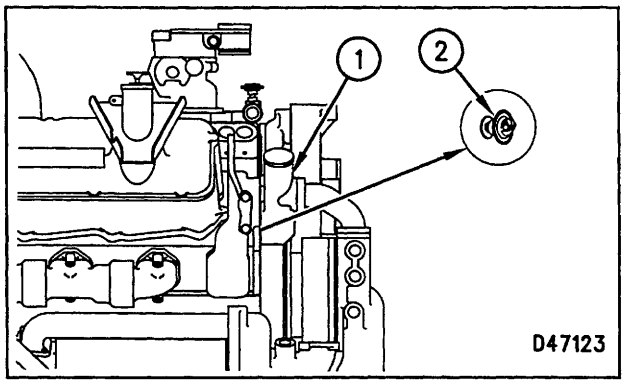
You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Thermostat

Replace

NOTE: If replacing the thermostat ONLY, drain the coolant from the cooling system to a level below the thermostat housing.

Refer to the Disassembly and Assembly procedure in the Service Manual or contact your Caterpillar dealer to perform the following maintenance.



Thermostat housing (1) and thermostat (2).

1. Stop the engine. Allow the engine to cool. Loosen the radiator filler cap slowly to relieve any pressure, then remove the cap.

2. Loosen the hose clamps to disconnect hose assembly from the thermostat housing (1). Remove the housing.

3. Remove thermostat (2) and gasket from the housing. Remove the seal from the housing.

Install Thermostat

NOTICE
If the thermostat is installed wrong, it will cause the engine to overheat.
Caterpillar engines incorporate a shunt design cooling system and require operating the engine with a thermostat installed. Depending on load, failure to operate with a thermostat could result in either an overheating or excessive cooling condition.

4. Install a new seal in the housing counter bore seat with the lip of the seal away from the thermostat.

5. Install the thermostat in the housing.

6. Position a new gasket on the housing. Install the housing.

7. Connect the hose assembly and tighten the hose clamps.

Cooling System

NOTICE
Make sure you read and understand the information in the Safety and Cooling System Specifications sections of this manual before you proceed with cooling system maintenance.

Add Extender (Long Life Coolant/Antifreeze Only)

Extender should be added to LLCA after 3,000 service hours or two years, whichever comes first. The cooling system should be treated with .95 L (1 qt) of Extender for every 46 L (12 US gal) of cooling system capacity.

For more Extender information, refer to the Cooling System Specifications LLCA Extender topic in this manual.

Drain/Clean/Replace Coolant (Conventional Coolant/Antifreeze Only)

Clean/Flush the cooling system before the recommended maintenance interval if:

- Coolant is heavily contaminated.
- The engine overheats frequently.
- Foaming is observed in the radiator.
- The oil cooler has failed, allowing oil to contaminate the coolant.

NOTICE
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

Drain

1. Stop the engine and allow the engine to cool. Loosen the coolant filler cap slowly to relieve any pressure, and remove the cap.

2. Open the radiator drain valve. Remove the block and oil cooler drain plugs. Remove the drain plug from the bottom of the water pump housing. Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding disposal and recycling of used coolant:

Contact Caterpillar Service Technology Group:
Outside Illinois: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL

Clean

3. Flush the cooling system with clean water to remove any debris.

4. Clean and install all drain plugs and/or close the drain valve(s).

NOTICE

Fill the cooling system no faster than (19 L) (5 US gal) per minute to avoid air locks.

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5. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of Cleaner per 15 L (4 US gal) of cooling system capacity. Install the radiator filler cap.

6. Start and run the engine for a minimum of 30 minutes with the coolant temperature at 82°C (180°F). Stop the engine and allow the engine to cool.

7. Loosen the filler cap slowly to relieve any pressure, and remove the cap. Remove the cooling system drain plug(s) or open the drain valve(s). Allow the cleaning solution to drain. Flush the cooling system with clean water until the draining water is clear. Clean and install all drain plugs and/or close the drain valve(s).

Cooling Systems with Heavy Deposits or Plugging

NOTE: For the following procedure to be effective, there must be some active flow through the radiator and the other cooling system components.

Follow the same steps as outlined above, with the following modifications to steps 5 and 6:

5. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of Cleaner per 3.8 to 7.6 L (1 to 2 US gal) of cooling system capacity. Install the radiator filler cap.

6. Start and run the engine for a minimum of 90 minutes with the coolant temperature at 82°C (180°F). Stop the engine and allow the engine to cool.

Fill

Refer to the Cooling System Specifications for all information regarding acceptable water, coolant/antifreeze, and supplemental coolant additive requirements. Refer to the Refill Capacities chart in this publication for the capacity of your engine's system.

8. Fill the system with the recommended coolant/antifreeze mixture.

9. Start and run the engine with the filler cap removed. Allow the coolant to warm, the thermostat to open and the coolant level to stabilize. Check the coolant level. Add coolant mixture if necessary to bring the coolant to within 13 mm (½ in) below the bottom of the fill tube or the correct level on the sight glass (if equipped).

10. Check the condition of the filler cap gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a 9S8140 Service Tool (available from your Caterpillar dealer) to pressure test the filler cap. The correct filler cap pressure is stamped on the face of the filler cap. If the filler cap does not hold the correct pressure, install a new filler cap.

11. Start the engine and inspect for coolant leaks and proper operating temperature. Check for coolant leaks.

Turbocharger

NOTICE

Turbocharger bearing failures can cause large quantities of oil to enter the air intake and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation will not cause problems as long as a turbocharger bearing failure has NOT occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine speed up at no load), DO NOT continue engine operation until the turbocharger is repaired or replaced.

An inspection/check of your turbocharger will minimize unscheduled downtime and reduce the chance for potential damage to other engine parts.

Inspect/Check

1. Remove the exhaust outlet and air inlet piping from the turbocharger. Visually check for oil leaks.

2. Turn the turbine and compressor wheel by hand. The assembly should turn freely.

3. Inspect the turbine wheel and compressor wheel for contact with the turbocharger housing. There should NOT be any visible signs of contact between the turbine or compressor wheels and the turbocharger housing.

4. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, it indicates a possible turbocharger oil seal leak.

The leak may be the result of extended engine operation at low idle or an intake air line restriction (plugged air filters), which causes the turbocharger to "slobber".

- Maintain the compressor wheel/turbine housing by cleaning with standard shop solvents and a soft bristle brush.

5. Check the end play and bearing clearance on the turbine wheel and shaft. If the measurements are not within specifications (see the Service Manual), the turbocharger must be repaired or replaced.

6. When installing or replacing V-band clamps, position the gap (tightening screw) down if possible so any accumulation of moisture will drain away.

NOTE: Turbocharger components require precision clearances and balancing due to operation at high rotational (torsional) speeds. Severe Service Applications can accelerate component wear and may suggest the need to Inspect/Repair/Replace the cartridge at reduced intervals to ensure maximum reliability and retention of the full core.

Removal and Installation

For removal and installation, or repair/replacement options of turbochargers, see your Caterpillar dealer. Refer to the Service Manual for this engine or consult your Caterpillar dealer for the procedure and specifications.

Engine Mounts and Crankshaft Vibration Damper

Inspect/Check Engine Mounts

Caterpillar recommends checking the engine mounts for deterioration and proper bolt torque. This will prevent excessive engine vibration caused from improper mounting. See your Service Manual or Caterpillar dealer for recommended torque values.

Inspect/Check Crankshaft Vibration Damper

Damage to, or failure of the damper will increase torsional vibrations and result in damage to the crankshaft and other engine components. A deteriorating vibration damper will cause excessive gear train noise at variable points in the engine speed range.

Rubber Damper

Your engine may be equipped with a standard Rubber Crankshaft Torsional Vibration Damper. A standard damper uses a rubber mounted ring to reduce crankshaft vibration. Some engines also have a Visconic Torsional Vibration Damper. A visconic damper uses a weight suspended in oil to reduce crankshaft vibration. Mounted to the crankshaft, the vibration damper is located behind the belt guard on the front of the engine.

Inspect/Check

Inspect rubber dampers for:
- deterioration and cracking.
- movement of the rubber from its original location.

If any of the above conditions exist, replace the damper. Refer to the service manual for replacement procedure.

Visconic Damper (If Equipped)

If your engine is equipped with a Visconic damper, the vibration damper weight is located inside a fluid filled case. The weight moves in the case to limit torsional vibration. A failing visconic damper has the same detrimental effects as a failing rubber cushioned damper.

Inspect visconic dampers for evidence of dents, cracks, and fluid leaks. Replace the damper if it is dented, cracked, or leaking. Refer to the Service Manual or contact your Caterpillar dealer for replacement procedure.

NOTE: Refer to the Service Manual for the necessary specifications and replacement procedure.

Valve Lash and Valve Rotators

Check/Adjust

Valve Lash

Initial valve lash adjustment on new, rebuilt or remanufactured engines is recommended at the first scheduled oil change interval (First 250 Hours) due to initial wear and seating of valve train components. Subsequent adjustments should be made at Every 3000 Hour interval.

This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule to provide maximum engine life.

Valve Rotators

⚠ WARNING

When inspecting the valve rotators, protective glasses or face shield and protective clothing must be worn, to prevent being burned by hot oil or spray.

Observe rotation of valves with engine idling after setting the valve lash. Caterpillar recommends replacement of improperly operating valve rotators. An improperly operating valve rotator will shorten valve life through accelerated valve face and valve seat wear. If a damaged rotator is not replaced, valve face guttering could result in pieces of the valve to fall into the cylinder and cause piston and cylinder head damage.

NOTICE
The procedures for engine valve lash should be performed according to the information in the Service Manual. Refer to the Service Manual or your Caterpillar dealer for the complete valve adjustment procedure.

Fuel Ratio Control, Set Point, and Low Idle

Check/Adjust

The fuel ratio control limits the amount of fuel to the cylinders during acceleration. This affects the amount of exhaust smoke. The set point check is a method for diagnosing engine performance. Slow engine response and low power indicate that a fuel control adjustment or repair is necessary.

These engines are equipped with a protection group that prevents any tampering with the fuel ratio control setting. This is required by emissions regulations. Standard bolts have been replaced by tamper resistant bolts.

NOTICE
Only a mechanic with training in governor adjustments should make adjustments to the low and high idle rpm.

The fuel ratio control, set point, and idle speed checking and adjusting should only be performed by Caterpillar authorized service personnel or other properly trained mechanics. Consult with your Caterpillar dealer for assistance. Authorized Caterpillar dealers are equipped to properly perform these services.

Every 5000 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Fuel Injection Nozzles

Test/Exchange

Fuel injection nozzles are subject of tip wear. Tip wear, a result of fuel contamination, can cause:

- increased fuel consumption.
- black smoke.
- misfire.
- rough running.

Fuel nozzles should be cleaned, inspected, tested, and replaced if necessary. Refer to Special Instruction SEHS7292, for using the 8S2245 Nozzle Cleaning Kit. Consult with your Caterpillar dealer about fuel injection nozzle cleaning and testing.

NOTICE

Never wire brush or scrape a fuel injection nozzle. Wire brushing or scraping a fuel injection nozzle will damage the finely machined orifice. Proper tools for cleaning and testing fuel injection nozzles can be obtained from authorized Caterpillar dealers.

Abnormal engine running, smoke emission, and engine knock can be symptoms of nozzle malfunction. Each nozzle must be isolated one at a time in order to determine the malfunctioning nozzle.

1. Start the engine.

NOTICE

A fuel injection nozzle will be damaged if the top of the nozzle turns in the body. The engine will be damaged if a defective fuel injection nozzle is used because the fuel spray pattern that comes out of the nozzle will be incorrect. Fuel injection nozzles can be permanently damaged by twisting if only one wrench is used to loosen or tighten the fuel line nuts. Do NOT let the tops of the fuel nozzles turn when the fuel lines are loosened. Use one wrench to hold the nozzle and another to loosen the fuel line nut.

2. Loosen each fuel line nut at the fuel injection pump, one at a time. A cloth or similar material must be used to prevent fuel from spraying on the hot exhaust components. Tighten each nut before loosening the next nut.

3. A defective nozzle may be identified when a nut is loosened and:
- the exhaust smoking is partially or completely eliminated.
- irregular running is not affected.

A nozzle suspected of being defective should be removed. A new nozzle should be installed in the cylinder to determine if the removed nozzle is defective.

Removing and Installing Fuel Injection Nozzles

Special tooling is required to remove and install nozzles. Refer to the Service Manual for information. Consult with your Caterpillar dealer for assistance.

Inspect, Rebuild or Exchange

If the engine is operated until the component(s) fails, additional engine damage can result. Caterpillar recommends that the following components be inspected at the 5000 Hour maintenance interval.

- Jacket Water Pump
- Turbocharger
- Alternator
- Starting Motor
- Air Compressor (if equipped)

Caterpillar Recommendation

To minimize downtime, Caterpillar recommends the use of Remanufactured components (subject to availability) as the most cost effective option.

Removal and Installation

Refer to the Service Manual or contact your Caterpillar dealer for assistance with removal and installation of engine components.

Jacket Water Pump

A failed water pump might cause severe engine overheating problems that could result in cracks in the cylinder head, a piston seizure or other potential damage to the engine.

Visually inspect the water pump for leaks. If leaking is observed, replace all seals. Refer to the Service Manual for the procedure to replace the seals.

Turbocharger

Refer to the Turbocharger topic in the Every 3000 Hours maintenance interval for information regarding turbocharger inspection. Refer to the Service Manual, or consult with your Caterpillar dealer for the complete turbocharger inspection procedure.

Alternator

Caterpillar recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and proper battery charging. Inspect the ammeter gauge during engine operation to ensure the batteries and/or electrical system is performing correctly. Make repairs as necessary. Refer to the Service Manual.

Check the alternator and battery charger for proper operation. If the batteries are properly charged, ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, it will not crank the engine, even if the engine is warm.
When the engine is not run for long periods of time or run for short periods, the batteries may not fully recharge. Ensure the alternator performs properly to charge the battery and to help prevent the battery from freezing.

Starting Motor

If the starting motor fails, the engine may not start in an emergency situation. Caterpillar recommends a scheduled inspection/check of your starting motor. The starting motor should be checked for correct operation. All electrical connections should be cleaned and checked. Refer to the established procedure for inspection and specifications in the Service Manual, or contact your Caterpillar dealer for assistance.

Air Compressor

Refer to OEM literature for all compressor maintenance information.

Every 6000 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Cooling System

NOTICE
Do not perform this maintenance until you read and understand the material in the Safety and Cooling System Specifications sections of this publication.

Drain/Flush/Replace Coolant (Long Life Coolant/Antifreeze Only)

Caterpillar Long Life Coolant/Antifreeze should be replaced every 6,000 Service Hours or 4 Years, whichever comes first. Only clean water is needed to clean and flush the cooling system when LLCA is drained and replaced.

Drain

1. Stop the engine and allow the engine to cool. Loosen the coolant filler cap slowly to relieve any pressure, and remove the cap.

2. Remove the radiator drain plug, or open the radiator drain valve (if equipped). Remove the block and oil cooler drain plugs. Remove the drain plug from the bottom of the water pump housing. Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant. Contact your Caterpillar dealer for information regarding disposal and recycling of used coolant.

For information regarding disposal and recycling of used coolant:

Contact Caterpillar Service Technology Group:
Outside Illinois: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL

Flush

3. Flush the cooling system with clean water to remove any debris.

4. Clean and install all drain plugs and/or close the drain valve(s).

5. Fill the cooling system with clean water. Install the filler cap. Operate the engine until warm 49 to 66°C (150 to 120°F).

6. Stop the engine and allow the engine to cool. Loosen the coolant filler cap slowly to relieve any pressure, and remove the cap. Remove the cooling system drain plug(s) or open the drain valve. Allow the water to drain. Flush the cooling system with clean water.

7. Repeat steps 6 and 7.

Fill

8. Fill the cooling system with LLCA. Refer to the refill capacities chart in this manual for the amount of LLCA needed to refill your system.

9. Start and run the engine with the filler cap removed. Allow the LLCA to warm, the thermostat to open, and the coolant level to stabilize. Add LLCA if necessary to bring the coolant to the proper level.

10. Check the condition of the filler cap gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a 9S8140 Service Tool (available from your Caterpillar dealer) to pressure test the filler cap. The correct filler cap pressure is stamped on the face of the filler cap. If the filler cap does not hold the correct pressure, install a new filler cap.

11. Start the engine and inspect for coolant leaks and proper operating temperature.

Overhaul

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Overhaul Considerations

Reduced hours of operation at full load and/or operating at reduced settings result in lower average power demand. Lower average power demand should increase the length of operating time before an engine overhaul is required.

An overhaul is generally indicated by increased fuel consumption and reduced power. Overhaul includes completely reconditioning your cylinder head, but the cylinder components are not worn enough to need repair.

Factors such as: conscientious preventive maintenance, fuel quality used, operating conditions, S•O•S oil analysis results, etc., are important considerations in deciding when to perform an overhaul.

Estimating Oil Consumption

Oil consumption, fuel consumption, and maintenance information can be used to estimate the total operating cost for your Caterpillar engine. Oil consumption can also be used to estimate the capacity of a makeup oil system required to accommodate your maintenance intervals.

Oil consumption is proportional to the engine operating percent load. The higher the percent load, the higher the amount of oil consumed per hour.

The oil consumption rate, or brake specific oil consumption (BSOC) is measured in grams/brake kW-hour (lb/bhp-hour). The BSOC varies depending on the load on your engine. Contact your Caterpillar dealer for assistance in determining typical oil consumption for your engine.

Oil Consumption as an Overhaul Indicator

When an engine's oil consumption has risen to three times the initial (new) consumption rate due to normal wear, then the engine should be scheduled for overhaul. There may be a corresponding increase in blowby and a slight increase in fuel consumption.

Overhaul Before Failure

A planned Overhaul Before Failure may be your best value, because you can:

- Avoid costly unplanned downtime.
- Reuse as many original parts as standards permit.
- Extend your engine's service life without the risk of a major catastrophe had you continued to operate to failure.
- Get the best cost/value relationship per hour of extended life.

After Failure Overhaul

If you experience a major engine failure which requires removal of the engine from the hull, there are also many After Failure Overhaul options available. An overhaul should be performed if your block or crankshaft needs to be repaired.

If the block and/or crankshaft is repairable, overhaul cost should be between 40 and 50 percent of the cost of a new engine (with like exchange core).

This lower cost can be attributed to Caterpillar "designed-in" features, Caterpillar dealer and Caterpillar Remanufactured exchange components.

Overhaul Recommendation

To minimize downtime and provide you with the lowest cost and highest value, Caterpillar recommends that the engine be overhauled before failure by scheduling an overhaul with your Caterpillar dealer.

NOTE: Overhaul programs vary with engine application and from dealer to dealer. Therefore, Caterpillar recommends that you confer with your dealer to obtain specific information regarding the types of programs offered and overhaul services provided for extending the life of your engine.

If you elect to perform an overhaul without Caterpillar dealer overhaul service, you should be aware of the maintenance that follows.

Inspect/Rebuild or Exchange

Cylinder Head, Connecting Rods, Pistons, Cylinder Liners, Turbocharger, Oil Pump, Spacer Plates, Fuel Ratio Control, Cam Followers, Fuel Transfer Pump, and Timing Advance.

These components should be inspected according to the instructions found in various Caterpillar reusability publications. The Index of Publications on Reusability or Salvage of Used Parts, SEBF8029, lists reusability publications needed for inspecting parts.

If your parts comply with established inspection specifications expressed in the reusable parts guideline, the parts should be reused.

If your parts are not within specification, the parts should be salvaged, repaired, or replaced. Failure to salvage, repair, or replace out-of-spec parts can result in unscheduled downtime, costly repairs, and damage to other engine parts.

In addition, using out-of-spec parts can reduce your engine's efficiency and increase fuel consumption. Reduced engine efficiency and increased fuel consumption translates into higher operating costs. Therefore, Caterpillar recommends that you salvage, repair, or replace your out-of-spec parts.

Install New

Piston Rings, Main Bearings, Rod Bearings, Valve Rotators and Crankshaft Seals.

Your thrust, main, and rod bearings, valve rotators, and crankshaft seals will probably not last until your second overhaul. Caterpillar recommends the installation of new parts at each overhaul period.

Inspect/Replace

Crankshaft, Camshaft, Camshaft Followers and Bearings, Crankshaft Vibration Damper, Governor, Fuel Pump Camshaft, Fuel Racks, Gear Train Gears and Bushings, and Driven Unit Alignment.

The ideal time for inspecting these items is while your engine is disassembled for overhaul. Inspect each component for potential damage as follows.

- Crankshaft–Inspect for deflection, journal damage, and bearing material seized to the journal. At the same time, check the taper and profile of the crankshaft journals by interpreting your main and rod bearing wear patterns.

NOTE: If the crankshaft is removed for any reason, use the magnetic particle inspection process to check the crankshaft for cracks.

- Camshaft–Inspect the camshaft to journal damage and lobe damage.

NOTE: If the camshaft is removed for any reason, use the magnetic particle inspection process to check the camshaft for cracks.

- Camshaft Followers and Bearings–Inspect the Cam Bearings for scuffing and wear.

- Crankshaft Vibration Damper–Refer to the Crankshaft Vibration Damper topic in the Every 3000 Hour section of this publication for inspection information.

- Fuel Pump–Inspect the camshaft and fuel racks for excessive wear.

Clean/Test

Oil Cooler and Aftercooler Cores

Caterpillar recommends that the oil cooler and aftercooler cores be removed, cleaned and pressure tested at Overhaul.

NOTICE
Do not use caustic cleaners to clean the core. Caustic cleaners will attack the internal metals of the core and cause leakage.

NOTE: This cleaning procedure may be used for both the oil cooler and the aftercooler cores.

1. Remove the core. Turn the core upside down to remove debris from the inlet.

2. Back flush internally with cleaner to loosen foreign substances and to remove oil. Caterpillar recommends the use of Caterpillar Hydrosolv Liquid Cleaners. The following chart lists part numbers and quantities of recommended cleaners available from your Caterpillar dealer.

HYDROSOLV LIQUID CLEANERS		
Part No.	**Description**	**Size**
1U8812 1U5490 8T7570	Hydrosolv 4165	4 L (1 US gal) 19 L (5 US gal) 208L (55 US Gal)
1U8804 1U5492 8T7571	Hydrosolv 100	4 L (1 US gal) 19 L (5 US gal) 208L (55 US Gal) Drum

The cleaners listed in this chart should be used at a two to five percent concentration and at temperatures up to 93°C (200°F). For more information, see Application Guide, NEHS0526, or contact your Caterpillar dealer.

3. Steam clean the core to remove cleaner film. Flush air and side fins of aftercooler cores. Remove any other trapped debris.

4. Wash the core with hot, soapy water. Rinse thoroughly with clean water.

5. Dry the core with compressed air. Blow air in reverse direction of the normal flow. Use all necessary safety equipment while working with compressed air.

6. Inspect the system to ensure cleanliness. The core should be pressure tested. Test and repair the core as necessary. Install the core.

For more information on cleaning the cores, contact to your Caterpillar dealer.

Test

Fuel Injection Pump and Fuel Injection Nozzles

Fuel costs are 80 to 85 percent of the total engine operating cost. Caterpillar recommends testing the fuel injection pump and nozzles at Overhaul. Your Caterpillar dealer can test these components in order to ensure they are operating within specifications.

Obtain Coolant Analysis

The concentration of SCA should be checked regularly for over or under concentration. This should be done with test kits, or Caterpillar's S•O•S Coolant Analysis (Level I) at the Every 250 Hours interval.

Further coolant analysis is recommended at Overhaul.

For example, suppose considerable deposits are found in the water jacket areas on the external cooling system, yet coolant additive concentrations were carefully maintained. Chances are that the coolant water had minerals which deposited on the engine over time.

One way to verify the water condition, or to be sure of new water at fill time, is to have a coolant analysis conducted. Full water analysis can sometimes be obtained locally by contacting your local water utility company or an agricultural agent. Private laboratories are also available.

Caterpillar recommends Caterpillar's S•O•S Level II Coolant Analysis.

Level II: Comprehensive Cooling System Analysis

Completely analyzes coolant and coolant effects on the cooling system. Level II Analysis provides:

- full Level I analysis
- visual properties inspection
- metal corrosion and contaminant identification
- identification of built-up impurities that point to corrosion and scaling problems BEFORE they lead to costly repairs.

Level II Analysis provides a report of results, and makes recommendations.

For more information on coolant analysis and how it can help you manage your equipment, see your Caterpillar dealer.

Maintenance Records

Caterpillar recommends that accurate maintenance records be kept. Accurate maintenance records can be used for determining operating costs, establishing maintenance schedules for other engines being operated in the same environment and for a variety of other related business decisions.

Accurate maintenance records can also be used to show compliance with the required maintenance practices and intervals. Maintenance records are a key element of a well managed maintenance program. With accurate maintenance records your Caterpillar dealer can help you fine tune the recommended maintenance intervals to meet your specific operating situation. This should result in a lower engine operating cost.

The key elements to keep records on are:

- Fuel Consumption

This is essential for determining when load-sensitive items should be inspected or repaired and for determining overhaul intervals.

- Service Hours

This is essential for determining when revolution-sensitive items should be inspected or repaired.

- Documents

The following types of documents should be kept as proof of maintenance or repair for warranty and should not be difficult to obtain and keep in the engine history file. All documents should show date, service hours, liters (gallons) of fuel consumed, unit number and engine serial number. If the engine is sold, transfer the records with the engine.

The following types of documents should be kept as proof of maintenance or repair for warranty and should not be difficult to obtain and keep in the engine history file.

1. Dealer work orders and itemized bills.
2. Owner's repair orders.
3. Owner's receipts.
4. Maintenance log (see following example).

Maintenance Log

Engine Model ______________________________ **Customer Identifier**______________________________

Serial Number ______________________________ **Arrangement Number**______________________________

Service Hours	Quantity Of Fuel	Item Serviced	Date	By Initials

Troubleshooting

Troubleshooting a failure on an engine can be a difficult procedure. For a troubleshooting manual, see the Service Manual for your engine. All repairs should be made by a properly trained mechanic. Your Caterpillar dealer has the personnel and special tools needed to troubleshoot and make repairs to your engine.

See the Service Manual for troubleshooting information. The list of problems, causes and corrections given in the Service Manual, will only give an indication of where a possible problem can be, and what repairs may be needed.

Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts.

The Service Manual can not give all possible problems and corrections. The serviceman must find the problem and its source, then make the necessary repairs.

Your Caterpillar dealer is equipped with the necessary tools and personnel to provide assistance when necessary.

Reference Materials

Caterpillar Reference Material

The following literature can be obtained through any Caterpillar dealer.

Oil

SEBD0640, Oil and Your Engine

PEDP7122, Question & Answer Booklet

PEDP1129, Listen To Your Oil

PEHP6001, How to Take a Good Oil Sample

SEBU6251, Lubricant Recommendations

PEHP1027, Product Data Sheet for Cat Diesel Engine Oil (CD)

PEHP0002, Product Data Sheet for Cat Molybdenum Grease (MPGM)

PEHP0003, Product Data Sheet for Cat Lithium Grease (MPGL)

PEHP0017, Product Data Sheet for Cat Special Purpose Grease (SPG)

PEWP9733, Cat Fluids Selector

PEDP7105, Scheduled Oil Sampling

Fuel

SEBD0717, Diesel Fuels and Your Engine

Coolant

SEBD0518, Know Your Cooling System

SEBD0970, Coolant and Your Engine

Miscellaneous

SEBF8029, Index to Guidelines for Reusable Parts and Salvage Operations

SEBF8062, Guideline for Reusable Parts - Cleaning and Inspection of Air Filters

SEHS9031, Storage Procedure for Caterpillar Products

SENR1110, Service Manual, 3406C Industrial Engines

SEHS7654, Alignment-General Instructions

LEBH9324, Agricultural and Material Handling Application and Installation Guide

SEHS7292, Use of 5P4150 Nozzle Testing Group

SEHS8622, Using the FT1984 Air-To-Air Aftercooler Leak Test Group

SEHS7795, Use of Pump & Governor Tool Group

SEHS8024, Governor Adjusting Tool Group

SEHS8094, Use of Nozzle Puller Group

Emissions Warranty

The engine described in this Manual may be Certified and covered by an Emissions Warranty. A detailed explanation of the Emissions Warranty, applicable to Certified engines, is found in SEBU6981, Emissions Control Warranty Information. The Engine is Certified if it has a special Certification Label. A Caterpillar dealer can also inform you if the engine is Certified.

Additional Reference Material

ASTM D2896, TBN Measurements

ASTM D21768, Worked Penetration

ASTM D445, Viscosity

ASTM D893, Insoluble Test For Oils

ASTM 498589, GM-6038M Specification

ASTM Specs can normally be obtained from your local technological society, library or college.

SAE J313, Diesel Fuels

SAE J754, Nomenclature

SAE J183, Classification

Society of Automotive Engineers (SAE) Specs can be found in your SAE handbook or can be obtained from your local library, college or technological society.

- SAE handbooks can be obtained directly from:
  SAE International
  400 Commonwealth Drive
  Warrendale, PA USA 15096-0001

Engine Manufacturers Association (EMA) information for lube oil selection can be obtained from your local library, college or technological society, or contact:

- Engine Manufacturers Association
  Lubricating Oils Data Book
  401 N. Michigan Ave. Ste. 2400
  Chicago, IL 60611
  (312) 644-6610 ext. 3626

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September 1995

Operation & Maintenance Manual

3304B and 3306B Industrial and EPG Generator Set Diesel Engines

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2TM1-UP
4XB1-UP
7JB1-UP
10E300-UP
64Z1-UP
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85Z1-UP

Table of Contents

Foreword

Literature Information

This manual contains information and instructions concerning engine safety, operation, lubrication, and maintenance. Read, study, and keep it available with other literature and engine information.

Some photographs or illustrations in this publication show details or attachments that may differ from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this publication.

Whenever a question arises regarding your engine, or this publication, please consult your Caterpillar dealer for the latest available information.

Safety

The safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance and/or repair on this product.

Operation

Engine operation outlined in this publication is basic. Engine operators gain knowledge of the engine through experience, developing operation skills and techniques which enhance efficient and economical engine operation.

The operation section is a reference for operators. Photographs and illustrations guide operators through correct procedures of inspecting, starting, operating and stopping the engine. Discussion of gauges and engine control information is included.

Maintenance

The maintenance section is a guide to engine care. The illustrated instructions are grouped by maintenance service intervals. The actual operating environment of the engine also governs the maintenance schedule. Under extremely severe, dusty, or frigid operating conditions, lubrication and maintenance checks more frequent than those specified in the Maintenance Schedule may be necessary.

Maintenance Intervals

Use the service hour meter to determine service intervals. Calendar intervals shown (daily, weekly, monthly, etc.) can be used instead of service hour meter intervals, if they provide more convenient servicing schedules and approximate the indicated service hour meter reading. Recommended service should always be performed at the interval that occurs first.

We recommend that the maintenance schedules be reproduced for ease of inspection. We also recommend that ongoing maintenance records be kept to document engine service.

See the Maintenance Records section of this publication for information regarding documents that are generally accepted as proof of maintenance or repair. Your Caterpillar dealer can assist you in tailoring your Maintenance Schedule to meet the needs of your operating environment.

Overhaul

Major engine repair details are not covered in this manual. Major repairs are best left to trained personnel or an authorized Caterpillar dealer.

If a major engine failure requiring removal of the engine occurs, numerous after-failure overhaul options available from your Caterpillar dealer. Contact your dealer for information regarding these options.

Engine Description

The engines described in this publication are 3304B and 3306B Industrial and EPG diesel engines.

They are designed primarily for agricultural, prime power and standby electrical power generation, petroleum and auxiliary industrial applications.

Engine Storage

For general information, refer to the Engine Lifting & Storage topic. For complete engine storage information refer to Special Instruction SEHS9031, Storage Procedure for Caterpillar Products.

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.

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "WARNING" as shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning, explaining the hazard, can be either written or pictorially presented.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. Caterpillar dealers have the most current information available. For a list of the most current publication form numbers available, see the Service Manual Contents Microfiche, REG1139F.

Safety

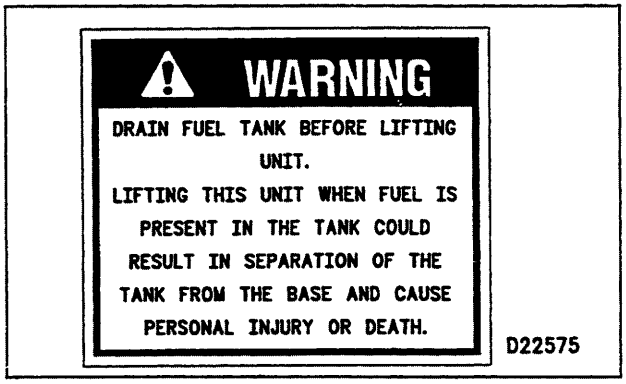
Warning Signs and Labels

There may be several specific warning signs on your engine. Please familiarize yourself with all warning signs.

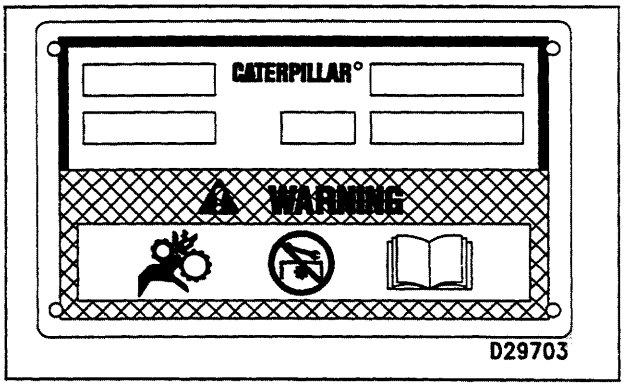
Make sure that you can read all warning signs. Clean or replace warning signs if you cannot read the words or see the pictures. When cleaning the labels use a cloth, water and soap. Do not use solvents, gasoline, etc., to clean warning signs. The use of solvents, gasoline, etc., could loosen the sign's adhesive and cause the sign to fall off.

You must replace a warning sign if it is damaged, missing or cannot be read. If a warning sign is attached to a part, and that part is replaced, make sure a new warning sign is installed on the replaced part. See your Caterpillar dealer for new warning signs.

Do not operate or work on the engine unless you have read and understand the instructions and warnings in this Manual. Proper care is your responsibility. Failure to follow the instructions or heed the warnings could result in injury or death.



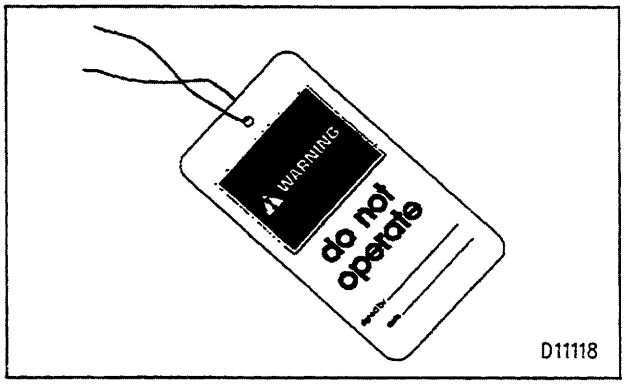
Located on the fuel tank.



This warning plate may be located on the clutch housing (if equipped). Rotating gears– finger or hand entanglement. Do not service until reading the operator's manual.

General Hazard Information

Attach a DO NOT OPERATE or similar warning tag to the start switch or controls before performing maintenance or repairing the engine. These tags, SEHS7332, are available from your Caterpillar dealer. When appropriate, attach the tags at the engine and at each operator's position. Disconnect starting controls when appropriate.



Do not allow unauthorized personnel on, around or in the engine unit when it is being serviced.

Diesel engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Use caution when removing filler cap, grease fittings, pressure taps, breathers or drain plugs. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure.

- Wear a hard hat, protective glasses, hearing protection and other protective equipment as required by job conditions.
- Do not wear loose clothing or jewelry that can catch on controls or other parts of the engine.
- Make certain all protective guards and covers are secured in place.
- Use all cleaning solutions with care.
- Never put maintenance fluids into glass containers since glass containers can break.
- Report all needed repairs.

UNLESS INSTRUCTED DIFFERENTLY, PERFORM ALL MAINTENANCE AS FOLLOWS:

- Stop the engine.
- Ensure the protective locks or controls are in the applied position.
- Disconnect the batteries whenever performing any maintenance or before servicing the electrical system. If the engine has electric starters, disconnect and tape the battery ground leads to prevent accidental starting.
- Do not attempt any repairs or adjustments to the engine or driven equipment while it is running.
- Do not attempt repairs you do not understand. Use proper tools; replace or repair broken or damaged equipment.
- Apply the parking brakes (if equipped).
- Block or restrain the vehicle or machine, if applicable before operating or performing maintenance.
- When starting an engine after repairs have been made to the fuel system or governor, make provisions for shutting off the engine's intake air supply (to stop the engine), in case there is an overspeed on start-up.
- Start the engine only from the operator's station. Never short across the starter terminals or the batteries as this could bypass the engine neutral-start system as well as damage the electrical system.

Pressure Air and Water

Pressure air can cause personal injury. When using pressure air for cleaning, wear a protective face shield. protective clothing and protective shoes.

The maximum air pressure must be below 205 kPa (30 psi) and maximum water pressure must be below 275 kPa (40 psi) for cleaning purposes.

Wear eye protection at all times when cleaning the cooling system. Pressurized water could cause debris and/or hot water to be blown and result in personal injury.

Fluid Penetration

Always use a board or cardboard when checking for a leak. Escaping fluid under pressure, even a pin-hole size leak, can penetrate body tissue, causing serious injury or possible death.

If fluid is injected into your skin, it must be treated by a doctor familiar with this type of injury immediately.

Asbestos Information

This Caterpillar product and replacement parts shipped from the factory are asbestos free. Caterpillar recommends the use of only genuine Caterpillar replacement parts. If any replacement parts containing asbestos fibers are used, the following guidelines should be used in handling these parts and asbestos debris.

Asbestos used in components is usually bound in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust which contains asbestos is not generated.

Caution should be used to avoid breathing dust that may be generated when handling components containing asbestos fibers. If this dust is inhaled, it can be hazardous to your health.

If dust, which may contain asbestos is present, there are several common sense guidelines that should be followed.

- Never use compressed air for cleaning.
- Avoid brushing or grinding of asbestos containing materials.

- For clean up, use wet methods or a vacuum equipped with a high efficiency particulate air (HEPA) filter.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. (For example in the U.S.A., OSHA requirements as set forth in 29 CFR 1910.1001).
- Follow environmental rules and regulations for disposal of asbestos.
- Avoid areas where airborne asbestos particles may be present.

Lines, Tubes and Hoses

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses.

Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires.

Inspect all lines, tubes and hoses carefully. Do not use your bare hands to check for leaks. Tighten all connections to the recommended torque.

Check for the following:

- End fittings damaged, leaking or displaced.
- Outer covering chafed or cut and wire reinforcing exposed.
- Outer covering ballooning locally.
- Evidence of kinking or crushing of the flexible part of the hose.
- Armoring embedded in the outer cover.

Make sure that all clamps, guards and heat shields are installed correctly to prevent vibration, rubbing against other parts and excessive heat during operation.

Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any repair or maintenance is performed on the engine.

Relieve all pressure in air, oil, fuel or cooling systems before any lines, fittings or related items are disconnected or removed.

Coolant

Use caution when removing filler cap, grease fittings, pressure taps, breathers or drain plugs. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure.

To prevent personal injury, do not step up on engine to remove the filler cap, if applicable. Use an adequate ladder.

At operating temperature, the engine coolant is hot and under pressure. The radiator and all lines to heaters or the engine contain hot water. When pressure is relieved rapidly, this hot water can turn into steam.

Allow cooling system components to cool before draining. Any contact with hot water or steam can cause severe burns.

Check the coolant level only after the engine has been stopped and the filler cap is cool enough to remove with your bare hand.

Remove the cooling system filler cap slowly to relieve pressure.

Cooling system additive (conditioner) contains alkali. To prevent personal injury, avoid contact with the skin and eyes and do not drink.

Oils

Hot oil and components can cause personal injury. Do not allow hot oil or components to contact the skin.

Keep all exhaust manifold and turbocharger shields in place to protect hot exhaust from oil spray in the event of a line, tube or seal failure.

Batteries

Battery electrolyte contains acid and can cause injury. Avoid contact with the skin and eyes.

Wash hands after touching batteries and connectors. Use of gloves is recommended.

Batteries give off flammable fumes which can explode. Ensure there is proper ventilation for batteries which are located in an enclosure.

Always thaw a frozen battery before jump starting. Frozen batteries can explode.

Do not smoke when observing the battery electrolyte levels.

Always wear protective glasses when working with batteries.

Never disconnect any charging unit circuit or battery circuit cable from the battery when charging unit is operating. A spark can cause the flammable vapor mixture of hydrogen and oxygen to explode.

Fire or Explosion Prevention

Fire may result from lubricating oil or fuel sprayed on hot surfaces causing personal injury and property damage. Inspect all lines and tubes for wear or deterioration. They must be routed, supported or clamped securely. Tighten all connections to the recommended torque. Leaks can cause fires.

Determine whether the engine will be operated in an environment in which combustible gases could be drawn through the air inlet system. These gases could cause the engine to overspeed, which in turn could seriously damage the engine and result in bodily injury or property damage.

If your application involves the presence of combustible gases, consult your Caterpillar dealer to obtain additional information concerning protection devices (i.e. air inlet shutoff) suitable for the application involved.

All fuels, most lubricants and some coolant mixtures are flammable.

Diesel fuel is flammable. Gasoline is flammable. The mixture of diesel and gasoline fumes are extremely explosive.

Do not smoke while refueling or in a refueling area.

Do not smoke in areas where batteries are charged, or where flammable materials are stored.

Batteries give off flammable fumes which can explode.

Keep all fuels and lubricants stored in properly marked containers and away from all unauthorized persons.

Store all oily rags or other flammable material in a protective container, in a safe place.

Do not weld or flame cut on pipes or tubes that contain flammable fluids. Clean them thoroughly with nonflammable solvent before welding or flame cutting on them.

Remove all flammable materials such as fuel, oil and other debris before they accumulate on the engine.

Do not expose the engine to flames, burning brush, etc., if at all possible.

Shields (if equipped), which protect hot exhaust components from oil or fuel spray in the event of a line, tube or seal failure, must be installed correctly.

Provide adequate and proper waste oil disposal. Oil and fuel filters must be properly installed and housing covers tightened to proper torque when being changed.

Batteries must be kept clean, covers kept on all cells, recommended cables and connections used and battery box covers kept in place when operating.

When starting from an external source, always connect the positive (+) jumper cable to the POSITIVE (+) terminal of the battery of the engine to be started.

To prevent potential sparks from igniting combustible gases produced by some batteries, attach the negative (−) boost ground cable last, to the starter NEGATIVE (−) terminal (if equipped) or to the engine block. See the Operation Section of this manual for specific starting instructions.

Clean and tighten all electrical connections. Check regularly for loose or frayed electrical wires. Refer to maintenance schedules for interval. Have all loose or frayed electrical wires tightened, repaired or replaced before operating the engine.

Wiring must be kept in good condition, properly routed and firmly attached. Routinely inspect wiring for wear or deterioration. Loose, unattached, or unnecessary wiring must be eliminated. All wires and cables must be of the recommended gauge and fused if necessary. Do not use smaller gauge wire or bypass fuses. Tight connections, recommended wiring and cables properly cared for will help prevent arcing or sparking which could cause a fire.

Fire Extinguisher

Have a fire extinguisher available and know how to use it. Inspect and have it serviced as recommended on its instruction plate.

Crushing or Cutting Prevention

Support equipment and attachments properly when working beneath them.

Never attempt adjustments while the engine is running unless otherwise specified in this manual.

Stay clear of all rotating and moving parts. Guards should be in place whenever maintenance is not being performed.

Keep objects away from moving fan blades. They will throw or cut any object or tool that falls or is pushed into them.

Wear protective glasses when striking objects to avoid injury to your eyes.

Chips or other debris can fly off objects when struck. Make sure no one can be injured by flying debris before striking any object.

Mounting and Dismounting

Do not climb on, or jump off the engine or stand on components which cannot support your weight. Use an adequate ladder. Always use steps and handholds when mounting and dismounting.

Clean steps, handholds and areas of the engine you will be working on or around.

Enclosure Doors

Strong winds may lift the enclosure doors off their hinge pins.

If strong winds threaten to lift the enclosure doors, the doors should be removed from their hinges to prevent damage.

Before Starting the Engine

Inspect engine for potential hazards.

Be sure all protective guards and covers are installed if an engine must be started to make adjustments or checks. To help prevent an accident caused by parts in rotation, work carefully around them.

Do not disable or bypass automatic shutoff circuits. They are provided to prevent personal injury and engine damage.

Never start an engine with the governor linkage disconnected.

Make provisions for shutting off the air or fuel supply to stop the engine if there is an overspeed on start-up after performing repair or maintenance to the engine.

See the Maintenance section of this manual for adjustment, or the Service Manual for repairs.

Engine Starting

DO NOT start the engine or move any of the controls if there is a warning tag attached to the controls. Check with the person who attached the tag before starting.

Make sure no one is working on, or close to the engine or engine driven components before starting it. Always make an inspection of the engine before and after starting.

Start the engine only from the operator's station. Never short across the starter terminals or the batteries as this could bypass the engine neutral-start system as well as damage the electrical system.

Always start the engine according to the required Engine Starting procedure described in this manual to prevent major engine component damage and personal injury.

Check the jacket water and oil temperature gauges frequently during the operation of jacket water and/or lube oil heaters to ensure proper operation.

Diesel engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well-ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Starting Aids (if Used)

Ether and other starting aids are poisonous and flammable. Do not smoke while changing ether cylinders.

Use ether only in well ventilated areas.

Keep ether cylinders out of the reach of unauthorized persons.

Do not store replacement ether cylinders in living areas or in the engine compartment or cab (if equipped).

Do not store ether cylinders in direct sunlight or at temperatures above 39°C (102°F). Discard cylinders in a safe place. Do not puncture or burn cylinders.

Engine Stopping

Stop the engine according to the Engine Stopping instructions in the Operation Section to avoid overheating and accelerated wear of the engine components.

Only use the Emergency Stop button in an emergency situation. DO NOT start the engine until the problem necessitating the emergency stop has been located and corrected.

On initial startup or overhaul, be prepared to STOP the engine should an overspeed condition occur. This may be accomplished by cutting the fuel and air supply to the engine.

Emergency Service

North America Only
When a problem arises concerning the sale, operation or service of your engine, it will normally be handled by the dealer in your area. The service facility nearest you can be located twenty-four hours a day by calling the phone number below.

In U.S. and Canada: 1 (800) 447-4986.

Your satisfaction is a primary concern to Caterpillar and its dealers. If you have a problem that has not been handled to your complete satisfaction, we suggest the steps that follow.

Step One
Discuss your problem with a member of management from the dealership.

Step Two
When it appears that your problem cannot be readily resolved at the dealer level without additional assistance, use the above telephone numbers and ask to talk to a Field Service Coordinator. Regular Monday through Friday business hours are from 8:00 a.m. to 4:30 p.m. Central Standard Time (CST).

Step Three
If you are still not satisfied, present the engine matter in writing to: Caterpillar Inc.
Manager, Customer Service, Engine Division
Mossville Bldg. A
P.O. Box 600
Peoria, Illinois 61552-0600

When contacting the Manager, Customer Service, please keep in mind that ultimately your problem will likely be resolved at the dealership, using their facilities, equipment, and personnel. Therefore, it is suggested that you follow the above steps in sequence when experiencing a problem.

Outside North America
If a problem arises outside North America, and cannot be resolved at the dealer level, contact the appropriate Caterpillar subsidiary office.

Central/South America (except Brazil)
Caterpillar Americas Co.
100 NE Adams Street
Peoria, Illinois 61629 U.S.A.
Phone: 309-675-5876
Fax: 309-675-5384

Brazil
Caterpiliar Americas Co.
Edificio Brasil Interpart
Rua Guararapes, 2064 5.0 andar, cj.2
04561-004 - Sao Paulo-SP-Brazil
01.000-Sao Paulo-SP-Brazil
Phone: 011-536-3388
Fax: 011-505-1647

Far East (except Japan and Australia)
Caterpillar Far East Limited
28th Floor, Sun Hung Kai Centre
30 Harbour Road
G.P.O. Box 3069
Wanchai, Hong Kong
Cable Address: CATFAREAST HKG
Telex No.: HX73305 CFEL
Phone: 5-8326333

Australia and New Zealand
Caterpillar of Australia Ltd.
1 Caterpillar Drive
Private Mail Bag 4
Tullamarine, Victoria 3043
Australia
Telex: AA30240
Cable: CATERPILLAR MELB
Phone: (03) 339-9333
Fax: (03) 335-3366

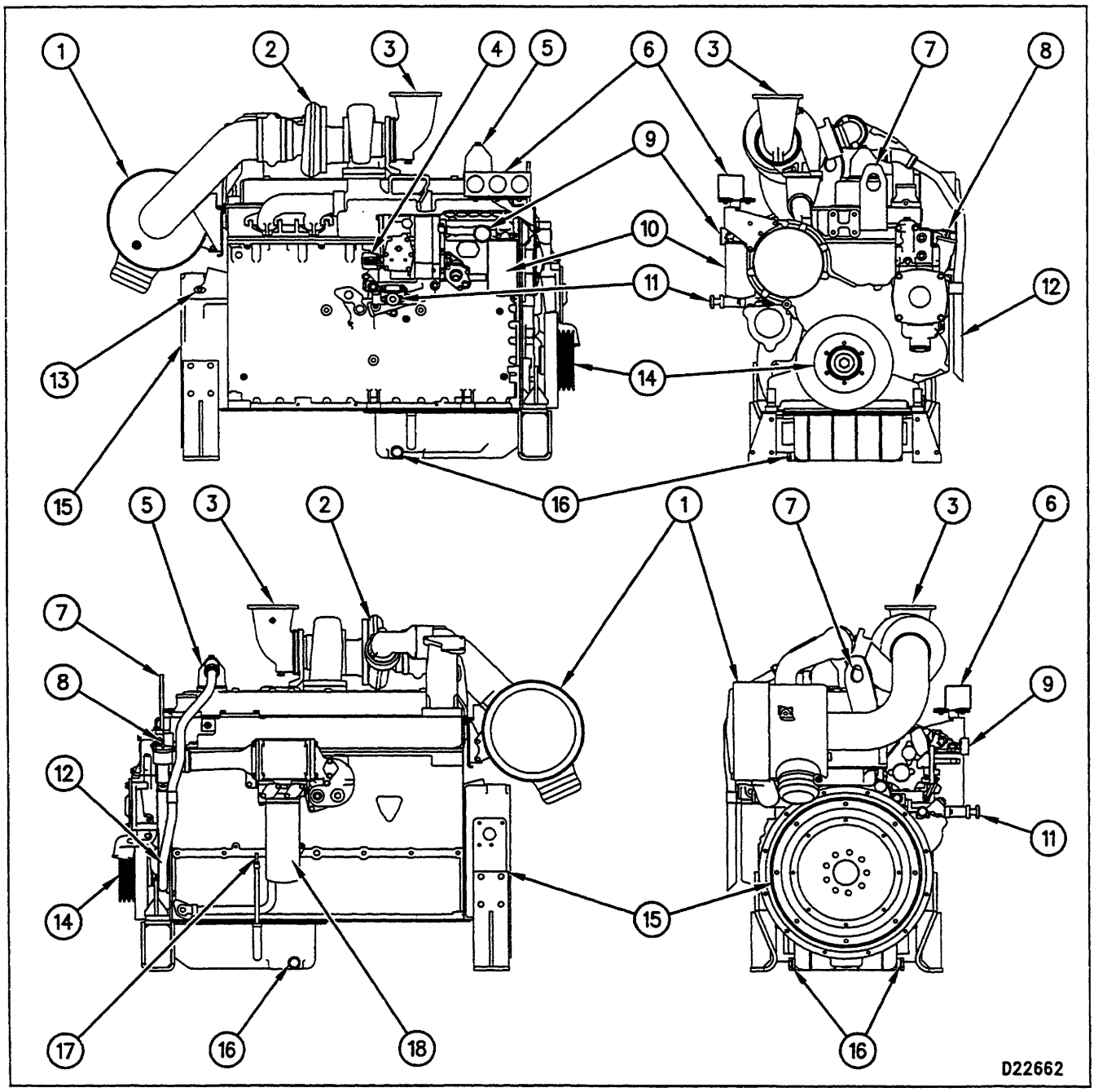
Japan
Caterpillar Mitsubishi Ltd.
3700, Tana, Sagamihara-shi
Kanagawa-ken, 229
Japan
Telex No.: 2872-261CM HAJ
Cable Address: CATERBISHICO SAGAMIHARA
Phone: Sagamihara (0427) 62-1121
Fax: (0427) 62-8542

Europe, Africa, and Middle East
Caterpillar Overseas S.A./Power Systems
YA50 76, Route de Frontenex
P.O. Box 456
1211 Geneva 6
Switzerland
Cable Address: CATOVERSEA
Telex No.: 413323
Phone: (022) 849-4444
Telecopier: (022) 849-4984
Fax: (022) 849-4544

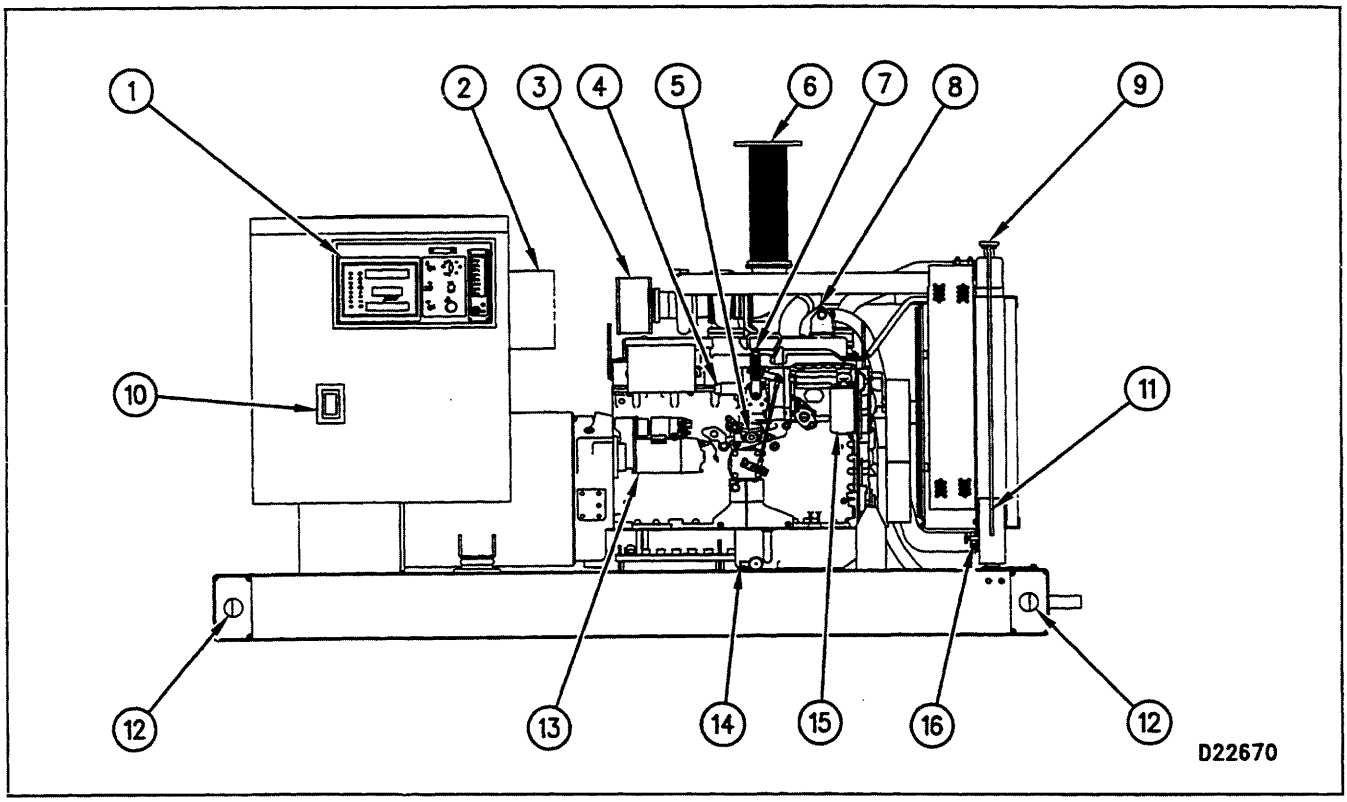
Model Views and Engine Information

Engine Model Views

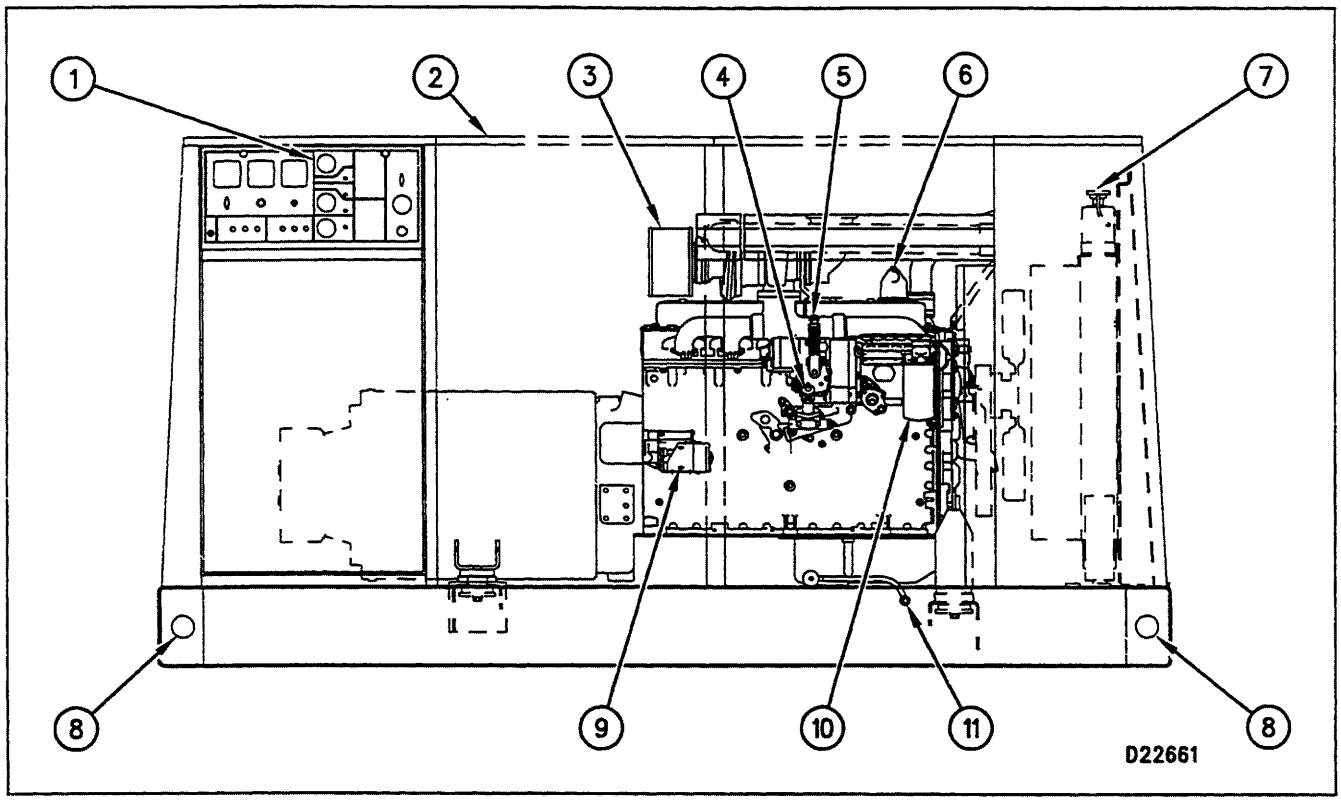
Typical views and attachments are shown.



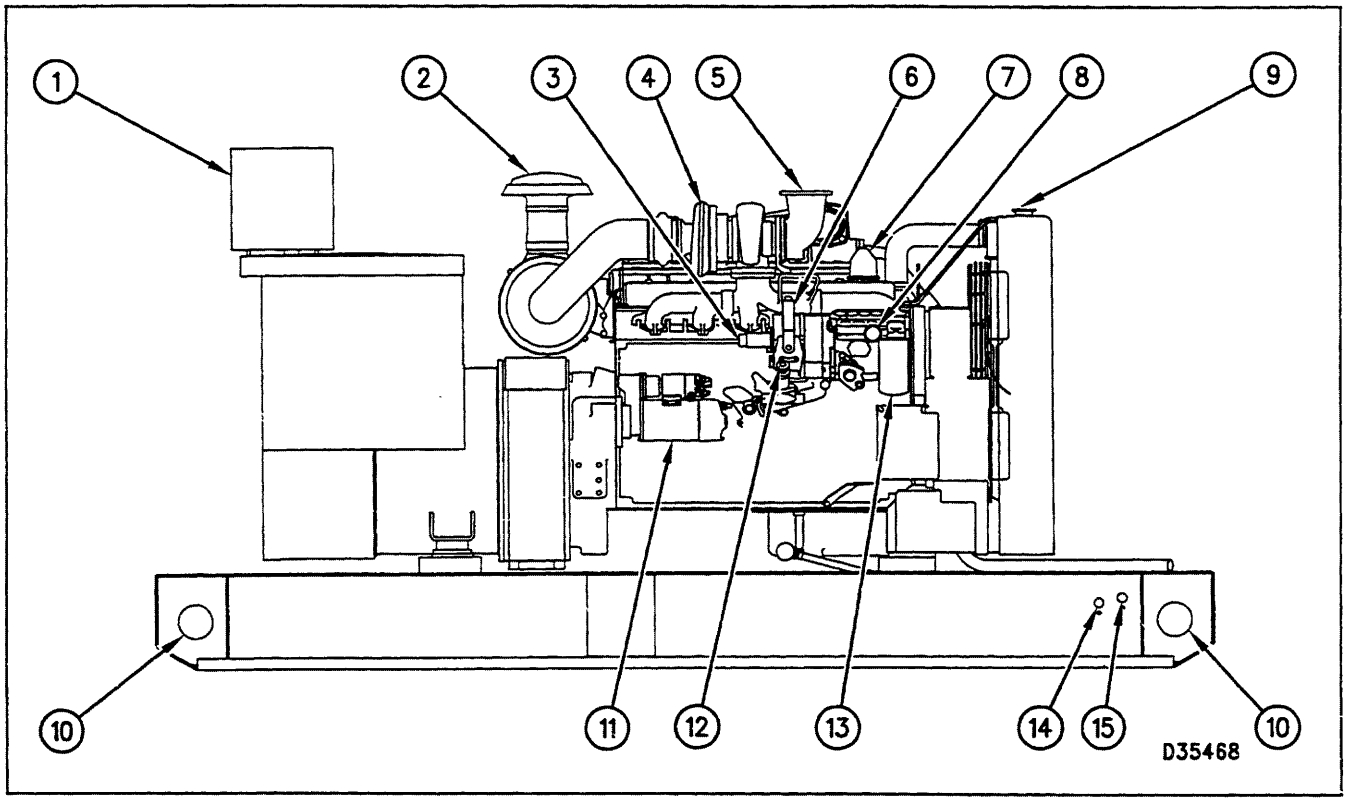
3306B Model Views: Air Cleaner (1), Turbocharger (2), Exhaust (3), Service (Hour) Meter (4), Crankcase Breather (5), Instrument Panel (6), Lifting Eye (7), Oil Filler (8), Fuel Pressure Gauge (9), Fuel Filter (10), Fuel Priming Pump (11), Fumes Disposal Tube (12), Magnetic Pickup Location (13), Crankshaft Vibration Damper (14), Flywheel Housing (15), Oil Drain (16), Oil Level Gauge (17), and Oil Filter (18).



Standby Generator Set: Control and Power Panel (1), Optional Battery Charger Mounting Location (2), Air Cleaner (3), Solenoid (4), Fuel Priming Pump (5), Exhaust (6), Governor Control Lever (7), Crankcase Breather (8), Radiator Fill Cap (9), Circuit Breaker (10), Optional Radiator Vent Hose (11), Lifting Location (12), Starting Motor (13), Oil Drain (14), Fuel Filter (15), and Water Drain (16).



Building Service Standby (BSSB) Generator Set: Control and Power Panel (1), Optional Total Enclosure (2), Air Cleaner (3), Fuel Priming Pump (4), Governor Control Lever (5), Crankcase Breather (6), Radiator Fill Cap (7), Lifting Location (8), Starting Motor (9), Fuel Filter (10), and Oil Drain (11).



Prime Generator Set: Control and Power Panel (1), Air Inlet (2), Solenoid (3), Turbocharger (4), Exhaust (5), Governor Control Lever (6), Crankcase Breather (7), Fuel Pressure Gauge (8), Radiator Fill Cap (9), Lifting Location (10), Starting Motor (11), Fuel Priming Pump (12), Fuel Filter (13), Oil Drain (14), and Water Drain (15).

Engine Information

The engines are available with direct fuel injection. The engines can be naturally aspirated, turbocharged, or turbocharged with jacket water aftercooling. The 3306B is also available turbocharged with air-to-air aftercooling (ATAAC).

A full-range hydramechanical governor controls the fuel injection pump output, maintaining the engine rpm selected by the operator. Individual injection pumps (one for each cylinder) meter and pump fuel under high pressure to injection nozzles. Automatic timing advance provides the best fuel injection timing over the full range of engine speed.

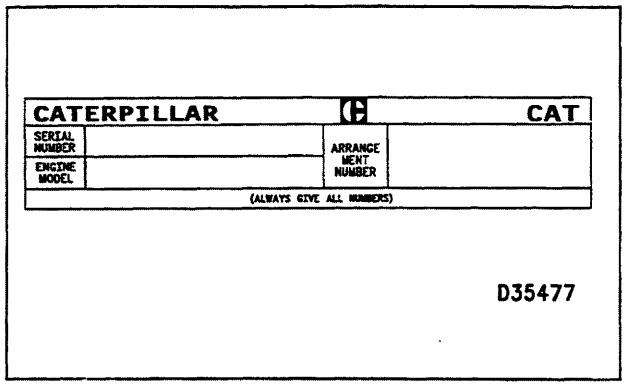
The cooling system consists of:
- a gear driven centrifugal pump (with one thermostat which regulates the engine coolant temperature)
- an oil cooler, and
- a radiator (incorporating a shunt system).

The engine lubricating oil, which is both cooled and filtered, is supplied by a gear-type pump. Bypass valves provide unrestricted flow of lubrication oil to the engine parts if oil viscosity is high, or if the oil cooler or the oil filter elements become plugged.

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to proper operation and maintenance recommendations. Engine performance and efficiency also depend on the use of recommended fuels and lubrication oils. Follow the recommended Maintenance Schedule found in this publication, paying attention to emission related components, air cleaner, oil, oil filter, fuel and fuel filter maintenance.

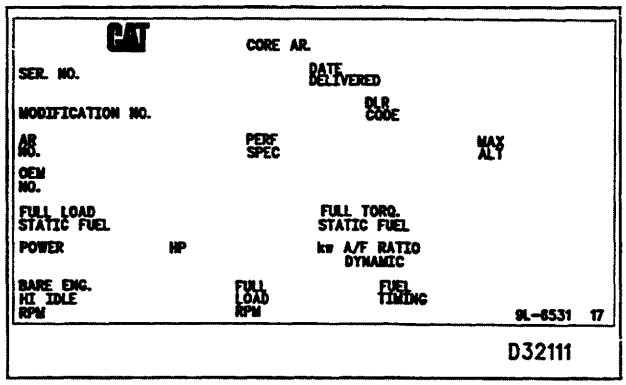
Serial Number, Information Plate and Reference Numbers

Serial Number Plate



The Serial Number Plate is located on the rear of the cylinder block.

Information Plate



The Information Plate is located on the left side of the cylinder block, or on the valve cover.

Engine Identification

Caterpillar engines are identified with serial numbers, fuel system setting numbers, and arrangement numbers. In some cases, modification numbers are used. These numbers are shown on the serial number plate mounted on the engine.

Caterpillar dealers need all of these numbers to determine which components were included on the engine when it was assembled at the factory. This permits accurate identification of replacement part numbers.

Quality Caterpillar replacement parts are available from Caterpillar dealers throughout North America and the world. Their parts stocks are up to date and include all parts normally required to protect your Caterpillar engine investment.

Reference Numbers

NOTE: Locate the following information for your engine, and record it on the appropriate line below. You may wish to make a copy of this record. Retain the information for future reference.

Record for Reference

Engine Model_____

Engine Serial No._____

Engine Arrangement No._____

Engine Power_____

Engine Low Idle rpm_____

Engine Full Load rpm_____

Performance Specification No._____

Governor Group No._____

Fuel Filter Element No._____

Lubrication Oil Filter Element No._____

Auxiliary Oil Filter Element No._____

Lubrication Oil System Capacity_____

Supplemental Coolant Additive Maintenance Element No._____

Supplemental Coolant Additive Precharge Element (Optional) No._____

Cooling System Capacity_____

Air Cleaner Element No._____

Fan Drive Belt Set No._____

Alternator Belt No._____

Ordering Parts

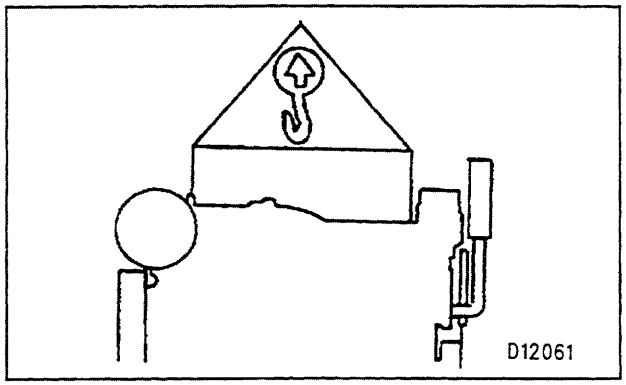
When ordering parts, your order should specify the quantity, part number, part name and serial number, arrangement number and modification number of the engine for which the parts are needed. If in doubt about the part number, please provide your dealer with a complete description of the needed item.

When service or maintenance is needed for your Caterpillar engine, be prepared to give the dealer all the information that is provided on the Information Plate.

Discuss the problem with the dealer, such as when it occurs, what happens, etc. This will help the dealer in troubleshooting and solving the problem faster.

Engine Lifting and Storage

Engine Lifting



NOTICE

When it is necessary to remove a component on an angle, remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees. Eye Bolts and brackets should never be bent, and should only be loaded under tension.

Use a hoist to remove heavy components. Use an adjustable lifting beam to lift the engine. All supporting members (chains and cables) should be parallel to each other, and perpendicular as possible to the top of the object being lifted.

Some removals require the use of lifting fixtures, to obtain proper balance and provide safe handling.

To remove the engine ONLY, use the lifting eyes equipped with the engine.

The lifting eyes are designed for the engine arrangement as sold. Modifying the lifting eyes and/or engine arrangement weight renders the lifting eyes and devices obsolete.

If you modify the lifting eyes and/or engine arrangement weight, you are responsible for providing adequate lifting devices. Contact your Caterpillar dealer for information regarding fixtures for proper engine package lifting.

Engine Lifting With Generator

NOTE: Do not use the engine lifting eyes to remove the engine and generator together.

Lifting the engine and generator together requires special equipment and procedures. Contact your Caterpillar dealer for information regarding fixtures for proper lifting of your engine package.

Engine Lifting With Fuel Tank

Lifting the engine along with a mounted fuel tank requires special equipment and procedures. Do not lift the unit with fuel in the tank. Contact your Caterpillar dealer for information regarding proper engine and fuel tank lifting.

Engine Storage

The following Engine Storage procedures and recommendations minimize the possibility of damage to engines stored for one year or less.

When an engine is not started for several weeks, the lubricating oil drains from the cylinder walls and piston rings. Rust can then form on the cylinder liner surface, increasing engine wear and decreasing engine life.

Special precautions should be used with engines remaining out of service for extended periods.

After one year, a complete protection procedure must be followed if the engine is kept in storage longer.

To prevent excessive engine wear:

- Be sure all lubrication recommendations mentioned in the Maintenance Schedule intervals chart are completed.
- If freezing temperatures are expected, check the cooling system for adequate protection against freezing. A 50/50 solution of Caterpillar (permanent-type) Antifreeze and approved water will give protection to −29°C (−20°F).

If it will be impossible to start the engine periodically, consult your Caterpillar dealer for instructions to prepare your engine for longer storage periods.

Refer to Storage Procedures For Caterpillar Products, SEHS9031, for more detailed information on engine storage.

Generator Storage Procedure

When a generator is stored, moisture may condense in the windings. Use a dry storage space and space heaters to minimize condensation. Refer to: Service Manual for SR4 Generators, SENR3985, or Special Instruction, SEHS9124, Cleaning and Drying of Caterpillar Electric Set Generators, or contact your Caterpillar dealer.

After Storage

NOTE: Test the main stator windings with a megohmmeter:

- Before the initial startup of the generator set.
- Every 3 months* if the generator is operating in a humid environment.
- If the generator has not been run under load for 3 months* or more.

* This is a guideline only. It may be necessary to megger more frequently if the environment is extremely humid or salty.

⚠ WARNING

When servicing or repairing electric power generation equipment:

Make sure the unit is off-line (disconnected from utility and/or other generators power service), and either locked out or tagged DO NOT OPERATE[1]. Remove all fuses.

Make sure the generator engine is stopped.
Make sure all batteries are disconnected.
Make sure all capacitors are discharged.
Failure to do so could result in personal injury or death.

Make sure residual voltage in the rotor, stator and the generator is discharged.

[1]DO NOT OPERATE tags, SEHS7332, are available from your Caterpillar dealer.

To Remove Moisture

NOTICE
Drying does not always produce desired results. It may be necessary for the generator to be dipped and baked by a qualified rebuild shop.

- Energize the space heaters in the generator (if equipped).
- Space heaters, of the same type used in marine applications, can be installed on generators (see the Parts Manual.) These heaters warm the windings to remove moisture. These heaters should be connected at all times in high humidity conditions, whenever the generator is not running.

The megohmmeter test is described in Service Manual for SR4 Generators, SENR3985 or Special Instruction, SEHS9124, Cleaning and Drying of Caterpillar Electric Set Generators, or contact your Caterpillar dealer.

Engine Specifications

3304B Engine

3304B ENGINE SPECIFICATIONS	
Number of Cylinders	4 In-Line
Bore	121 mm (4.75 in.)
Stroke	152 mm (6.0 in.)
Compression Ratio	15:1
Aspiration	NA & T
Displacement	7.0 L (425 cu in.)
Firing Order	1-3-4-2
Rotation (viewed from flywheel)	Counterclockwise

3304B VALVE LASH (CLEARANCE) SETTING	
Intake	0.38 mm (0.015 inch)
Exhaust	0.64 mm (0.025 inch)

CRANKSHAFT POSITIONS FOR INJECTOR TIMING AND VALVE LASH (CLEARANCE) SETTING		
	Check/Adjust With No. 1 Piston on:[1]	
3304B Engine	TC Compression Stroke	TC Exhaust Stroke
SAE Standard (Counterclockwise) Rotation Engines – as Viewed from Flywheel End		
Intake Valves	1-2	3-4
Exhaust Valves	1-3	2-4
Firing Order	1-3-4-2	

[1] Put No. 1 piston at top center (TC) position and make identification for the correct stroke. After top center position for a particular stroke is found and adjustments are made for the correct cylinders, remove the timing bolt and turn the flywheel 360° in the direction of normal engine rotation. This will put No. 1 piston at top center (TC) position on the other stroke. Install the timing bolt in the flywheel and complete the adjustments for the cylinders that remain.

3306B Engine

3306B ENGINE SPECIFICATIONS	
Number of Cylinders	6 In-Line
Bore	121 mm (4.75 in.)
Stroke	152 mm (6.0 in.)
Compression Ratio	15:1
Aspiration	NA, T & TA
Displacement	10.5 L (638 cu in.)
Firing Order	1-5-3-6-2-4
Rotation (viewed from flywheel)	Counterclockwise

3306B VALVE LASH (CLEARANCE) SETTING	
Intake	0.38 mm (0.015 inch)
Exhaust	0.64 mm (0.025 inch)

CRANKSHAFT POSITIONS FOR INJECTOR TIMING AND VALVE LASH (CLEARANCE) SETTING		
	Check/Adjust With No. 1 Piston on:[1]	
3306B Engine	TC Compression Stroke	TC Exhaust Stroke
SAE Standard (Counterclockwise) Rotation Engines – as Viewed from Flywheel End		
Intake Valves	1-2-4	3-5-6
Exhaust Valves	1-3-5	2-4-6
Firing Order	1-5-3-6-2-4	

[1] Put No. 1 piston at top center (TC) position and make identification for the correct stroke. After top center position for a particular stroke is found and adjustments are made for the correct cylinders, remove the timing bolt and turn the flywheel 360° in the direction of normal engine rotation. This will put No. 1 piston at top center (TC) position on the other stroke. Install the timing bolt in the flywheel and complete the adjustments for the cylinders that remain.

Torque Specifications

Torque for Standard Bolts, Nuts and Taperlock Studs

NOTICE

The following charts give general torques for bolts, nuts, and taperlock studs. For torque specifications not included in this section, refer to Torque Specifications, SENR3130, available from your Caterpillar dealer.

Torques for Bolts and Nuts With Standard Threads

Thread Size Inch	Standard Bolt & Nut Torque	
	N•m[1]	lb ft
1/4	12 ± 3	9 ± 2
5/16	25 ± 6	18 ± 4.5
3/8	47 ± 9	35 ± 7
7/16	70 ± 15	50 ± 11
1/2	105 ± 20	75 ± 15
9/16	160 ± 30	120 ± 20
5/8	215 ± 40	160 ± 30
3/4	370 ± 50	275 ± 37
7/8	620 ± 80	460 ± 60
1	900 ± 100	660 ± 75
1 1/8	1300 ± 150	950 ± 100
1 1/4	1800 ± 200	1325 ± 150
1 3/8	2400 ± 300	1800 ± 225
1 1/2	3100 ± 350	2300 ± 250

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

Torques for Taperlock Studs

Thread Size Inch	Standard Taperlock Stud Torque	
	N•m[1]	lb ft
1/4	8 ± 3	6 ± 2
5/16	17 ± 5	13 ± 4
3/8	35 ± 5	26 ± 4
7/16	45 ± 10	33 ± 7
1/2	65 ± 10	48 ± 7
5/8	110 ± 20	80 ± 15
3/4	170 ± 30	125 ± 22
7/8	260 ± 40	190 ± 30
1	400 ± 60	300 ± 45
1 1/8	525 ± 60	390 ± 45
1 1/4	750 ± 80	550 ± 60
1 3/8	950 ± 125	700 ± 92
1 1/2	1200 ± 150	890 ± 110

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

NOTE: Use these standard torque values for all fasteners, unless otherwise specified in this manual or in the Service Manual.

Torque for Metric Fasteners

NOTICE

Be very careful never to mix metric with customary (SAE standard) fasteners. Mismatched or incorrect fasteners will cause engine damage or malfunction and may even result in personal injury.

Original fasteners removed from the engine should be saved for reassembly whenever possible. If new fasteners are needed, they must be of the same size and grade as the ones that are being replaced.

Material strength identification is usually shown on the bolt head by numbers (8.8, 10.9, etc.). The following chart gives general torque values for bolts and nuts. Use these standard torque values unless otherwise specified in this publication.

NOTE: Metric hardware must be replaced with metric hardware. Check Parts Manual for proper replacement.

Torques for Bolts and Nuts with Metric Threads

METRIC ISO[2] THREAD		
Thread Size Metric	Standard Torque	
	N•m[1]	lb ft
M6	12 ± 3	9 ± 2
M8	28 ± 7	20 ± 5
M10	55 ± 10	40 ± 7
M12	100 ± 20	75 ± 15
M14	160 ± 30	120 ± 20
M16	240 ± 40	175 ± 30
M20	460 ± 60	340 ± 40
M24	800 ± 100	600 ± 75
M30	1600 ± 200	1200 ± 150
M36	2700 ± 300	2000 ± 225

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.
[2] ISO–International Standard Organization.

Torque for Standard Hose Clamps–Worm Drive Band Type

NOTE: The following chart gives the torques for initial installation of hose clamps on new hose and for reassembly or tightening of hose clamps on existing hose.

	Initial Installation Torque on New Hose	
Clamp Width	N•m[1]	lb in
16 mm (.625 in)	7.5 ± 0.5	65 ± 5
13.5 mm (.531 in)	4.5 ± 0.5	40 ± 5
8 mm (.312 in)	0.9 ± 0.2	8 ± 2
	Reassembly or Retightening Torque	
Clamp Width	N•m[1]	lb in
16 mm (.625 in)	4.5 ± 0.5	40 ± 5
13.5 mm (.531 in)	3.0 ± 0.5	25 ± 5
8 mm (.312 in)	0.7 ± 0.2	6 ± 2

[1] 1 Newton meter (N•m) is approximately the same as 0.1 mkg.

Torque for Constant Torque Hose Clamps

NOTICE

Due to extreme temperature changes, hose will heat set. Heat setting causes hose clamps to loosen. Loose hose clamps can result in leaks. There have been reports of component failures caused by hose clamps loosening. The new constant torque hose clamp will help prevent these failures. A constant torque hose clamp can be used in place of any standard hose clamp. Make sure the constant torque hose clamp is the same size as the standard clamp.

Installation

Each installation application can be different depending on the type of hose, fitting material, and anticipated expansion or contraction of the hose and fittings. A torque wrench should be used for proper installation of constant torque hose clamps. Constant torque hose clamps should be installed as follows:

- To allow for maximum expansion, install clamps at 5.7 N•m (50 lb in).
- To allow for equal expansion and contraction, install clamps at 10.2 N•m (90 lb in).
- To allow for maximum contraction, install clamps at 14.1 N•m (125 lb in).

Cooling System Specifications

Caterpillar Long Life Coolant/Antifreeze (LLCA)

Caterpillar has introduced a commercial Long Life Coolant/Antifreeze (LLCA) for use in Caterpillar and other heavy duty diesel engines. LLCA provides improved corrosion protection for the engine cooling system. LLCA replaces conventional type antifreeze.

LLCA extends coolant life to 6,000 service hours or four years with only one maintenance addition. LLCA does not require Supplemental Coolant Additive (SCA). A "one time only" coolant "Extender" is the only maintenance addition that is required, at 3,000 service hours or two years.

LLCA is ethylene glycol based for freeze and anti-boil protection. The anti-corrosion LLCA package is totally different from the standard silicate, molybdate, nitrate, borate and phosphate antifreezes that have been in use. Because of this difference, **the two coolants CAN NOT be mixed.**

NOTICE

Mixing LLCA with other products reduces the effectiveness of the coolant. Mixing LLCA with other products could result in damage to cooling system components. Do not mix LLCA with other products.

Although Caterpillar is not presently using LLCA for standard factory fill, an engine or machine may be special ordered with LLCA as the fill coolant. Due to the non-mixing requirements, the owner will initiate the use of this coolant.

LLCA has an effective operating temperature range of −46 to 127°C (−50 to 260°F). At temperatures below −46°C (−50°F), the coolant viscosity will increase, presenting a pumping problem unless provisions are made for a larger water pump. Brief departures of temperatures above 127°C (260°F) are acceptable for short periods of time. However, prolonged operation above the limits will degrade the glycol and inhibitor system. The system must be pressurized to maintain the coolant in a liquid phase at all times. Any boiling will result in precipitation on the surfaces of the engine coolant jacket.

LLCA has been developed with the antifreeze and additive at a specific level for maximum protection. If the proportion of antifreeze is reduced, the additive is also reduced, lowering the coolant's ability to protect the system from pitting, cavitation, erosion, and deposits.

LLCA is available as an antifreeze formulation, premixed 50/50 with deionized water, or in concentrate, in the following quantities.

CATERPILLAR LONG LIFE COOLANT/ANTIFREEZE QUANTITIES AVAILABLE

Type	Size	Part No.
Pre-mix[1]	Bulk 208.5 L (55 US gal) 3.8 L (1 US gal)	119-5148 101-2845 101-2844
Concentrate[2]	3.8 L (1 US gal)	119-5150
Extender[3]	.95 L (1 qt)	119-5152

[1] 50 percent Long Life Coolant/Antifreeze and 50 percent water.
[2] Use ONLY distilled or deionized water to mix with the concentrate.
[3] Extender must be added to the cooling system only one time at 3,000 hours or two years in the quantity recommended by Caterpillar.

LLCA concentrate is available to lower the freeze point for arctic conditions. LLCA concentration can be increased for lower operating temperatures without a problem to 60 percent for −60°C (−76°F). Do not use LLCA at reduced concentrations (less than 50 percent), since the additives would be reduced along with the antifreeze.

LLCA Extender

LLCA does not require the frequent Supplemental Coolant Additive (SCA) additions associated with the present conventional coolants. Only a "one time" coolant Extender addition is required. The Extender is added to the cooling system halfway through the LLCA service life.

NOTICE

Depletion of the additives in LLCA is a function of operating time. However, the Extender may not be required for engines with very low operating miles or hours. For more information, contact your Caterpillar dealer.

RECOMMENDED AMOUNT OF EXTENDER BY COOLING SYSTEM CAPACITY	
Cooling System Capacity Liters (US Gallons)	**Recommended Amount of Extender**
22 to 30 L (6 to 8 US gal)	0.57 L (20 oz)
30 to 38 L (8 to 10 US gal)	0.71 L (24 oz)
38 to 49 L (10 to 13 US gal)	0.95 L (1 qt)
49 to 64 L (13 to 17 US gal)	1.2 L (40 oz)

NOTICE

Use only Caterpillar Extender with LLCA. Failure to follow this recommendation can result in shortened cooling system component life.

LLCA can be recycled in the same manner as conventional antifreeze/coolant. The drained coolant mixture can be "distilled" to remove the ethylene glycol and water for reuse. The inhibitor system and other contaminants are left behind as residual for disposal. Contact your Caterpillar dealer for more information.

Cooling System Maintenance When Using LLCA

Changing the Cooling System from Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) or Commercial Coolants to LLCA

When the cooling system coolant is changed from conventional antifreeze to LLCA, Caterpillar cleaner **should** be used. Refer to the Caterpillar Cooling System Cleaner chart in this publication. After the use of Caterpillar cooling system cleaner, the system MUST be thoroughly flushed with clean water.

To switch from conventional antifreeze/coolant to LLCA:

1. Drain the antifreeze.

2. Flush the system with clean water to remove any debris.

3. Use Caterpillar cleaner to clean the cooling system. Follow the instructions on the label.

4. Drain the cleaner, and flush the cooling system with clean water.

5. Fill the cooling system with clean water. Operate the engine until warm 49 to 66°C (150 to 120°F).

6. Drain the cooling system. Flush the cooling system with clean water.

7. Repeat steps 5 and 6.

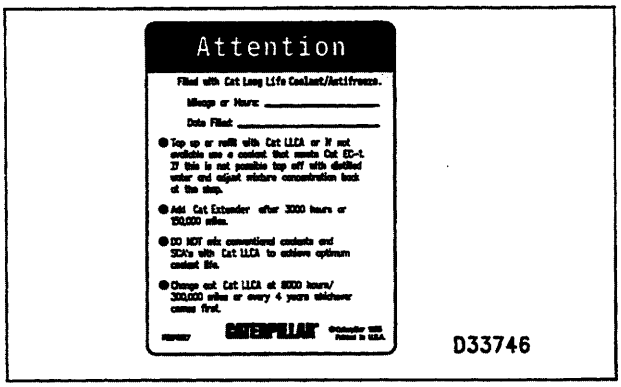
8. Fill the cooling system with LLCA. Refer to the refill capacities chart in this manual for the amount of LLCA needed to refill your system.

LLCA Cooling System Draining, Cleaning, and Refilling

No cleaning agents are to be used when a cooling system already filled with LLCA is drained, flushed, and refilled. When LLCA is drained from the cooling system, **CLEAN WATER** is the only system cleaning/flushing agent required.

When LLCA is already in the cooling system, drain, clean, and refill the system after 6,000 service hours or four years, whichever comes first. Do not use cooling system cleaners. Follow the preceeding steps 4 through 8. The drained LLCA should be recycled, as with conventional coolants.

Use the PEEP5027 decal to avoid mixing conventional coolants with LLCA, and to help document LLCA maintenance. Attach the decal close to the coolant fill tube on the expansion tank or radiator. The decal is heat resistant for surface temperatures up to 193°C (380°F).



Conventional Antifreeze/Coolant Information

Diesel engine operating temperatures have increased to improve engine efficiency. This makes proper cooling system maintenance especially important. Coolant quality is as important as the quality of fuel and lubricating oil. It is important that this section be read carefully.

Overheating, over cooling, pitting, cavitation erosion, cracked heads, piston seizures, and plugged radiators are results of typical cooling system failures. Such failures can be avoided by practicing good maintenance.

Due to individual engine applications, maintenance practices may need periodic re-evaluation to properly maintain the engine's cooling system.

If the engine is to be stored in or shipped to a climate with freezing temperatures, the cooling system must be protected to the lowest expected outside (ambient) temperature.

NOTE: The engine cooling system is normally shipped dry from the factory, unless special requirements are defined.

NOTICE

Never operate without thermostats in the cooling system. Thermostats maintain the engine coolant at the proper operating temperature. Cooling system problems can arise without thermostats.

Coolant Mixture for Caterpillar Engines

Proper engine coolant is a combination of:
- water,
- coolant/antifreeze, and
- Supplemental Coolant Additive (SCA).

Each ingredient of the mixture must meet specific guidelines for the engine coolant to perform properly. The coolant mixture used in Caterpillar engines must provide:
- adequate heat transfer.
- cavitation erosion protection.
- freeze & boil protection.
- sludge & scale protection.
- corrosion protection.
- compatibility with system hoses & seals.

NOTICE

Use only Caterpillar products or commercial products that have passed the Caterpillar EC-1 specification for pre-mixed or concentrate coolants. Follow the instructions provided by the antifreeze supplier.

NOTE: For more detailed specifications, refer to: Know Your Cooling System, SEBD0518, and Coolant and Your Engine, SEBD0970, or contact your Caterpillar dealer.

Coolant Water

Coolant Water Characteristics

Water may contain several types of dissolved solids, such as phosphates, calcium, magnesium, chlorides, and sulfates. Dissolved solids in water can combine with mineral silicates and phosphates in SCA. The combinations may drop out of solution, depositing inside the radiator. The deposits are in the form of sludge and scale. The deposits can accumulate on hot engine surfaces and reduce the effectiveness of the cooling system, especially after a number of heating and cooling cycles.

NOTICE

All water is corrosive at engine operating temperatures. The cooling system should be protected against water corrosion with a three to six percent concentration of liquid Supplemental Coolant Additive (SCA) at all times, regardless of the concentration of antifreeze/coolant.

Recommendations for Coolant Water

Distilled or deionized water is recommended because of less mineral drop out than hard or tap water. Tap water artificially softened with salt is NOT recommended for use in engine cooling systems.

If Distilled or deionized water is NOT available, use water that meets the minimum acceptable requirements listed in the following chart.

MINIMUM ACCEPTABLE WATER	
Water Content	**Limits gr/U.S. gal (ppm)**
Chlorides	2.4 (40) maximum
Sulfates	5.9 (100) maximum
Total Hardness	10 (170) maximum
Total Solids	20 (340) maximum
Acidity (pH)	5.5 to 9.0

ppm = parts per million

If you are not sure of your water's contents, contact your local water department, agricultural agent, or an independent laboratory to analyze the water.

Caterpillar Diesel Engine Antifreeze/Coolant (DEAC)

Most commercial antifreeze/coolants are formulated for gasoline engine applications and have high silicate content. Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) is formulated with a low silicate content and the proper coolant additives for heavy duty diesel engines.

If conventional antifreeze is to be used rather than LLCA, Caterpillar recommends: Caterpillar DEAC, or any low silicate (ethylene or propylene glycol) antifreeze that meets ASTM D4985-89 requirements.

Caterpillar recommends that the coolant mixture contain a minimum of 30 percent Caterpillar DEAC (or equivalent), and 70 percent distilled or deionized water. The recommended mixture maintains an adequate water pump cavitation temperature for efficient water pump performance.

NOTICE

Only use a greater concentration (above 30 percent) of Caterpillar DEAC as needed for anticipated outside (ambient) temperatures. Do not exceed a coolant mixture of 60 percent antifreeze to 40 percent water. Antifreeze concentration above 60 percent reduces engine freeze protection and increases potential deposit formation in the cooling system.

Some engine applications operate with SCA treated water without antifreeze/coolant. Do not mix SCA treated water in the cooling system with Caterpillar DEAC. Incompatibility could cause cooling system damage because the coolant will have an excessive SCA concentration.

Major advantages of Caterpillar DEAC:

- Significantly reduces water pump seal leakage problems caused by excessive concentration of chemical additives.
- There is no need to add SCA on initial fill, which must be done with other commercially available antifreezes.
- Caterpillar DEAC is formulated with a low silicate content. High silicate antifreeze/coolants used with a SCA can cause a build-up of solids over a period of time. Build-up of solids can cause plugging, loss of heat transfer, and water pump seal damage.

Caterpillar DEAC is available through your Caterpillar dealer in the following quantities.

CATERPILLAR DIESEL ENGINE ANTIFREEZE/COOLANT[1]		
Part No.	**Type**	**Size**
8C3684	Concentrate	3.8 L (1 US gal)
8C3686	Concentrate	208.5 L (55 US gal)
2P9868	Concentrate	18,950 L (5,000 US gal) (Bulk)
3E9439	50/50 Premix	18,950 L (5,000 US gal) (Bulk)
119-5147	40% DEAC/ 60% Water Premix	18,950 L (5,000 US gal) (Bulk)

[1] Caterpillar Diesel Engine Antifreeze/Coolant (DEAC) contains necessary Supplemental Coolant Additive (SCA). Caterpillar DEAC does not require SCA on initial fill. SCA liquid or SCA spin-on element is required on a maintenance basis. Check the coolant concentration of SCA regularly.

Make proper antifreeze additions.

Unless freeze protection is needed for arctic conditions, DO NOT add pure antifreeze as a makeup solution for cooling system top-off. Using pure antifreeze as a makeup solution increases the concentration of antifreeze in the cooling system, which increases the concentration of dissolved solids and undissolved chemical inhibitors. When you top-off the cooling system, add antifreeze, mixed with acceptable water, to the same concentration as the coolant in the system.

NOTE: Premix the coolant solution prior to pouring it into the cooling system. Pure undiluted antifreeze will freeze at −23°C (−10°F). Use a mixture which will provide protection to the lowest expected outside (ambient) temperature.

Use the following chart to determine concentrations of Caterpillar DEAC to mix with acceptable water.

ANTIFREEZE CONCENTRATIONS (GLYCOL)	
Protection Temperature	**Concentration**
Protection to −15°C (5°F)	30% antifreeze and 70% water
Protection to −23°C (−10°F)	40% antifreeze and 60% water
Protection to −37°C (−34°F)	50% antifreeze and 50% water
Protection to −51°C (−60°F)	60% antifreeze and 40% water

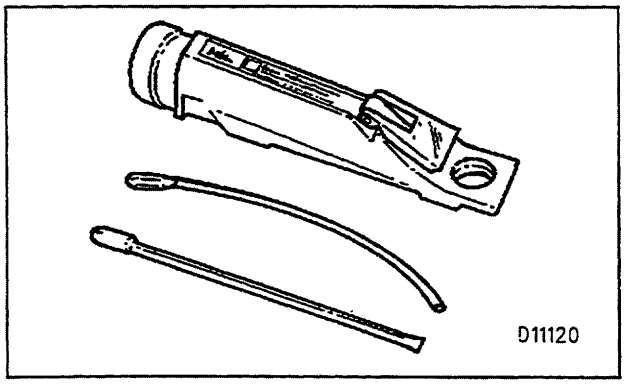
FREEZING POINT OF COOLANT		
Concentration of Antifreeze (%) by Volume	**Ethylene[1]**	**Propylene[2]**
0	0°C (32°F)	0°C (32°F)
20	−9°C (16°F)	−7°C (19°F)
30	−15°C (4°F)	−12°C (10°F)
40	−24°C (−12°F)	−21°C (−6°F)
50	−37°C (−34°F)	−33°C (−27°F)
60	−52°C (−62°F)	-

[1] Caterpillar does not recommend concentrations of over 60 percent ethylene glycol.
[2] If propylene glycol based antifreeze is used, DO NOT allow greater than a 50/50 antifreeze to water mixture.

Check the antifreeze frequently in cold weather to ensure adequate freeze protection.

The measurement of freeze protection must be made with a refractive-type tester rather than a commercially available hydrometer-type tester. Hydrometer-type testers can only be used to test ethylene glycol based antifreeze.

Test the antifreeze concentration with the 5P3514 (measures °C) or 5P0957 (measures °F) Test Kit. The Test Kits give immediate, accurate readings, and can be used on ethylene or propylene glycol antifreezes. Both Test Kits are available from your Caterpillar dealer.



5P3514(°C) or 5P0957 (°F) Coolant Test Kit .

Supplemental Coolant Additive (SCA)

Supplemental Coolant Additive (SCA) is necessary for proper engine maintenance. SCA is necessary to inhibit rust, scale, deposits, cavitation, pitting, and corrosion of the engine parts that coolant comes in contact with. Most antifreeze solutions DO NOT contain sufficient SCA.

Some engines are equipped with a Caterpillar SCA spin-on element. Use SCA liquid or a spin-on element (if equipped) to maintain a three to six percent SCA concentration in the coolant.

⚠ WARNING

Supplemental coolant additive contains alkali. To prevent personal injury, avoid contact with the skin and eyes and do not drink.

NOTICE

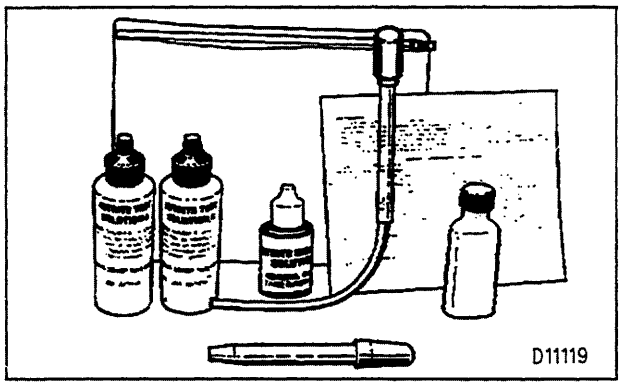
The cooling system MUST contain supplemental coolant additive (SCA) for proper engine protection, regardless of antifreeze concentration.

DO NOT mix Caterpillar SCA or SCA spin-on elements with another manufacturer's SCA products. DO NOT use both liquid SCA and a SCA spin-on element at the same time. Select a cooling system treatment and use it exclusively.

DO NOT mix SCA with antifreeze/coolant products containing methoxy propanol.

Do not exceed the recommended six percent SCA concentration together with antifreeze concentrations greater than 60 percent. Excessive SCA concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive SCA concentration could also result in radiator tube blockage, overheating, and/or accelerated water pump seal wear.

Use the 8T5296 Test Kit to check the concentration level of Caterpillar SCA.



Caterpillar 8T5296 SCA Test Kit.

NOTE: The Caterpillar 8T5296 Test Kit checks for concentration of nitrates in the coolant solution. Some other manufacturers' SCA is phosphate based. The 8T5296 Test Kit provides inaccurate results with phosphate based SCA. Commercial SCA products must contain silicates and a minimum of 70 gr/U.S. gallon (1200 ppm) nitrites. If other manufacturers' SCA is used, also use the SCA manufacturer's test kit. Follow the manufacturer's recommendation for cooling system treatment and test evaluation.

The following chart lists the part numbers and quantities of liquid SCA available from your Caterpillar dealer. Follow the instructions on the label.

LIQUID SUPPLEMENTAL COOLANT ADDITIVE QUANTITIES AVAILABLE	
Part No.	**Size**
6V3542	0.24 L (8 oz)
111-2372	0.35 L (12 oz)
8T1589	0.47 L (1 pt)
3P2044	0.95 L (1 qt)
8C3680	19 L (5 US gal)
5P2907	208.5 L (55 US gal)

Water-Only Coolant

Caterpillar recommends a minimum concentration of 30 percent DEAC and 70 percent deionized or distilled water in a coolant solution. Supplemental coolant additive (SCA) should comprise three to six percent of that solution. However, a coolant mixture of acceptable water and SCA can be used in applications where conditions do not require freeze protection, or where antifreeze is not available.

A coolant mixture of water and SCA will cool and provide some protection to engine components, but it will not provide normal engine service life. SCA/water mixtures provide better performance life than water-only coolant.

If the engine cooling system is filled with water ONLY, SCA concentration should be maintained at six to eight percent maximum. Do not exceed the eight percent maximum concentration. Monitor SCA concentration levels with a SCA test kit.

The 8T5296 Test Kit can be used to evaluate the SCA concentration of water-only coolant. Follow the instructions on the Test Kit package, making these modifications to label instruction steps 3 and 5:

STEP 3–Add tap water to the vial up to the 20 ml mark.
STEP 5–With the defined procedure, the six to eight percent concentration will yield a 20 to 27 drop range. Fewer drops indicate under-concentration of SCA and more drops indicate over-concentration. Adjust the concentration appropriately.

NOTE: If the SCA concentration of your water/SCA mixture is greater than the maximum of eight percent: drain some of the coolant, refill the system with acceptable water, and re-test the concentration level.

Initial Fill

SCA is pre-mixed in Caterpillar Antifreeze. SCA is not needed for initial fill when Caterpillar Antifreeze is being used. SCA is required on a maintenance basis, even when using Caterpillar DEAC.

NOTICE

SCA is required on initial fill and for subsequent maintenance when using coolant/antifreeze products other than Caterpillar's which meet ASTM D4985 standards.
On initial fill or refill, add one liter (one quart) of SCA or equivalent for each 19 liters (5 US gal) of ASTM D4985 coolant/antifreeze solution. The solution should have a three to six percent concentration of SCA.

NOTICE

For engines equipped with SCA spin-on elements: the spin-on element can be installed at initial fill, when the coolant is replaced, and at overhaul. However, the element should not be turned on until after 250 service hours, or as determined by testing for SCA concentration. This prevents over-concentration of SCA.

INITIAL FILL SUPPLEMENTAL COOLANT ADDITIVE REQUIREMENTS	
Antifreeze	**Initial Fill**
Caterpillar DEAC[1]	None Required
ASTM D4985	Use Caterpillar supplemental coolant additive liquid in the quantities listed in following chart.

[1] Caterpillar Diesel Engine Antifreeze/Coolant.

INITIAL FILL LIQUID SUPPLEMENTAL COOLANT ADDITIVE BY CAPACITY[1]		
Cooling System Capacity Liters (US gal)	**Add Initial Fill Quantity[2] Or**	**Commercial Bulk Volume**
22 to 30 (6 to 8)	3P2044 (1)	0.95 L (1 qt)
30 to 38 (8 to 10)	3P2044 (1) 6V3542 (1)	1.2 L (40 oz)
(38 to 49) (10 to 13)	3P2044 (1) 8T1589 (1)	1.4 L (48 oz)
49 to 64 (13-17)	3P2044 (2)	1.9 L (2 qt)
64 to 83 (17 to 22)	3P2044 (2) 8T1589 (1)	2.4 L (80 oz)
83 to 114 (22 to 30)	3P2044 (3) 8T1589 (1)	3.3 L (112 oz)
114 to 163 (30 to 44)	3P2044 (5)	4.7 L (5 qt)
163 to 243 (44 to 64)	3P2044 (8)	7.6 L (8 qt)

[1] Caterpillar Diesel Engine Antifreeze Coolant (DEAC) contains necessary Supplemental Coolant Additive (SCA). Caterpillar DEAC does not require additional SCA on initial fill. Only use SCA on initial fill when using coolant/antifreeze products which meet ASTM D4985 standards.

[2] Number in brackets () indicates quantity required.

Maintenance

Maintaining the cooling system is important because the cooling system has a direct effect on the operation and service life of the engine. Improper maintenance can cause a variety of problems which could reduce engine performance and service life.

Check the antifreeze concentration frequently in cold weather to ensure adequate freeze protection. Use the 5P3514 (°C) or 5P0957 (°F) test kit.

Use the 8T5296 Test Kit to test and monitor the SCA concentration in your engine's coolant mixture. SCA concentration should be tested every 250 service hours or one year, whichever comes first. Add liquid SCA or a new SCA spin-on element (if equipped) as required to maintain a three to six percent SCA concentration.

NOTICE

To prevent over-inhibiting the engine's cooling system, NEVER use both the supplemental coolant additive AND the supplemental coolant additive element (if equipped) at the same time. Use one method or the other exclusively.

When using Caterpillar DEAC and SCA, the cooling system should be drained, cleaned, and refilled with new coolant every 3000 service hours or two years.

When NOT using Caterpillar DEAC and SCA as recommended, the drain/flush/clean/refill must be performed at least every year.

NOTICE

Never add coolant water to an overheated engine – engine damage can result. Allow the engine to cool first. Do not add coolant water too quickly. Filling the cooling system at over 19 liters (5 US gal) per minute can create air pockets in the cooling system.

After cleaning and refilling the cooling system, operate the engine with the coolant filler cap removed until the coolant reaches normal operating temperature and the coolant level stabilizes. Add coolant mixture as necessary to fill the system to the proper level. Add 0.24 L (8 oz) of SCA for each 19 L (5 US gal) of coolant mixture.

LIQUID MAINTENANCE SUPPLEMENTAL COOLANT ADDITIVE BY CAPACITY[1]		
Cooling System Capacity Liter (US gal)	**Add Maintenance Quantity[2] Or**	**Commercial Bulk Volume**
22 to 30 (6 to 8)	6V3542 (1)	0.24 L (8 oz)
30 to 38 (8 to 10)	111-2372	0.35 L (12 oz)
38 to 49 (10 to 13)	111-2372	0.35 L (12 oz)
49 to 64 (13 to 17)	8T1589 (1)	0.47 L (1 pt)
64-83 (17 to 22)	6V3542 (1) 111-2372 (1)	.64 L (20 oz)
83 to 114 (22 to 30)	3P2044 (1)	0.95 L (1 qt)
114 to 163 (30 to 43)	3P2044 (1) 6V3542 (1)	1.2 L (40 oz)
163 to 243 (43 to 64)	3P2044 (2)	1.9 L (2 qt)

[1] Do not exceed six percent maximum supplemental coolant additive (SCA) concentration. Check SCA concentration at each oil change with the supplemental coolant additive test kit.
[2] Number in brackets () indicates quantity required

The following chart applies ONLY to engines with supplemental coolant additive (spin-on) elements.

SUPPLEMENTAL COOLANT ADDITIVE[1] ELEMENTS BY CAPACITY	
System Size Liter (US gal)	**250 Hour Maintenance Element[2]**
22 to 30 (6 to 8)	111-2370 (1)
30 to 49 (8 to 13)	111-2369 (1)
49 to 64 (13 to 17)	9N3368 (1)
64 to 83 (17 to 22)	111-2371 (1)
83 to 114 (22 to 30)	9N3718 (1)
114 to 163 (30 to 43)	111-2371 (2)
163 to 243 (43 to 64)	9N3718 (2)

[1] Do not use elements at initial fill or refill. Do not exceed six percent maximum supplemental coolant additive (SCA) concentration. Check SCA concentration at each oil change with the supplemental coolant additive test kit.
[2] Number in brackets () indicates quantity required

NOTICE

The SCA element can be installed at initial fill and refill. However, the elements should not be used until SCA is needed, as determined by testing for SCA concentration.

Cooling System Cleaning

When you drain, clean, flush and replace the coolant, small particles, undesirable chemicals, scale, and other deposit formations are removed. The deposits reduce the necessary heat transfer characteristics of the cooling system, and accelerate wear to the water pump seal. Disregard for performing maintenance on the cooling system can eventually cause engine overheating problems that could result in severe damage to the engine and its components.

NOTE: Clean the cooling system if: it becomes contaminated, the engine overheats, or foaming is observed in the radiator.

When using Caterpillar DEAC, drain, clean, and refill the cooling system every two years or 3,000 service hours, whichever comes first.

NOTICE

When using commercial antifreeze/coolant products from a manufacturer other than Caterpillar, drain, clean, and refill the cooling system every year or 1,500 service hours, whichever comes first.

Caterpillar Cooling System Cleaners are designed to clean the system of harmful scale and corrosion. Cleaners dissolve mineral scale, corrosion products, light oil contamination, and sludge.

Cooling system cleaners are available from your Caterpillar dealer in the quantities listed below. Refer to the maintenance instructions in the Maintenance Schedule, and follow the product label directions for proper usage.

CATERPILLAR COOLING SYSTEM FAST ACTING CLEANER	
Part No.	**Size**
4C4609	0.47 L (1 pt)
4C4610	0.95 L (1 qt)
4C4611	3.8 L (1 US gal)
4C4612	19 L (5 US gal)
4C4613	208.5 L (55 US gal)

Fuel Specifications

Fuel Recommendations

NOTICE

Fill the fuel tank at the end of each day of operation to drive out moist air and prevent condensation. Maintain a fairly constant level in the day tank (near the top) to avoid drawing moisture into the tank as the level decreases.

Do not fill the tank to the top. Fuel expands as it warms, and may overflow.

Do not fill fuel filters with fuel before installing them. Contaminated fuel causes accelerated wear to fuel system parts.

Use fuel only as recommended in this section. Fuel grades recommended for use in Caterpillar diesel engines are: No.2-D diesel fuel with low sulfur (0.05 percent maximum), or regular sulfur (0.5 percent maximum). No.1 grades are acceptable.

The following chart lists worldwide fuel standards which meet Caterpillar requirements.

WORLDWIDE FUEL SPECIFICATIONS–DIESEL ENGINES	
Specifications	**Fuel Designation**
U.S. STANDARDS ASTM D975	No.1-D & No.2-D diesel fuel oil
BRITISH STANDARDS BS 2869	Classes A1, A2 & B1 engine fuels
GERMAN STANDARDS DIN 51601	Diesel Fuel
AUSTRALIAN STANDARD AS 3570	Automotive diesel fuel
JAPANESE STANDARD JIS K2204	Types 1(spl), 1, 2, 3 & 3(spl) gas oil
U.S. GOVERNMENT VV-F-800C	DF-1,DF-2 conus & DF-20 conus diesel fuel
U.S. MILITARY MIL-F-16884G	Marine Oil

Caterpillar Diesel Engines are capable of burning a wide range of distillate fuels. Burning clean, stable blends of distillate fuel meeting the following requirements will provide quality engine service life.

DISTILLATE FUEL RECOMMENDATIONS–DIESEL ENGINES	
Specifications	**Requirements[1]**
Aromatics (ASTM D1319)	35% Max.
Ash (ASTM D482)	0.02% Weight Max.
Cetane Number (ASTM D613)	40 Minimum
Cloud Point (ASTM D97)	Not Above Lowest Expected Ambient Temperature
Gravity API (ASTM D287)	30 Min. and 45 Max.
Pour Point (ASTM D97)	6°C (10°F) Below Ambient Minimun
Sulfur (ASTM D2788, D3605 or D1552)	0.5% Max. (See Sulfur Topic)
Viscosity, Kinematic @ 38°C (100°F) (ASTM D445)	20.0 cSt Max. 1.4 cSt Min.
Water & Sediment (ASTM D1796)	0.01% Max.

[1] As delivered to fuel system

NOTE: When economics or fuel availability dictate, other fuel types may be burned in the engine. Consult your Caterpillar dealer for more information and advice on any specific fuel.

Cetane Number

Under average starting conditions, direct injection engines require a minimum cetane number of 40. A higher cetane value may be required for high altitude or coid weather operation.

Filterability

Clean fuels should have no more than 0.1 percent of sediment and water. Fuel stored for extended periods of time may oxidize and form solids, causing filtering problems.

Pour Point

Fuel pour point should be at least 6°C (10°F) below the lowest ambient temperature at which the engines must start and operate. Lower pour points of No.1 or No.1-D fuel may be necessary in extremely cold weather.

Cloud Point

The cloud point should be below the lowest ambient temperature at which the engines must start and operate, to prevent the fuel filter elements from plugging with wax crystals. Refer to Fuel Problems in Cold Weather Operation for additional information.

Viscosity

Fluid viscosity is a measure of resistance to flow. Fuel viscosity is important because it effects lubrication of fuel system components, and fuel atomization. The provided viscosity limits address both of those effects.

Additives

Fuel additives are generally not recommended or needed for the specified fuels listed. Cetane improvers can be used as necessary for direct injection engine requirements. Biocides may be needed to eliminate microorganism growth in storage tanks. In cold conditions, treatment for entrained water may also be necessary.

Consult your fuel supplier about the use of additives to prevent incompatibility among additives already in the fuel and the additives to be used.

Fuel Sulfur

The percentage of sulfur in fuel affects engine oil recommendations. Fuel sulfur can change chemically during combustion, forming both sulfurous and sulfuric acids. The acids attack metal surfaces and cause corrosive wear. Sulfur oxides formed during combustion also produce particulate exhaust emissions.

Some lubricating oil additives contain alkaline compounds to neutralize acids in combustion gases and minimize corrosive wear. Reserve alkalinity in lubricating oil is measured and defined with a Total Base Number (TBN).

Periodically request fuel sulfur content information from your fuel supplier. Fuel sulfur content can change with each bulk delivery.

More information concerning fuel sulfur and lubrication can be found in the Lubricant Specifications section of this manual.

Refer to Diesel Fuels and Your Engine, SEBD0717, or contact your Caterpillar dealer for more information on fuel selection and fuel properties.

Lubricant Specifications

Lubricant Information

Engine oil performs several basic functions in order to provide adequate lubrication. It keeps the engine clean and free from rust and corrosion, acts as a coolant, and reduces friction and wear by minimizing metal-to-metal contact.

Certain abbreviations in this section follow Society of Automotive Engineers (SAE) J754 and SAE J183 nomenclature, classifications, and abbreviations. The definitions other than Caterpillar's will be of assistance in purchasing lubricants. SPC is a Caterpillar designation for special synthetic oils that do not contain viscosity improvers. Recommended oil viscosities can be found in the Lubricant Viscosities chart in this publication.

A new oil performance category has been released by the American Petroleum Institute (API) for diesel engine oil and by Caterpillar for engine oil. The new category is:

API CG-4 (engine oil)

This oil is performance tested on the new Cat 1N single cylinder oil test engine, and on other engine tests.

Caterpillar Oils have been developed, tested, and approved by Caterpillar to maximize the performance designed and built into our engines. Caterpillar Oils are offered in a full line of appropriate single and multi-viscosity grades to meet performance and ambient temperature requirements. Refer to the Literature Reference Materials section of this publication for additional lubricant information.

Engine Lubricant Specifications

Performance characteristics of lubricant oil depends on the base oil and the additives. Additives in the oil will vary according to the properties of the base oil and the environment in which the oil will perform.

Maximum engine life and performance can be expected when the proper engine oil is used. There are significant variations in the quality and performance of commercially available oils.

To achieve the maximum engine life and superior performance in your diesel engine, Caterpillar recommends:

Caterpillar Diesel Engine Oil (DEO)– CG-4

Caterpillar Oils are performance rated as
SAE 10W30–API CG-4: API CF-4
SAE 15W40–API CG-4: API CF-4

Caterpillar DEO (CG-4/CF-4) is formulated with strong dispersion effectiveness, sufficient alkalinity, and low sulfated ash level for performance requirements of present and future engine designs. Oils meeting the API CG-4/CF-4 standards operate effectively at the higher piston temperatures of some current and future engines.

DEO (CG-4) selection depends on engine type, fuel sulfur content, engine application, and customer preference. Caterpillar DEO CG-4 is recommended for use in North America for all applications, excluding Caterpillar 3600 Engines. CF-4 will continue to be the recommended oil for countries continuing to operate at fuel-sulfur levels higher than 0.05 percent.

Lubricant Viscosity Specifications

Multi-grade oils are required because they are consumed at levels significantly lower than single grade oils. Caterpillar DEO (CG-4/CF-4) is blended in viscosity grades of SAE 10W30 and 15W40. Qualified as API SH, these oils may be used in gasoline engine applications requiring this performance rating.

The proper SAE grade of oil to select is determined by the minimum outside temperature at which the engine will be started, and the maximum outside temperature in which the engine will be operating. This recommendation is to ensure the correct viscosity is used until the next oil change. Refer to the Lubricant Viscosity chart in this publication for recommended viscosity and temperature ranges.

The minimum temperature for the viscosity grade provides guidelines for the lowest starting temperature with a "cold soaked" engine. Base stocks for blending oil formulations differ. Variations on low temperature characteristics can exist within a viscosity grade. Therefore, a particular oil may allow lower starting temperatures than given in the chart. Your oil supplier can provide additional information on oil properties.

The use of API CG-4 or CF-4 multi-viscosity oils is preferred because of full protection through a wider temperature range. The highest viscosity oil possible is recommended. Even though the ambient temperature may be low, operating engines can still be subjected to normal oil temperatures because of regulated temperature components. The higher viscosity oils will provide better protection to all components during the full operating cycle.

To determine if the oil in the crankcase will flow in cold weather, remove the oil dipstick before starting. If the oil flows off, the oil is fluid enough to circulate properly.

NOTE: Start-up at oil temperatures below the minimum requires caution. Do not increase engine rpm or add load until oil temperatures are within the recommended range and oil pressures are normal.

Lubricant Viscosity Chart

LUBRICANT VISCOSITIES FOR AMBIENT (OUTSIDE) TEMPERATURES					
Compartment or System	Oil Viscosities	°C		°F	
		Min	Max	Min	Max
Engine Crankcase	SPC SAE 5W20	-30	+10	-22	+50
	SAE 5W20	-25	+10	-13	+50
	SAE 10W30	-20	+40	-4	+104
	SAE 15W40	-15	+50	+5	+122

The following chart lists Caterpillar Diesel Engine Oil quantities and part numbers, available from your Caterpillar dealer.

Caterpillar Engine Oil DEO (CG-4)	3.8 L (1 US gal)	19 L (5 US gal)	208.5 L (55 US gal)
SAE 10W30	3E9904	3E9709	3E9708
SAE 15W40	3E9714	3E9713	3E9712

Commercial Oils

API CC and CD oils are unacceptable in this Caterpillar diesel engine. The following chart provides specification guidelines for selecting commercial oil products other than Caterpillar oils.

Engine Model	Alternate Oils*
3304B & 3306B	API CG-4, CG-4/SH API CF-4, CF-4/SG, SH

* Consult with your Caterpillar dealer for oil recommendations. Commercial oils which have been used with success in the past may continue to be used, provided the formulations have not changed (consult with your oil supplier). However, the use of these oil products does not allow their wider use in all Caterpillar engines, as compared to the API CF-4 and CG-4 oils.

Commercial oils other than Caterpillar oils may require shortened oil change intervals, determined by S•O•S analysis monitoring.

NOTICE

Failure to follow the commercial oil recommendations can cause shortened engine life due to piston carbon deposits, liner bore polish and/or abnormally increased oil consumption. Follow the recommendations to protect your engine investment.

Total Base Number (TBN)

Fuel sulfur content affects engine oil recommendations. Engine combustion can chemically change fuel sulfur into sulfurous and sulfuric acids. Sulfur products formation varies with fuel sulfur content, oil formulation, crankcase blowby, engine operating conditions, and ambient temperature.

Alkaline compounds are added to lubricating oils to neutralize combustion acids. A Total Base Number (TBN) measures and defines reserve alkalinity in lubricating oil. Infrared Analysis (ASTM D2896 procedure) can help evaluate fuel sulfur effects, such as the residual neutralization properties of engine oil.

New engine oil must have a TBN of 20 times (for Precombustion Chamber engines) and ten times (for direct injection engines) the percent fuel sulfur as measured by ASTM D2896 method.

Caterpillar's 20 times rule for TBN (Reference: Oil and Your Engine, SEBD0640) versus fuel sulfur was a general requirement developed in the early 1980's for Cat prechamber combustion (PC) system engines. Caterpillar still maintains 20 times TBN value for PC engines when using API CD, CE or CF-4 oil (related to fuel sulfur above 0.5 percent). Engines built prior to 1990 can continue to use DEO-CD single grade viscosity oil or commercial oils, provided the engine operates to user satisfaction.

Fuel sulfur neutralization of new oil formulations in direct injection (DI) system engines are more effective. Field results indicate that direct injection combustion (DI) systems and the oils now recommended for those engines will operate at an oil TBN equal to ten times the fuel sulfur.

Caterpillar requirements now reflect the new value of ten times instead of 20 for oil TBN, regarding fuel sulfur in Cat DI engines and API CG-4/CF-4 oils. New engine oil for DI engines must have a TBN of ten times the percent fuel sulfur, as measured by ASTM D2896 method. The minimum TBN is 5, regardless of fuel sulfur level.

The "ten times" rule should be used for fuels with 0.5 percent or more sulfur by weight. For fuels with 0.5 percent sulfur or more by weight, new engine oil must have a TBN of ten times the percentage of fuel sulfur, as measured by the ASTM (American Society of Testing Materials) D2896 method.

For example, if your fuel is 0.5 percent sulfur by weight:

$0.5 \times 10 = 5$

If your fuel is 0.5 percent sulfur by weight, your oil should have a minimum TBN of 5. ASTM D2896 can normally be found at your local technological society, library or college.

Oil analysis is strongly recommended for determining new oil change intervals.

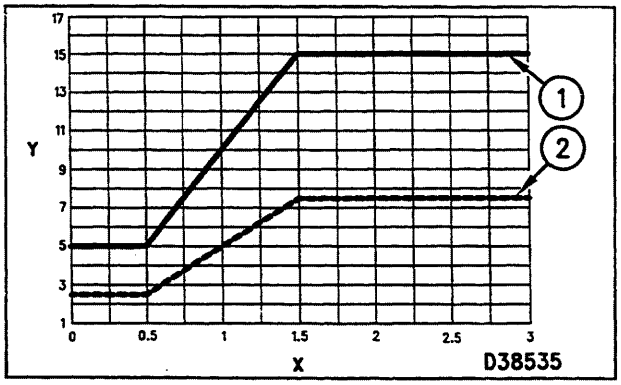
Caterpillar recommends using S•O•S analysis **including** infrared analysis (IR) to help monitor TBN depletion. The ASTM procedure, D2896 for base number, may also be used to determine the TBN of both new and used oil.

S•O•S analysis should be part of overall engine maintenance, to assure that a particular engine installation with all its parameters (engine, oil, operation, maintenance and fuel) is under control.

In most oil formulations, the TBN is a function of the ash bearing additives in the oil. Excessive amounts of ash bearing additives can lead to excessive piston deposits and loss of oil control. Excessively high TBN or high ash oils should not be used in Caterpillar diesel engines using distillate fuel.

When fuel sulfur levels exceed the oil's ability to protect, the oil change interval should be reduced to maintain proper oil TBN. Minimally, proper oil TBN is no less than ½ the new oil TBN.

TBN vs Fuel Sulfur for Caterpillar Diesel Engines



New Oil TBN (1), and Used Oil TBN Limit (2). The Y axis represents oil TBN shown by ASTM D2896. The X axis represents the percent of fuel sulfur by weight.

Operation at fuel sulfur levels over 1.5 percent may require shortened oil change periods to maintain adequate wear protection.

Synthetic Base Stock Oils (SPC)

Synthetic base stock oils are acceptable for use in Caterpillar engines if the oils meet performance requirements specified for a particular compartment. Performance requirements for engines using synthetic oils is API CG-4/CF-4.

The use of a synthetic base stock oil does NOT allow extension of the oil drain period simply because the oil is synthetic. Any drain period extension must be validated by S•O•S oil analysis and test evaluation, to ensure no excessive component wear occurs in a particular application.

Oils are drained and replaced because they become contaminated with dirt, soot, wear particles, etc. during normal use. Additives in an oil formulation are depleted as the oil is used. Oil contamination and additive depletion occurs independently of the oil base stock type.

Synthetic lubricants may be superior to petroleum oils in specific areas. Many exhibit higher viscosity index, better thermal and oxidation stability, and sometimes lower volatility. Because synthetic lubricants are higher in cost than petroleum oils, they are used selectively where performance is needed to exceed capabilities of conventional oils.

Synthetic oils have naturally low pour points which make them very good for low temperature applications. Caterpillar recommends synthetic base stock oils where engine starting in arctic conditions is required.

Re-refined Base Stock Oils

Caterpillar requires that any oil formulation meet the performance standards defined by the API classification, and have the proper viscosity as defined by the SAE J300 Specification. The base stock oil used in the formulation can be either virgin or re-refined (or a combination), as long as the final oil formulation meets the performance and viscosity requirements.

Military specifications and other engine manufacturers have also accepted the use of re-refined oil base stock with the same criteria.

Caterpillar Lubricating Grease

The National Lubricating Grease Institute (NLGI) classifies grease, based on ASTM D217-68 Worked Penetration characteristics. Grease characteristics are given a defined consistency number.

Grease is classified by the National Lubricating Grease Institute (NLGI) based on ASTM D217-68 Worked Penetration characteristics which are given a defined consistency number.

Caterpillar has greases and lubricants for all applications. Your Caterpillar dealer can provide you with complete information regarding all of the different types and sizes of Caterpillar lubrication and special application products.

CATERPILLAR LUBRICATING GREASE		
Part No.	**Item**	**Size**
2S3230	Bearing Lubricant[1]	411 g (14.5 oz)
5P0960	Molybdenum Grease[2]	411 g (14.5 oz)
1P0808	All-Purpose Lubricant[3]	411 g (14.5 oz)
4C4774	Water & Temperature Resistant Grease[4]	454 g (16 oz)

[1] NLGI No. 2 Grade, services heavily loaded ball and roller bearings operating at high speeds, extreme pressure, and temperatures from −34 to 163°C (−18 to 300°F). Use for bearings in electric motors, fan drives, starting motors, alternators/generators and to pack similar bearings in many other applications.

[2] NGLI No. 2 Grade, three to five percent molybdenum disulfide, multi-purpose grease with an operating temperature range from −28 to 149°C (−18 to 300°F).

[3] NGLI No. 2 Grade lithium grease has mechanical stability, resists oxidation, protects from rust, excellent breakaway torque. For light-duty automotive-type applications and temperatures up to 175°C (350°F).

[4] This NLGI No 2 Grade has exceptional water resistance, meets ASTM D-1264 Water Washout Test. This low and high temperature resistant grease has a starting torque at −40°C (−40°F), and is still not fluid at 316°C (600°F).

Caterpillar Specialty Lubricants

CATERPILLAR SPECIALTY LUBRUCANTS		
Part No.	**Item**	**Size**
6V4876	Molykote Paste Lubricant[1]	500 g (17.6 oz)
5P3931	High Temperature Anti-Seize[2]	150 g (5.3 oz)

[1] Recommended for typical uses such as on head bolt threads and washers.

[2] Recommended for connectors such as exhaust manifold studs and nuts.

Gauges

Gauges provide indications of engine performance. Be sure they are in good working order. You can determine what is the "normal" operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings indicate potential gauge or engine problems. This also applies to gauge readings that have changed significantly, but are still within specifications. The cause of any sudden or significant change in gauge readings should be determined and corrected. Contact your Caterpillar dealer for assistance as needed.

Oil Pressure – Indicates engine oil pressure. The oil pressure should be greatest after starting a cold engine. Oil pressure should read between 240 and 480 kPa (35 and 70 psi) when: the engine is running at rated engine speed with SAE 10W30 oil, and at operating temperature. A lower pressure is normal at low idling speed.

NOTICE

Engine damage can result if the engine is operated with no oil pressure gauge reading. If no pressure is indicated, stop the engine.

Jacket Water Temperature – Indicates engine coolant temperature. It should normally indicate between 77°C (170°F) and 98°C (209°F). Higher temperatures may occur under certain conditions. Maximum allowable temperature is 99°C (210°F) with the cooling system pressurized.

Ammeter – Indicates the amount of charge or discharge in the battery charging circuit. Normal operation of the indicator should be slightly to the positive (right) side of "0" (zero).

Check the charging system for malfunction if, during operation, the indicator is constantly to the negative (left) side of "0" (zero) or shows excessive charge.

Tachometer – Indicates engine rpm (speed). The engine can be operated at high idle without damage, but should not be allowed to overspeed. Overspeeding can seriously damage your engine.

NOTICE

Do not exceed "bare engine high idle" rpm in any situation.

Fuel Level – Indicates fuel level in the fuel tank. The electrically operated fuel level gauge registers only when the START/STOP (ignition key) switch is ON.

Fuel Pressure – Indicates fuel pressure to the injection pump. The indicator should register in the NORMAL (green) range.

If the indicator moves to the OUT position or registers below 160 kPa (23 psi) when equipped with a numerical gauge, the engine will not operate properly. In most cases this is caused by a plugged fuel filter.

Service Hour Meter – Indicates the total number of service meter units or clock hours the engine has operated.

Generator Set Control Panel 103-1582 (If Equipped)

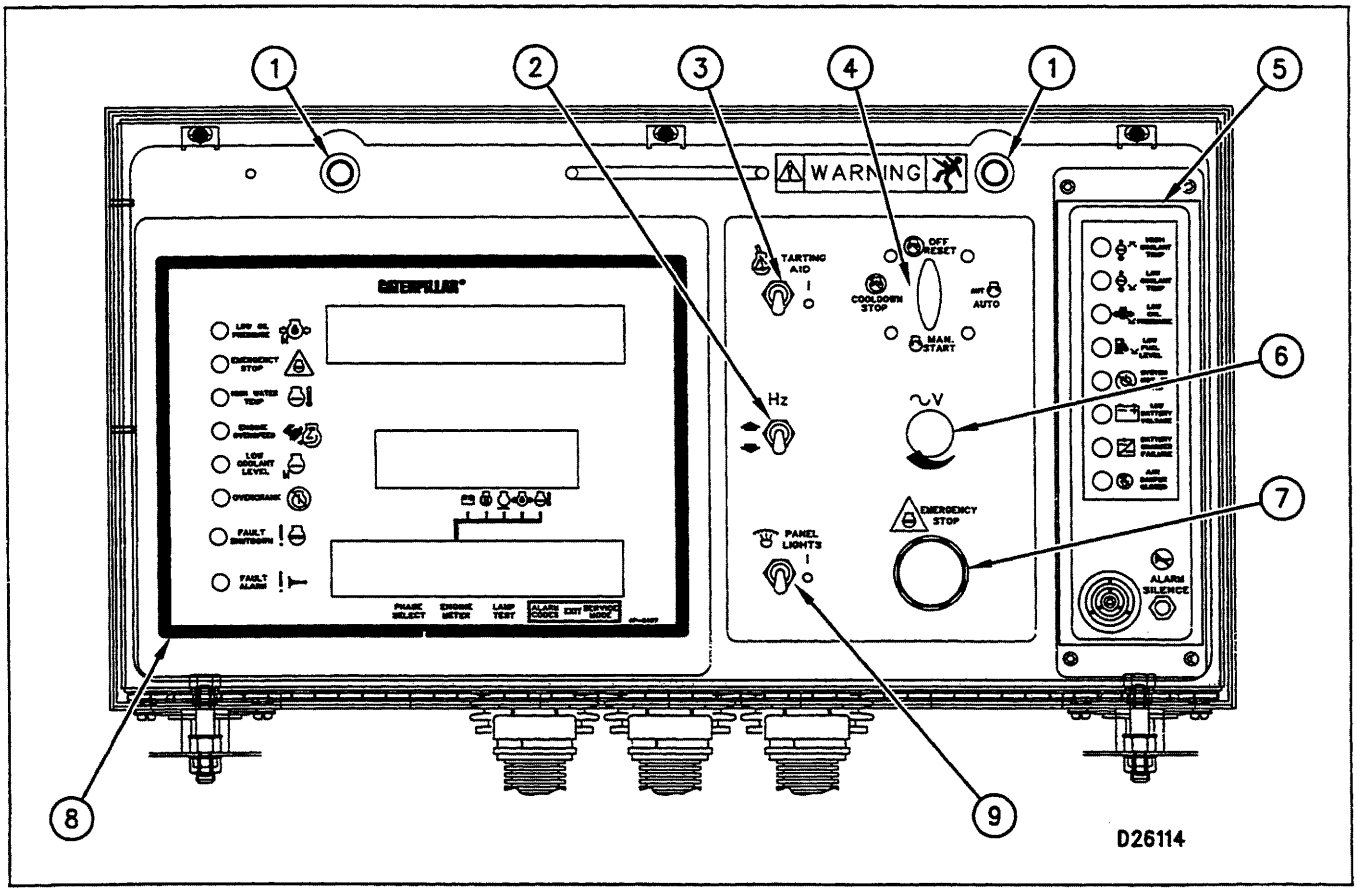
EMCP II Control Panel

The generator set Electronic Modular Control Panel II (EMCP II) is located on top of the generator regulator housing. The control panel consists of a main panel with indicators, meters, and control switches. The control panel may be equipped with optional modules to match the customer's needs and requirements. The right side may be blank, or contain one of the alarm modules, or a synchronizing lights module.

The left side of the control panel contains the Generator Set Control (GSC). This is the "main" component of the system. The GSC displays generator output, fault conditions, and key engine parameters.

Main Control Panel

The main control panel may or may not contain all of the components shown. Some components are optional, and may not be required for your particular application.



Optional panel lights (1), optional governor switch (shown) or speed potentiometer (2), optional starting aid switch (3), engine control switch (4), optional alarm module (shown) or synchronizing lights module (5), voltage adjust rheostat (6), emergency stop push button (7), generator set control (8), and optional panel light switch (9).

- The panel lights (PL) (1) are controlled by the panel light switch (PLS) (9).

- The voltage adjust rheostat (VAR) (6), is used to adjust the generator output voltage.

- The optional governor switch (GS) or speed potentiometer (SP) (2) is used to raise or lower the engine speed. If the governor is equipped with a speed adjust motor, the governor switch is mounted in this location. If the engine is equipped with an electric governor, a speed potentiometer is mounted in this location.

- The starting aid switch (SAS) (3) is used to inject ether into the engine for starting in cold weather conditions. When the starting aid switch is moved to the ON position, the switch energizes and meters a specific amount of ether in a holding chamber. When the switch is released, the solenoid releases the ether to the engine.

- The emergency stop push button (ESPB) (7) is used to shut down the engine during an emergency situation. The ESPB shuts off the fuel and activates the optional air shutoff (if equipped).

- The engine control switch (ECS) (4), determines the status of the control panel. In the Automatic position (3 o'clock), the engine will start automatically whenever the remote initiating contact is closed. The engine will shutdown after the initiating contact opens and adjustable cool down time has elapsed. The cool down time can be programmed to give a 0 to 30 minute cool down period before the engine shuts down.

When the ECS is in the Manual Run position (6 o'clock), the engine will start and run as long as the ECS remains in this position.

When the ECS is in the Stop position (9 o'clock), the fuel solenoid shuts the engine down, after a programmable cool down time period.

When the ECS is in the Off/Reset position (12 o'clock), the fault lights are reset and the engine shuts down immediately.

Generator Set Control (GSC)

The left side of the control panel contains the Generator Set Control (GSC). This is the "main" component of the system, and also displays generator output, generator set functions, fault conditions, and key engine parameters.

The GSC accepts information from the operator, magnetic pickup, oil pressure and water temperature sensors, and optional remote sources. The accepted information is used to determine the "on/off" state of the engine's air, fuel, and starter.

In the very basic operating conditions, the GSC receives a signal to run the generator set. The GSC turns on the engine's fuel and starter. When the engine speed reaches the crank termination speed, the starter is disengaged. When the GSC receives a signal to stop the engine, it shuts the fuel off.

GSC Features and Functions:

- Controls normal starting and stopping of the engine.

- Shows engine conditions and generator output information on two displays. The displays also show fault codes and GSC programming information.

- Monitors the system for faults. If a fault occurs, the GSC provides a fault alarm annunciation, or performs a controlled fault shutdown. The GSC uses indicators and displays to describe the fault.

- Contains programmable features for certain applications or customer requirements.

- Cycle Crank – The GSC can be programmed to crank-rest-crank, etc. for adjustable time periods. Refer to the Service Manual Module SENR5809 for programming instructions.

- 2301 or 2301A Control – When the engine oil pressure increases past the low oil pressure set point, the GSC will indicate to the governor that it should increase engine speed from IDLE to RATED rpm.

- Cool Down – Upon receiving a signal to perform a normal shutdown, the GSC will wait a preprogrammed amount of time before shutting the engine down by means of the fuel control.

- Automatic Operation – While in the automatic mode, the GSC can be started by a remote initiate signal (contact closure). Upon loss of the signal (contact opening), the GSC will perform a normal shutdown.

- Alarm Module Communication – The GSC can transmit fault and alarm conditions to an alarm module.

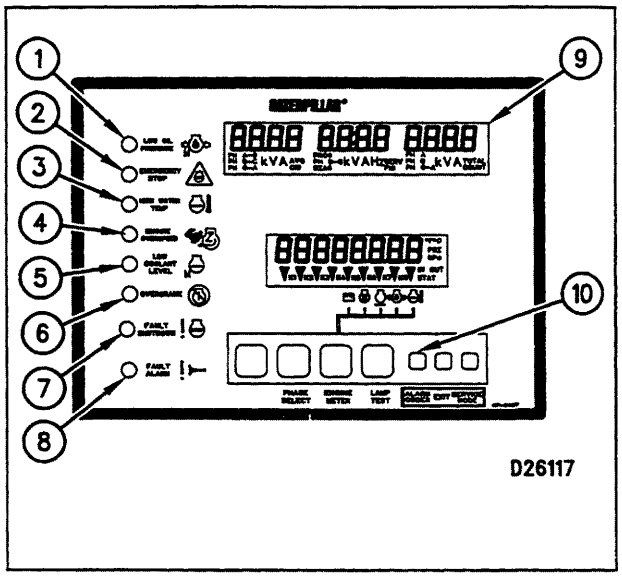
- Power Down – The Electronic Modular Control Panel II (EMCP II) system is designed to remove power from the GSC when in the off/reset mode and the proper jumper wire is removed. The GSC will not allow the power down until the crank termination relay and the fuel control relay are both "off" for about 70 seconds. If the wire is not removed, the GSC will remain powered up.

Refer to the Service Manual Module SENR5809 for the wiring diagram and the jumper wire location.

- Fuel Solenoid Type – The GSC can be programmed to work with either an energized to run (ETR) fuel system or an energized to shutdown (ETS) fuel system.

- Customer Communication – The GSC is provided with connections for an optional Customer Communications Module (CCM). The CCM will allow two way communication between the EMCP II and the operator. A customer-supplied personal computer (PC), or other device with a RS-232C port, interfaces with the CCM.

Fault Indicators



The eight fault indicators (1-8), located on the front of the GSC, are used to show and describe a fault that is present. The first seven are red fault shutdown indicators, and the eighth is a yellow fault alarm indicator.

- The yellow FAULT ALARM indicator (8) flashes when the GSC detects a fault that is an alarm condition. The engine continues to run and start. The FAULT ALARM indicator is accompanied by an alarm fault code, shown on the upper display when the alarm codes key is pressed. Refer to SENR5809 for fault code descriptions.

- The red FAULT SHUTDOWN indicator (7) flashes when the GSC detects a fault that is a shutdown condition. The engine is shutdown if it is running and is not allowed to start. The FAULT SHUTDOWN indicator is accompanied by a diagnostic fault code that is immediately shown on upper display. Refer to SENR5809 for fault code descriptions.

- Six red shutdown indicators are dedicated to the following shutdown conditions: low oil pressure (1), emergency stop (2), high water temperature (3), engine overspeed (4), low coolant level (5), and engine over crank (6). When the GSC detects a fault in one of these conditions, the dedicated shutdown indicator (corresponding to the fault) flashes. The engine shuts down if it is running, and is not allowed to start. There are no fault codes associated with the dedicated shutdown indicators because each indicator has an interpretive label. The conditions required for each dedicated fault and the results of each dedicated fault are as follows:

LOW OIL PRESSURE (1) – There are two low oil pressure set points. One set point is for when the engine is operating at idle speed. The other set point is for when the engine is operating at rated speed. The low oil pressure shutdown set points are programmed into the GSC. **Condition:** the engine oil pressure drops below the set points for low oil pressure shutdown. **Result:** the LOW OIL PRESSURE indicator flashes, the engine is shutdown and is not allowed to start.

EMERGENCY STOP (2) – **Condition:** the operator presses the emergency stop push button (ESPB) on the instrument panel. **Result:** the EMERGENCY STOP indicator flashes, the engine is shutdown and is not allowed to start.

HIGH WATER TEMPERATURE (3) – A high water temperature shutdown set point is programmed into the GSC. **Condition:** the engine coolant temperature rises above the set point for high water temperature shutdown. **Result:** the HIGH WATER TEMPERATURE indicator flashes, the engine is shutdown and is not allowed to start.

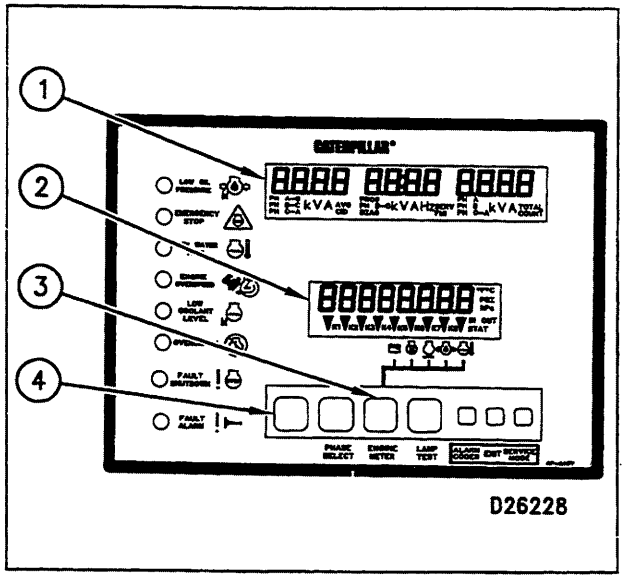
ENGINE OVERSPEED (4) – An engine overspeed set point is programmed into the GSC. **Condition:** the engine speed exceeds the engine overspeed set point. **Result:** The ENGINE OVERSPEED indicator flashes, the engine is shutdown and is not allowed to start.

LOW COOLANT LEVEL (5) – **Condition:** the engine coolant level drops below the probe of the coolant loss sensor (optional). **Result:** the ENGINE COOLANT LEVEL indicator flashes, the engine is shutdown and is not allowed to start. An optional low coolant level sensor is required for this function.

OVERCRANK (6) – A set point for total cycle crank time is programmed into the GSC. **Condition:** the engine does not start within the programmed set point. **Result:** the OVERCRANK indicator flashes and the engine is not allowed to start.

NOTE: The GSC can be programmed to override the shutdown for: the low oil pressure, the high water temperature, and the low coolant level faults. When these faults are overridden, the faults are treated as alarm conditions. The corresponding dedicated shutdown indicator is ON CONTINUOUSLY (instead of flashing) and the engine continues to run and start (instead of shutting down). The dedicated shutdown indicator that is ON CONTINUOUSLY means that the set point for shutdown has been exceeded, but the GSC is programmed to override the shutdown condition and treat the fault as an alarm condition. As provided from the factory, the GSC treats low oil pressure, high water temperature and low coolant level as shutdowns. Refer to the Service Manual Module SENR5809 for programming procedures.

Display



The upper display (1) and lower display (2) of the GSC provide information about the generator set.

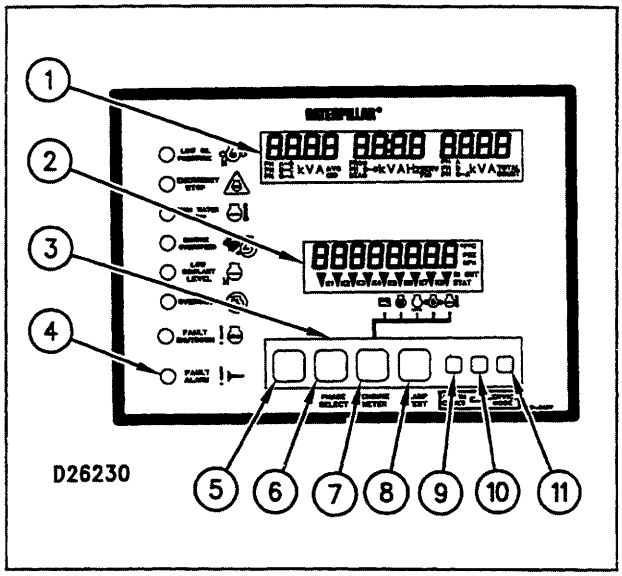
- The upper display (1) shows AC voltage, current, and frequency of one phase of the generator output. Each phase can be viewed one at a time by pushing phase select key (4). The upper display (1) is also used to show the various fault codes for system faults. For more information on fault codes, refer to the Service Manual Module SENR5809 for Fault Descriptions.

- The lower display (2) shows: system battery voltage, engine hours, engine speed, engine oil pressure, and engine coolant temperature. The value for one of those conditions is displayed for two seconds, then the display scrolls to the value for the next condition. A small pointer identifies the engine condition that corresponds to the value that is showing. When engine meter key (3) is pressed, the lower display stops scrolling and continuously shows one particular value. The pointer flashes above the condition whose value is showing. When the engine meter key is pressed a second time, the display returns to scrolling.

- The lower display also shows a relay status indicator. When a GSC relay is activated, the corresponding relay indicator (K1, K2, etc.) is shown on lower display (2). When a relay is not activated, the corresponding indicator (K1, K2, etc.) is not shown. Refer to the Service Manual Module SENR5809 for a description of the relay functions.

Both the upper and lower display are used for programming functions when in the service mode. For more information, refer to the Service Manual Module SENR5809 for Service Modes.

Keypad



The keypad (3) is used to control the information that is shown on upper display (1) and the lower display (2). The seven keys of keypad have two sets of functions: normal functions and service functions. For a description of the service functions of the keys, refer to the Service Manual Module SENR5809 for Service Modes. The normal functions of the keys are as follows.

Leftmost key (5) – This key only functions when the GSC is in the service mode. This key is used to scroll right.

PHASE SELECT key (6) – This key selects which phase of the generator output shows on the GSC upper display. Pressing this key allows the operator to check the voltage, current, and frequency of each phase, one at a time.

ENGINE METER key (7) – This key stops the scrolling of engine conditions on the lower display (2). The lower display continuously shows the value for one particular engine condition. The pointer for the particular engine condition flashes to indicate scrolling is stopped. Pressing the key again resumes the scrolling.

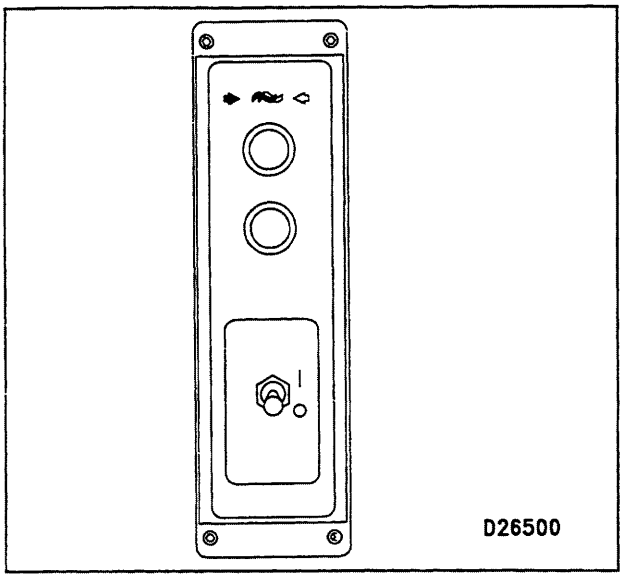
LAMP TEST key (8) – This key performs a lamp test on the GSC and the optional alarm module for a maximum of ten seconds, if held pressed. On the GSC: the eight fault indicators are ON CONTINUOUSLY– every segment of the upper display (1) and the lower display (2) are ON. For the optional alarm module: all of the indicators are ON and the horn sounds.

ALARM CODES key (9) – If the fault alarm indicator (4) is FLASHING, pressing this key causes the upper display (1) to show the corresponding alarm fault code. Pressing this key again resumes the showing of generator output information on the upper display. If the fault alarm indicator (4) is OFF, this key has no function. For more information on alarm fault codes, refer to the Service Manual Module SENR5809 for Fault Descriptions.

EXIT key (10) – This key only functions when the GSC is in service mode. Refer to the Service Manual Module SENR5809 for Service Modes.

SERVICE MODE KEY (10) – Pressing this key causes the GSC to enter the service mode. Refer to the Service Manual Module SENR5809 for Service Modes.

Synchronizing Lights Module (If Equipped)



The optional synchronizing lights module is mounted on the right side of the control panel. This module is not used when the control panel is equipped with the 2301A Governor.

Synchronizing lights are used as an aid in paralleling units at no load and under load. Each of two lights are connected across the generator to the load side of the generator circuit breaker. Together, the lights indicate when the voltages are in phase so the circuit breaker can be closed to place the generator on line with the load.

Refer to the topic "Parallel Operation" in this publication for a complete explanation on how to parallel two generators. Refer to the Service Manual Module SENR5809, for all wiring and installation information.

Synchronizing Lights Module With Reverse Power Relay (If Equipped)

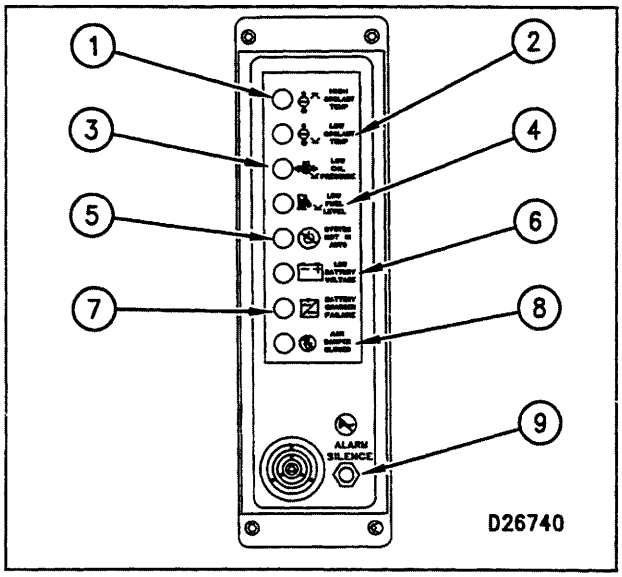
The synchronizing lights module with reverse power relay is the same as the synchronizing lights module with the following exceptions:

- The reverse power relay is mounted on the control panel interior.
- A reverse power fault is indicated by the Fault Shutdown Indicator on the front of the GSC.

The reverse power relay is a single phase protective relay. The reverse power relay is energized by power (amps-volts) in only one direction (power into generator instead of out). In a reverse power fault, the relay closes its contacts causing the engine to shutdown, taking the generator off line. The reverse power relay is equipped with a test switch and adjustments.

For additional information, refer to Service Manual Module SENR5809.

Alarm Module (If Equipped)



The alarm module (optional) is located on the right side of the control panel. The function of the alarm module is to provide a visual and audible warning of engine conditions before they become severe enough to shut the engine down or keep it from starting.

One basic alarm module is used to satisfy the requirements of: the standby NFPA 99 alarm module, the standby NFPA 110 alarm module, and the NFPA 99 remote annunciator panel and prime power alarm. This is accomplished by using different inputs to the module, and different decals on the front of the module to indicate alarms or shutdown conditions.

Refer to the Service Manual Module SENR5809, for all wiring and installation information as well as a listing of Indicators and Alarm (Horn) functions to meet NFPA requirements for your application.

The front of the alarm module consists of:

- Four amber LED's which can indicate: HIGH COOLANT TEMPERATURE (1), LOW COOLANT TEMPERATURE (2), LOW OIL PRESSURE (3), and LOW FUEL LEVEL. Other amber LED options (depending on module configuration) are: GENERATOR ON LOAD, CHARGER MALFUNCTION, LOW OIL LEVEL, and LOW COOLANT LEVEL

- Four red LED's which can indicate: a SYSTEM NOT IN AUTO (5) condition, LOW BATTERY VOLTAGE (6), BATTERY CHARGER FAILURE (7), and AIR DAMPER CLOSED (8). Other red LED options (depending on module configuration) are: AIR DAMPER CLOSED, LOW OIL PRESSURE SHUTDOWN, OVERCRANK SHUTDOWN, HIGH COOLANT TEMPERATURE SHUTDOWN, and OVERSPEED SHUTDOWN.

- An audible ALARM and acknowledge/SILENCE switch (9). For more detailed information refer to the Service Manual Module SENR5809.

Engine Protection Devices

NOTE: This section applies to engines equipped with junction boxes.

Shutoff and alarm systems are either electrically or mechanically operated. The operation of all electric shutoffs and alarms utilize components which actuate switches in a sensing unit.

Sensing switches are set at critical operating temperature, pressure, level or speed than the alarm components. More critical settings protect the engine from damage.

A shutoff switch opens or closes the circuit to the fuel shutoff solenoid. Opening the circuit to the fuel shutoff solenoid moves the fuel rack to the fuel OFF position. The particular shutoff may require resetting before the engine will start.

When any sensing switch shuts the engine down, the problem causing the shutdown must be corrected before attempting to restart the engine.

Familiarize yourself with the
- types and locations of the shutoff controls
- conditions which cause each control to function
- resetting procedure required to restart your engine

Manually or mechanically operated systems require resetting by pushing the RESET button until it latches. After the engine is started, oil pressure will activate the RESET button to the extended running position.

NOTICE

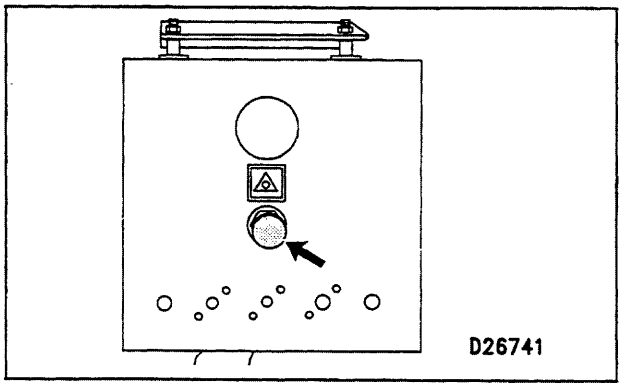
If the RESET button does not move to the extended position after the engine starts, the engine will NOT be protected by this particular switch.

If the RESET button remains in the reset position, the engine oil pump will not develop normal oil pressure. An inspection should be made to correct the problem.

Automatic START/STOP systems use oil pressure to automatically reset.

The Engine Protective Devices shutdown controls should be tested every 1000 service hours by authorized personnel.

Emergency Stop Push Button



Emergency Stop Push Button (ESPB)

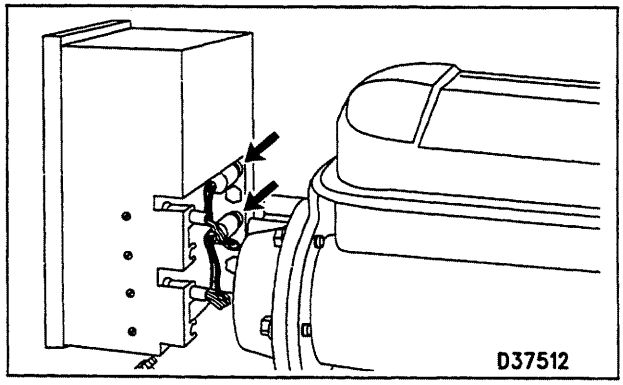
The Emergency Stop Push Button (ESPB) requires resetting both the push button and the air inlet shutoff (if equipped) before the engine will start.

NOTICE

Always determine the cause of the engine shutdown. Make necessary repairs before attempting restarting the engine.

Emergency shutoff controls are for EMERGENCY use ONLY. DO NOT use Emergency shutoff devices or controls for normal stopping procedure. Refer to the Engine Stopping section of this manual for normal stopping procedures.

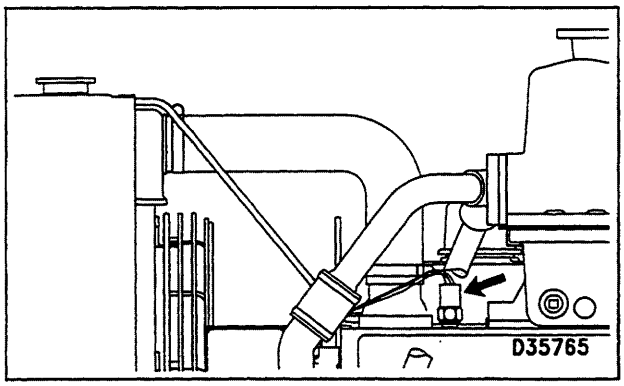
Oil Pressure Switch



Typical example of oil pressure switches, mounted in the rear of the junction box.

An oil pressure switch has wires connected to the electrical shutoff system for alarm or shutdown functions. The oil pressure switch senses oil pressure at the bearing oil gallery. Switches may close at 48 to 62 kPa (7 to 9 psi) below actual trip point. No resetting procedure is required.

Water Temperature Contactor Switch



This contactor switch is a coolant temperature sensor.

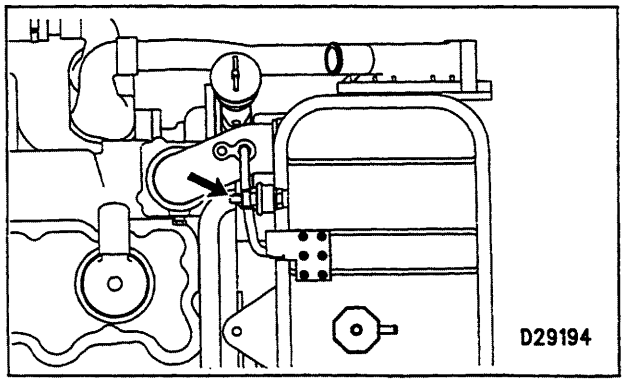
The water temperature contactor switch is located near the coolant water regulator housing. Excessive water temperature closes the switch. Maximum coolant temperature to trip shutoff is 104°C (219°F). The switch opens as the coolant cools. No resetting procedure is required. The unit has wires connected to the electrical shutoff system for alarm or shutdown functions.

NOTICE

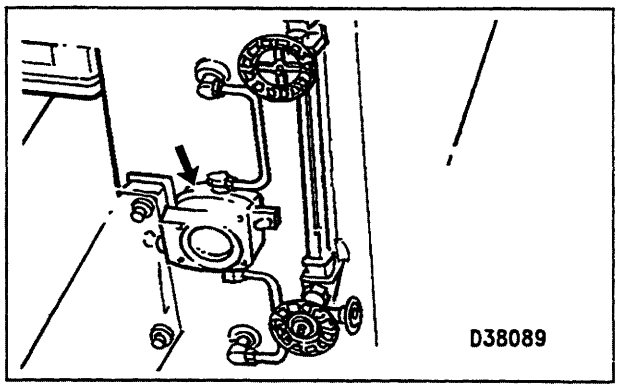
The sensing element must be submerged in the coolant to operate. Be sure to have an adequate water supply in the jacket water system, or engine damage could result.

Coolant Loss Sensor (If Equipped)

The optional coolant loss sensor is usually mounted near the top of the engine expansion tank or radiator. The sensor detects when the coolant level is below a preset minimum level.



This top view shows a typical coolant loss sensor, mounted in an expansion tank.



This coolant loss switch, shown next to a sight glass, is mounted on the side of a radiator.

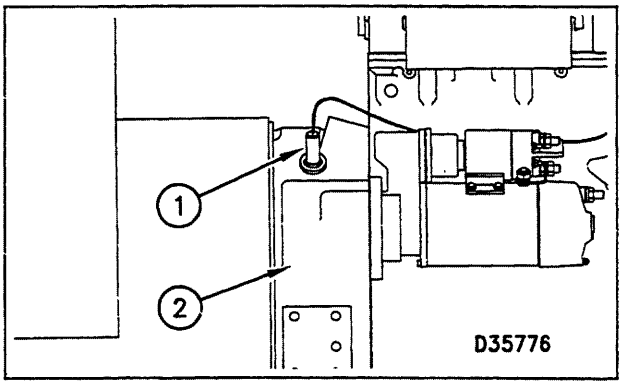
If the coolant level drops below the minimum level, the sensor may sound an alarm, or cause a shutdown to avoid engine overheating or possible engine damage. Coolant must be added to the radiator or expansion tank to clear or reset the condition.

NOTE: In the event of intermittent engine shutdowns, the coolant water level should be checked. Add premixed coolant water to the fill tank, to within 13 mm (½ inch) below the filler tube.

Check the expansion tank or radiator daily for proper coolant level.

Overspeed Shutoffs

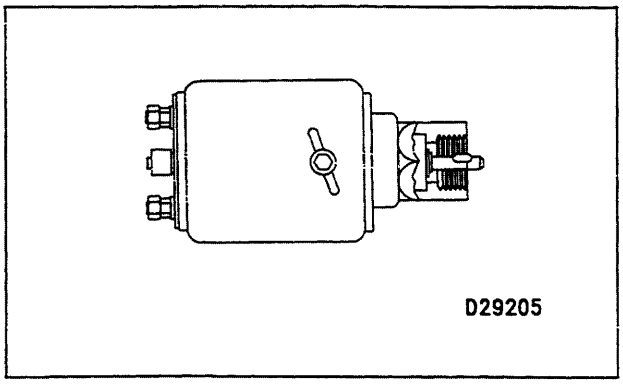
The electrical shutoff for the overspeed switch uses a magnetic pickup mounted in the flywheel housing. The electrical shutoff works through the fuel shutoff solenoid and air inlet shutoff (if equipped).



Magnetic pickup (1), mounted in the flywheel housing (2).

Should the engine overspeed, the magnetic pickup will sense the excess speed. If overspeed is sensed, the electrical shutoff closes the air and fuel shutoff solenoids (the fuel rack will move to fuel OFF position).

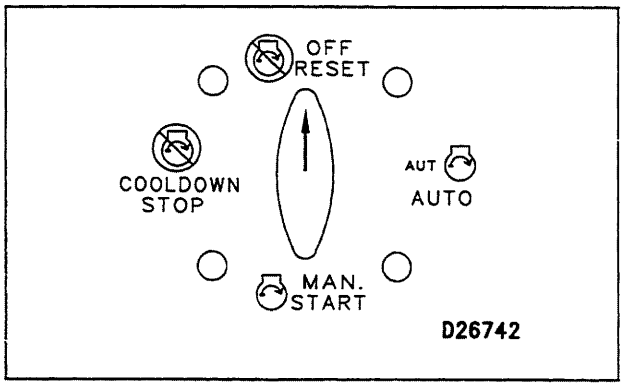
The overspeed shutdown has to be reset. Reset the air inlet shutoff (if equipped) and the overspeed switch. Both switches are located in the junction box or control panel.



Overspeed Shutoff Switch (Electro-Mechanical)

This switch is mounted either on the tachometer drive or the governor. Excessive engine speed closes the switch by centrifugal force.

If equipped with a Caterpillar Generator Set Control Panel, the devices on the panel must be reset after an overspeed shutoff.



Turn the Engine Control Switch to the OFF/RESET position.

Alarm Switches

Alarm switches consist of a sensor or contactor. Examples of sensors are the magnetic pickup for detecting speed, and the pressure and temperature contactors. Sensors are wired to a contactor. The contactor activates an alarm circuit in the Annunciator Panel.

Alarm switches and sensors are set at a less critical temperature, pressure, or level limit than the engine shutdown controls.

The purpose of the alarm switches is to warn the operator that an unsafe operating condition is beginning to occur.

The Annunciator Panel has lights and an audible device to warn the operator of a malfunction or abnormal engine operating condition. Each alarm contactor and switch is electrically connected to an indicator light or audible indicator. The alarm will continue until the condition is corrected.

When an alarm is activated, corrective measures must be taken, **before the situation becomes an emergency,** to avoid possible engine damage.

If corrective measures are not taken within a reasonable time, engine damage could result. Alternatively, a corresponding shutdown device (if equipped) will stop the engine.

The alarm will continue until the condition is corrected or the alarm is reset by the operator. The alarm circuits merely warn the operator, they do not shut the engine down to protect it from damage.

A switch may be installed in the alarm circuit for silencing the alarm while the engine is stopped for repairs. Before starting, be sure the switch is moved to the closed (ON) position and the warning lights are illuminated.

If the switch is left in the open (OFF) position when the engine is started, the engine will not be protected.

Shutoff and Alarm System Testing

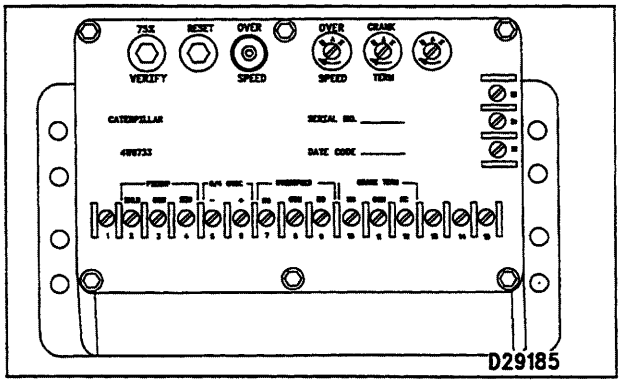
NOTICE

During testing, abnormal operating conditions must be simulated. Perform the tests correctly to prevent possible damage to the engine.

The Engine Protective Devices shutdown controls and alarms on the engine should be tested every 1000 service hours or twice a year for proper operation by authorized Caterpillar dealer personnel.

Most control panels are equipped with a test switch. Turn the switch to ON position to check indicator lights for proper operation. Replace defective or burnt bulbs immediately.

Abnormal operating conditions must be simulated which could cause engine damage if the tests are performed incorrectly. Refer to the Service Manual for the testing procedures.



The Electronic Overspeed Switch (if equipped) is located inside the junction box.

The Electronic Overspeed Switch with Cranking Termination has a 75 percent VERIFY button, a RESET button, and an OVERSPEED indicator light.

The Electronic Overspeed Shutoff Switch with Crank Termination has a sensing circuit which prevents the starter pinion from remaining engaged in the flywheel at excessive rpm. Crank Termination has an adjustable engine speed setting, and signals the starter motor when the engine is firing and cranking must be terminated. When the speed setting is reached, a switch opens to start the engine hour meter.

After the starting motor cranks the engine, the pinion gear can remain engaged with the flywheel as the engine speed increases. The magnetic pickup opens the circuit to the starting motor at 400 rpm and allows the pinion gear to disengage.

The circuit will remain open until the flywheel stops. This prevents energizing the starting motor circuit again while the flywheel is turning.

Your engine may be equipped with either an Overspeed Shutoff Switch or an Electronic Overspeed Switch with Cranking Termination. Both switches can be checked for proper operation at 75 percent of overspeed condition. Use the following procedure:

1. Determine full load rpm from the Engine Information Plate.

2. Operate the engine at or slightly above the corresponding speed shown in the OVERSPEED TEST RPM chart.

Full Load rpm	Overspeed Test rpm	Actual Overspeed rpm
1500	1328	1770
1800	1593	2124
2000	1770	2360
2200	1947	2596

If the Full Load rpm listed on your engine's Information Plate is not listed in this chart, then the Overspeed Test rpm equals the Full Load rpm times a factor of .885.

3. Maintain the test rpm, push and hold the VERIFY button. The engine should stop. If the engine does not stop at the specified test rpm, contact your Caterpillar dealer.

NOTE: As the engine stops, the OVERSPEED light will illuminate and the RESET button must be pushed before restarting the engine.

Engine Starting

Walk-Around Inspection

For maximum service life of your engine, make a thorough inspection before starting the engine. Look for items such as oil or coolant leaks, loose bolts, worn fan belts, and trash build-up. Remove trash build-up and have repairs made as needed.

Perform required Daily and other periodic maintenance before starting the engine. Make a walk-around inspection of the installation. It only takes a few minutes to make minor corrections. This can prevent major repairs at a later date.

NOTICE

All valves in fuel return line must be open before and during engine operation to prevent high fuel pressure. High fuel pressure may cause filter housing failure or other damage.

Each time any significant quantity of oil (or other fluid) is spilled on or near the engine it should be cleaned up. Accumulated grease and oil on an engine is a fire hazard. Remove this debris with steam cleaning or high pressure water.

Wipe clean all fittings, caps and plugs before servicing.

⚠ WARNING

Diesel engine exhaust contains products of combustion which may be harmful to your health. Always start and operate the engine in a well-ventilated area and, if in an enclosed area, vent the exhaust to the outside.

Do not start the engine or move any of the controls if there is a DO NOT OPERATE or similar warning tag attached to the start switch or controls.

The operator must be satisfied that no one will be endangered before starting the engine.

If the engine has not been run for several weeks, fuel may have drained and allowed air into the filter housing. Also, when fuel filters have been changed, some air space will be left in the housing. In these instances, prime the fuel system.

Refer to Priming the Fuel System in this publication for more information.

For starting below −18°C (0°F), use of optional cold weather starting aids are recommended. A cylinder block coolant heater or extra battery capacity may be required.

For temperatures below −23°C (−10°F) consult your Caterpillar dealer.

Electric Starting

NOTE: Startability will be improved at temperatures below 16°C (60°F) by the use of a starting aid. A jacket water (coolant) heater or other means can be used to heat the crankcase oil.

Start the engine using the following procedure:

1. Perform all before-starting inspections.

2. If the engine is equipped with a manual control, ensure that is in the RUN position. Place the transmission in NEUTRAL (and disengage the flywheel clutch, if equipped). For Generator Sets, open the main electrical circuit breaker.

2. Move throttle to approximately half engine speed to get the fuel rack to move to the FUEL ON position.

3. Turn the starter switch to START (or battery disconnect switch to the ON position) or the Engine Control Switch (ECS) to MAN. START. The starting motor will crank and attempt to start the engine. At temperatures below 0°C (32°F), it may be necessary to spray starting fluid into the air cleaner inlet. Additional injections of ether may be required to start and/or achieve low idle speed.

NOTICE

Excessive ether can cause piston and ring damage. When using starting fluid, follow the manufacturer's instructions carefully, use it sparingly and spray it ONLY WHILE CRANKING THE ENGINE. Failure to do so could result in an explosion and/or fire and possible personal injury.

Use ether for cold starting purposes only.

NOTICE

Do not crank the engine for more than 30 seconds.

If a warm engine fails to start within 30 seconds: release the starter switch and wait two minutes to allow the starter motor to cool before using it again.

4. As soon as the engine starts, allow the engine to idle for 3 to 5 minutes, or until the water temperature gauge indicator has begun to rise. The engine should run at low idle smoothly until speed is gradually increased to high idle.

NOTICE

Do not increase engine speed until the oil pressure gauge indicates normal. Oil pressure should rise within 15 seconds after the engine starts. If oil pressure is not indicated on gauge within 15 seconds, stop the engine, investigate and correct the cause.

5. Allow white smoke to clear up and proceed with normal operation. Do not apply load to the engine or increase engine speed until the oil pressure gauge indicates normal. Oil pressure should raise within 15 seconds after the engine starts.

For starting in cold weather, to minimize white smoke: start the engine and allow the engine to idle for 30 seconds. Increase rpm until engine speed reaches 1200 rpm. Then allow the engine to return to low idle.

6. Operate the engine at low load until all systems reach operating temperature. Check all gauges during the warm-up period.

Engine Starting With Jumper Cables

NOTICE

When boost starting an engine, follow the instructions to properly start the engine. This engine is equipped with a 12 or 24 volt starting system. Use only equal voltage for boost starting. The use of higher voltage will damage the electrical system.

⚠ WARNING

Batteries give off flammable fumes that can explode.

Improper jumper cable connections can cause an explosion resulting in personal injury.

Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jumper cable ends to contact each other or the engine.

Do not smoke when observing the battery electrolyte levels.

Always wear protective glasses when working with batteries.

Electrolyte is an acid and can cause personal injury if it contacts skin or eyes.

Engines installed without engine-to-frame ground straps can be damaged by electrical discharge. To prevent electrical discharge damage, check to make sure the engine's electrical system has an engine-to-frame ground strap.

For engines which have the alternator connected to an engine component, the ground strap must connect that component to the frame.

Some engines have starter-to-frame ground straps. Many of these starters have electrical insulation systems and are not electrically grounded to the engine. For this reason, the starter-to-frame ground strap may not be an acceptable engine ground.

When boost starting, refer to the instructions that follow to properly start the engine. Your engine may have a 12 or 24 volt starting system. Only use the same voltage for boost starting. Use of a welder or higher voltage will damage the electrical system and is not recommended.

NOTICE

When using an external electrical source to start your engine: turn the START switch off, remove the key, and turn off all electrical accessories before attaching cables.

When using jumper cables always connect the POSITIVE (+) cable to the POSITIVE (+) terminal of battery and the NEGATIVE (–) cable from the external source to the starter NEGATIVE (–) terminal. If not equipped with a starter NEGATIVE terminal, connect to the engine block.

Do not reverse the battery cables. The alternator can be damaged. Attach the ground cable last and remove first.

1. When using an external electrical source to start your engine, turn the ECS switch to the OFF position and turn off all electrical accessories before attaching cables.

2. Connect one end of the cable to the POSITIVE (+) terminal of the battery being started. Connect the other end to the POSITIVE (+) terminal of the power source.

3. Connect one end of the other cable to the NEGATIVE (–) terminal of the power source. Connect the other end to the starter NEGATIVE (–) terminal or to the engine block. This prevents potential sparks from igniting combustible gases produced by some batteries.

4. Start the engine. After the engine starts, disconnect the cable from the starter NEGATIVE (–) terminal or engine block. Disconnect the other end from the NEGATIVE (–) terminal of the power source.

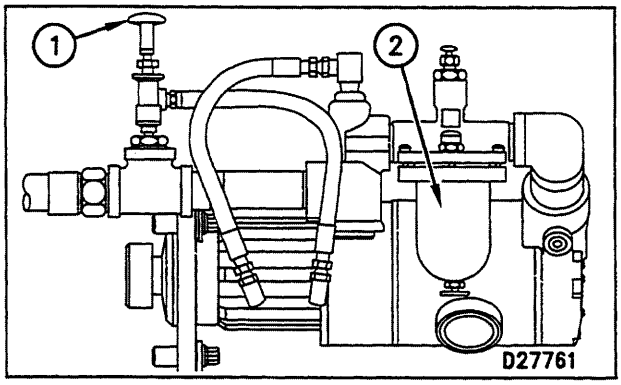
5. Disconnect the cable from the POSITIVE (+) terminal of the battery on the engine being started. Disconnect the cable from the POSITIVE (+) terminal of the power source.

Engine Starting with Air

For good life of the air starting motor, the air supply must be free of dirt and water. A lubricator must be used with the starting system. Use non detergent 10W engine oil for temperatures that are greater than 0°C (32°F) or use air tool oil for lower temperatures.

1. Open and close the drain valve on the bottom of the air tank to drain condensation and oil carryover.

2. Check the air supply pressure. The air starting motor requires a minimum of 620 kPa (90 psi) air pressure to operate properly. The maximum air pressure must not exceed 1550 kPa (225 psi). The normal air pressure will be 758 to 965 kPa (110 to 140 psi).



Air Starter showing Air Valve (1) and Lubricator Bowl (2)

3. Check the oil level in the lubricator bowl (2). Keep the bowl at least half full and add lubricant if necessary.

4. Push the air valve (1) or engine start button to crank the engine. Release the valve or button as soon as the engine starts.

Engine Operation

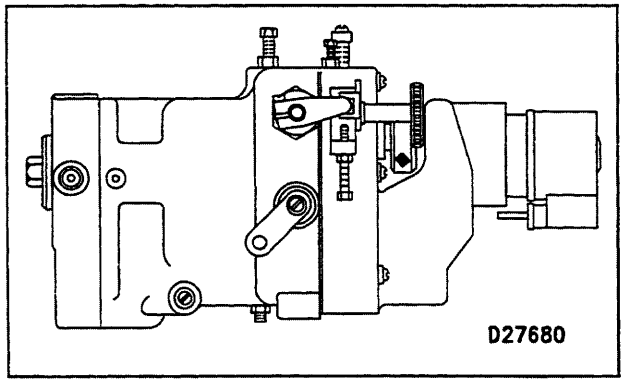
Proper operation and maintenance are key factors in obtaining the maximum life and economy of the engine. Following the directions in this manual will lower operating costs.

The time needed for the engine to reach the normal mode of operation is usually less than the time taken for a walk-around-inspection of the engine.

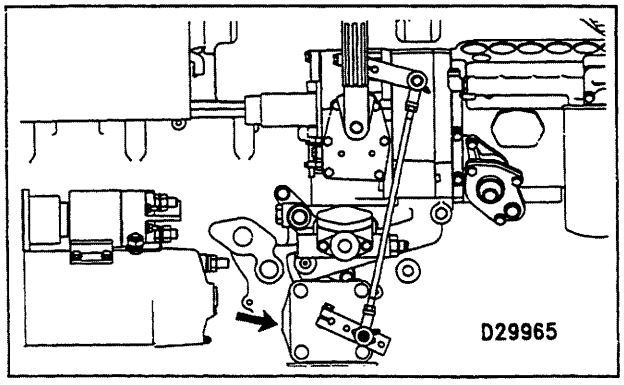
After the engine is started and the cold low idle operation is completed, the engine can be operated at rated speed and low power. The engine will reach normal operating temperature faster when operated at rated speed and low power demand than when idled at no load. Typically the engine should be up to operating temperature in a few minutes.

Governors and Actuators

Your engine may be equipped with a:
- full-range governor
- Woodward PSG Governor
- Woodward 1724 Actuator
- Woodward 524 Actuator



PSG Actuator



1724/524 Actuator

Woodward Governors/Actuators are usually electrically operated from a control panel. The application is usually an EPG power generator set. On standby gen sets the governor may be set to operate only at Full Load Speed.

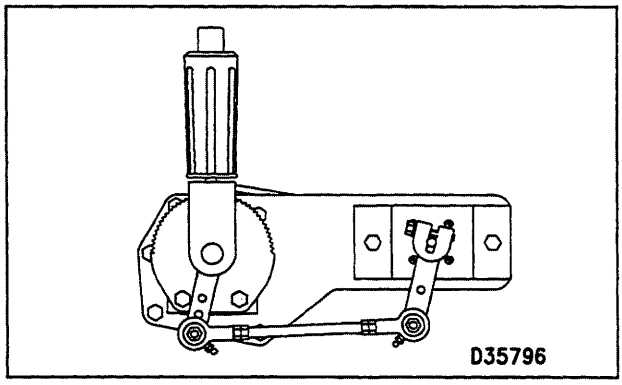
Change Engine Speed

If equipped with a control panel, a RAISE/LOWER switch or a speed setting potentiometer is used to adjust the operating speed.

Starting, Operating and Stopping Engines Equipped with Control Panels

For all information regarding the generator control panel used for starting, operating and stopping the engine, refer to the Engine Protection Devices Generator Set Control Panel topic in this publication or Caterpillar SR4 Generators and Control Panels, SEBU6150. Additional information and programming instructions are provided in the Service Manual for your specific control panel.

Mechanical Governors (If Equipped)



Governor Control Lever

Your engine may be equipped with a full-range governor. Most other manufacturers' engines have min-max type governors that only govern at high and low idle to prevent the engine from overspeeding or dying. With the min-max governor, the position of the speed lever determines the amount of fuel delivered to the engine.

With the full-range governor, the position of the speed lever sets engine speed and helps hold a constant speed independent of load which makes operation easier.

The governor control motor is a 24 volt motor which allows for engine speed control from a remote location through a governor RAISE/LOWER switch. This governor control switch is used with the optional EMCP II.

NOTE: Always increase engine speed to high idle before applying load.

For information regarding initial checks and adjustments, refer to the Service Manual or contact your Caterpillar dealer.

Driven Equipment Without Load

1. Move the governor control lever to half engine speed.

2. Interrupted starts put excessive stress on the drive train and waste fuel. To get the driven equipment in motion, engage the clutch smoothly, with no load on the equipment. This should result in a smooth, easy start without increasing the engine speed above low idle or slipping the clutch.

For generator sets, move the governor control to high idle (full load) position (1800 rpm for 60 Hz and 1500 rpm for 50 Hz).

3. Apply the load and check the gauges and equipment for proper operation. Begin operating the engine at low load. After normal oil pressure is reached and the temperature gauge begins to move, the engine may be operated at full load.

NOTE: Do not allow the engine speed (rpm) to exceed the limit above rated rpm. DO NOT allow the engine to overspeed.

If the load varies, or is cyclic, the governor will adjust the engine speed as required.

The governor control lever should remain in the full governed position while operating at full load.

Extended operation at low idle or reduced load may cause increased oil consumption and carbon build-up in the cylinders. This carbon build-up results in loss of power and/or poor performance. When operating at reduced load, the engine should be fully loaded to burn excess carbon from the cylinders at least every four hours.

NOTE: Check the gauges and equipment frequently while operating under load.

Engine Efficiency

Engine efficiency affects fuel economy. Caterpillar engines are designed and manufactured using state-of-the-art technology to provide maximum fuel efficiency in all applications. To insure optimum performance for the life of your engine, follow the recommended operation and maintenance procedures described in this publication.

Cold Weather Operation

Caterpillar Diesel Engines can operate effectively in cold weather. However, engine operation in cold weather is dependent on the type of fuel used and how well the fuel moves through fuel related components. The purpose of this section is to explain some of the problems and steps that can be taken to minimize fuel problems during cold weather operation, when the engine area is colder than 5°C (40°F).

Fuel and the Effect from Cold Weather

The two types of diesel fuel available for your engine are typically grades No. 1 and No. 2. No. 2 diesel fuel is the most commonly used fuel. No. 1 diesel fuel, or a blend of No. 1 and No. 2, is best suited for cold weather operation.

Quantities of No. 1 diesel fuel are limited, and generally only available during the winter months in the colder climates. During cold weather operation, if No. 1 fuel is unavailable, it may be necessary to use No. 2 diesel fuel.

There are three major differences between No. 1 and No. 2 diesel fuel. No. 1 diesel fuel has:
- a lower cloud point
- a lower pour point
- a lower BTU (kJ) (heat content) rating per unit volume of fuel than the average No. 2 diesel fuel.

When using No. 1 diesel fuel, you may notice a drop in power and fuel efficiency. You should not experience any other operating effects.

The cloud point is the temperature at which a cloud or haze of wax crystals begins to form in the fuel and cause fuel filters to plug. The pour point is the temperature which diesel fuel begins to thicken and be more resistant to flow through fuel pumps and lines.

Be aware of these fuel values when purchasing your diesel fuel. Anticipate the average outside (ambient) temperature for the area your engine will be operating. Engines fueled in one climate may not operate satisfactorily if moved to another because of problems that result from cold weather.

Before troubleshooting for low power or poor performance in winter months, check the type of fuel being used.

When No. 2 diesel fuel is used: starting aids, engine oil pan heaters, engine coolant heaters, fuel heaters, and fuel line insulation also provide a means of minimizing starting and fuel problems in cold weather .

Fuel Related Components in Cold Weather

Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off fuel tanks before leaving overnight.

Fuel tanks should contain some provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe.

Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If equipped with this system, regular maintenance of the fuel system filter(s) is important.

Check the fuel level in the day tank daily by observing the sight gauge. Drain the water and sediment from any fuel storage tank weekly, at the oil change period, and before the fuel tank is refilled. This will help prevent water and/or sediment from being pumped from the fuel storage tank into the engine fuel tank.

Fuel Filters

A primary fuel filter is installed between the fuel tank and the engine fuel inlet. After changing the fuel filter(s), always prime the fuel system (if equipped with a priming pump) to remove air bubbles from the system.

The micron rating and location of a primary fuel filter is important in cold weather operation. The primary filter and the fuel supply line to the primary filter are the most common components affected by cold fuel.

The micron rating of the primary fuel filter should only be fine (low) enough to protect the fuel transfer pump. A very fine (low micron rating) primary filter, can be more easily plugged by wax in cold weather. A primary filter, with a micron rating as fine as a secondary filter can cause waxing problems.

NOTE: A 9M2341 Filter Element is recommended as a cold weather primary fuel filter. Refer to the Parts Manual for this engine to determine the part numbers required for the primary fuel filter.

Fuel Heaters

Fuel heaters prevent fuel filters from plugging in cold weather due to waxing. A fuel heater should be installed so that the fuel is heated before it enters the first (primary) fuel filter.

Select a fuel heater that is mechanically simple, yet adequate for the application. The fuel heater should also prevent overheating of the fuel. High fuel temperatures reduce engine performance and power availability. Choose a fuel heater with as large a heating surface as practical. Small heaters can be too hot in their limited surface area.

Disconnect or deactivate the fuel heater in warm weather.

NOTE: Only thermostatically controlled or self-regulating fuel heaters should be used with this engine. Non-thermostatically controlled fuel heaters can heat the fuel in excess of 65°C (149°F). A loss of engine power can occur if the fuel supply temperature exceeds 37°C (100°F).

NOTE: Heat exchanger-type fuel heaters should have a bypass provision to prevent overheating of the fuel in warm weather operation.

The following fuel heaters are recommended for use with Caterpillar engines.

Thermoblend ..... Caterpillar part no. 7C3557
Hot Joint ..... Caterpillar part no. 7C3558

For further information on fuel heaters, contact your Caterpillar dealer.

Engine Stopping

NOTICE

Stopping the engine immediately after it has been working under load can result in overheating and accelerated wear of the engine components. Allow the engine to engine cool down before stopping. Avoiding hot engine shutdowns will maximize turbocharger shaft and bearing life.

If the engine has been operating at high load, run at low idle for at least three minutes before stopping. This cool down will reduce and stabilize internal engine coolant and oil temperatures before stopping the engine.

If the engine has been operating at low loads, run the engine at low idle for 30 seconds before stopping.

Make sure the shutoff procedure is understood. Refer to the Stopping the Engine instructions in the Generator Set Control Panel topic in this publication. Use the following general guidelines for stopping the engine.

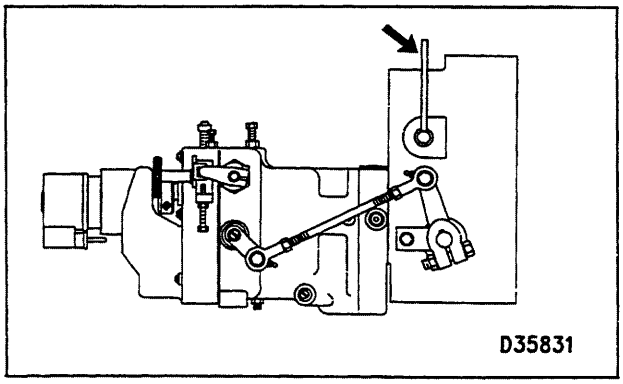
1. Open the Main electrical circuit breaker/Remove load from engine.

2. Move the governor control to no more than half engine speed. Run the engine for three to five minutes.

3. Reduce the engine speed to low idle.

4. The engine may be stopped by using the Woodward Governor (if equipped), the Mechanical Governor (if equipped), or the solenoid shutoff switch.

Woodward Actuator (If Equipped)

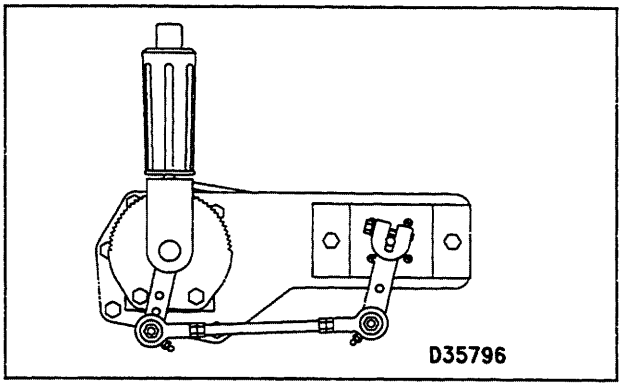


If equipped with a Woodward Actuator, move the control lever upward or forward, depending on the installation. Hold the lever to the OFF or STOP position until the engine stops.

Mechanical Governor Control

A manual shutoff lever is provided to shut off the fuel from the fuel injection pump and override the governor control. The manual shutoff lever is located on the side of the pump.

The engine can be shut OFF by rotating and holding the manual shutoff lever in the clockwise (CW) direction.



If equipped with a Mechanical Governor Control, to move control to the SHUT OFF position: pull upward on the vernier hand grip while pushing down on thumb button. This shutdown will only move the fuel control linkage (rack) to the FUEL-OFF position. This does not shut off the air inlet.

Solenoid Shutoff

Move the Control Panel Engine Control Switch (ECS, if equipped) to the STOP position.

After Stopping the Engine

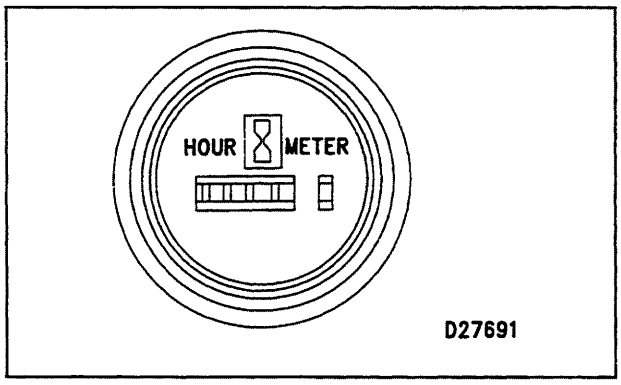
1. Fill the fuel tank to prevent accumulation of moisture in the fuel.

2. Check the coolant level. Maintain the cooling system to 13 mm (½ inch) from bottom of the fill pipe.

If freezing temperatures are expected, allow the radiator and engine jacket water system to cool, then check the coolant for proper antifreeze protection. The cooling system must be protected against freezing to the lowest expected ambient (outside) temperature. Add the proper coolant and water mixture if necessary.

3. Check the crankcase oil level. Maintain the oil level between the ADD and FULL marks in the FULL RANGE zone on the dipstick.

4. Repair any leaks, perform minor adjustments, tighten loose boits, etc.



5. Note the service hour meter reading. Perform periodic maintenance as instructed in the Maintenance Schedule.

Air-to-Air Aftercooling System (ATAAC) (If Equipped)

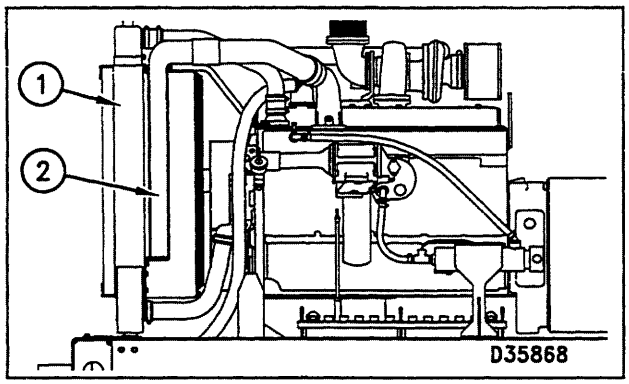
Air-to-air aftercooling (ATAAC) systems are simple, reliable, and easy to maintain. Generally, ATAAC benefits one or two of the following areas:

- Improved fuel consumption
- Lower emissions
- Increased power

NOTE: In some cases all three may be improved.

Operation of ATAAC

Inlet air is pulled through the air cleaner, compressed and heated by the compressor wheel in the compressor side of the turbocharger to about 150°C (300°F). The heated air is then pushed through the air to air aftercooler core and moved to the air inlet manifold in the cylinder head at about 43°C (110°F).



Radiator Core (1) and Aftercooler Core (2).

Cooling the inlet air increases combustion efficiency, which helps to lower fuel consumption and increase horsepower output. The aftercooler core (2) is a separate cooler core installed behind the standard radiator core (1). Ambient temperature is moved across both cores by the engine fan- this cools the turbocharged inlet air and the engine coolant.

Lower intake air temperature allows more air to enter the cylinder. More complete fuel combustion and reduced exhaust emissions are the results. Air-to-air aftercoolers can achieve charge air temperatures lower than water-to-air systems. The lower air temperatures provide improved efficiency.

NOTICE

To maintain an adequate water pump cavitation temperature for efficient water pump performance in an Air-to-Air Aftercooled engine: Caterpillar recommends that the coolant mix contain a minimum of 30 percent Caterpillar Antifreeze, or equivalent.

Air Intake System

An air hose failure or a significant air intake system leak will cause a large drop in boost pressure and power. The engine can be operated at this power level for a short period of time, however, sustained operation under this condition should be avoided.

A slight reduction in power or response, or a small increase in exhaust temperature may indicate a small air leak in the charge air cooler core or piping.

If air leaking is suspected, inspect the air intake hoses, elbows and gaskets for cracks or damage. Replace the parts as needed. Check for loose clamps and tighten the clamps as needed.

Radiator Restrictions

Caterpillar discourages the use of air flow restriction devices mounted in front of radiators with air-to-air aftercooled engines. Air flow restriction can cause higher exhaust temperatures, power loss, excessive fan usage, and a reduction in fuel economy.

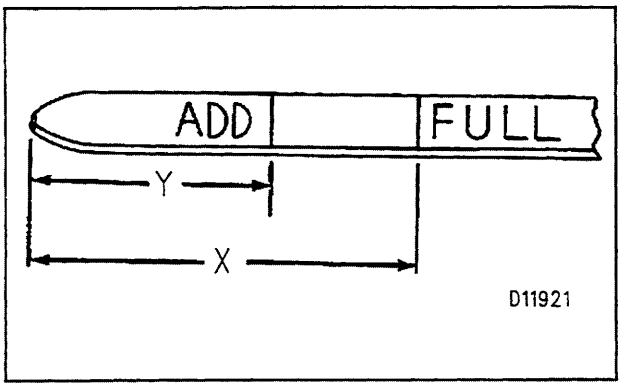
If an air flow restriction device must be used, the device should have a permanent opening directly in line with the fan hub. The device must have a minimum opening dimension of at least 770 cm^2 (120 in^2).

A centered opening, directly in line with the fan hub, is specified to provide sensing when viscous fan drives are used and/or to prevent an interrupted air flow on the fan blades. Interrupted air flow on the fan blades could cause a fan failure.

Caterpillar recommends that a package include an intake manifold temperature device, such as a light indicator, buzzer, etc., set at 65°C (150°F) and/or installation of an inlet air temperature gauge. For the ATAAC (Air-To-Air Aftercooled) engines, air temperature in the intake manifold should not exceed 65°C (150°F). Temperatures exceeding this limit can cause power loss and potential engine damage.

This temperature provides engine protection for full restriction device closure. This temperature can also serve as a diagnostic tool for a malfunction of the charge air cooling system. It is not anticipated that a temperature of 65°C (150°F) will be encountered under normal operating conditions.

Oil Level Gauge (Dipstick)



Calibration

NOTE: Refer to the complete Oil and Filter change procedure before performing Calibration (if applicable).

Your engine may use a dipstick that has a FULL RANGE zone rather than the traditional FULL mark. The FULL RANGE is between the ADD and FULL marks (X–Y). This dipstick allows for variations in engine installations. Engine oil level will vary, depending on angle (front to back tilt) and slant sideways tilt).

To determine the correct FULL mark in the FULL RANGE zone and prevent overfilling or under filling the crankcase, it is important to calibrate (or verify the calibration of) the dipstick at the first oil change.

To verify the ADD mark and establish the actual FULL mark in the FULL RANGE zone of the dipstick, use the following procedure.

NOTE: This procedure is correct for use with either the non-spacer plate oil pan or the spacer plate oil pan. Sump capacities and oil levels are the same for each oil pan.

NOTE: The engine must rest on a level surface for this procedure.

1. Operate the engine until it reaches normal operating temperature.

2. Stop the engine. Remove the crankcase drain plug(s). Let the oil drain from the crankcase for 20 minutes.

3. Remove the used oil filter(s). Install the new oil filter(s). Install the crankcase drain plug(s) and tighten to 50 ± 10 lb ft (70 ± 14 N•m).

4. Fill the crankcase with 27.5 L (29 qt) of oil for 3306B engines or 22 L (23.3 qt) of oil for 3304B engines. Allow the oil to drain back to the sump for a minimum of five minutes.

5. Start and operate the engine until the oil filters are full and the engine reaches normal operating temperature. Stop the engine.

6. Allow the oil to drain back to the sump for a minimum of ten minutes. Remove the dipstick. The oil level should be in the FULL RANGE zone. Use an engraving tool to mark the new FULL level on the dipstick.

7. This is the correct FULL mark in the FULL RANGE zone on the Engine Stopped side of the dipstick. The crankcase sump is considered FULL if the level is in the knurled FULL RANGE zone.

NOTE: Remote mounted or auxiliary oil filters require additional oil. For all information about auxiliary oil filters, refer to the OEM instructions.

Scheduled Oil Sampling (S•O•S)

Caterpillar's Scheduled Oil Sampling (S•O•S) analysis is the best indicator for determining what is happening inside your engine.

S•O•S analysis is a diagnostic tool used to determine oil performance and component wear rates. S•O•S analysis uses a series of tests designed to identify and measure contamination such as:

- soot, sulfur, etc.
- degradation such as the presence of fuel, water and antifreeze in a sample of oil.
- the amount of wear metals present in the oil sample.

Wear metals present in the oil sample are compared to established Caterpillar norms to determine acceptability. S•O•S analysis must be performed on a continuing basis to be effective as an indicator. Intermittent sampling does not allow wear rate trend lines to be established.

S•O•S INTERVAL CHART	
Compartment	**Interval**
Engine Crankcase	Every 250 Hours (T & TA Only)
Engine Crankcase	Every 500 Hours (NA Only)

Obtain Oil Sample Every 250 Hour Interval (T & TA) or Every 500 Hour Interval (NA).

Obtain S•O•S samples at regularly scheduled intervals to monitor the condition and maintenance requirements of your engine. Each oil sample should be taken when the oil is warm and well mixed to ensure that the sample is representative of the oil in the engine crankcase.

Consult your Caterpillar dealer for complete information and assistance in establishing an S•O•S analysis program for your engine(s).

S•O•S Analysis

S•O•S analysis is composed of three basic tests:

- Wear Analysis
- Chemical and Physical Tests
- Oil Condition Analysis

Wear analysis is performed with an atomic absorption spectrophotometer to monitor component wear by identifying and measuring concentrations, in parts per million, of wear elements present in the oil. Based on known normal concentration data, maximum limits of wear elements are established. Impending failures can be identified when test results deviate from concentration levels established as acceptable, based on normal wear.

Chemical and physical tests detect the presence of water, fuel and glycol (antifreeze) in the oil and determine whether or not their concentrations exceed established maximum limits.

Oil condition is evaluated with infrared analysis. This test determines the presence and measures the amount of contaminants such as soot, sulfur products, oxidation, and nitration products in the oil. Infrared analysis can also assist in customizing (reducing, maintaining or extending) oil change intervals for particular conditions and applications.

Infrared analysis should always be accompanied by wear element analysis and chemical and physical tests to assure accurate diagnosis.

NOTE: Infrared analysis must be used to determine oil change intervals. S•O•S analysis must include Infrared (IR) in the analysis.

The test results of the oil samples will then be used as a basis for determining the oil change interval for your engine, giving you the ultimate time between oil changes without the risk of engine damage.

Refer to Caterpillar pamphlet Listen To Your Oil (PEDP1129) for information and benefits of S•O•S analysis.

Maintenance Terminology

Adjust – to conform and correspond to specifications.

Check – to observe for satisfactory conditions, accuracy, safety or performance.

Exchange – to trade a worn or failing component for a remanufactured or rebuilt component.

Inspect – to examine closely, in critical appraisal, while testing or evaluating components or systems.

Inspect/Rebuild or Exchange – to examine closely, then making the decision on repair option (i.e. Rebuild or Exchange).

Lubricate – to apply a lubricant (oil, grease, etc.) as specified for reducing friction, heat and wear between solid surfaces.

Protective Devices – indicators such as gauges, lights, emergency shutoffs, etc., that alert an operator that a potential problem may exist. Failure to respond to these indicators in a timely manner could result in serious engine damage.

Rebuild – to repair a worn or failing component with new parts, components and/or remanufactured components.

Replace – to install something new, remanufactured or rebuilt in place of an existing worn or failing component.

Service Hours (Electrical) – records the time (clock hours) the engine is actually running but does not reflect variations in speed, load, etc.

NOTE: Some engines are equipped with mechanical service meters reading in Service Meter Units (SMU). The Maintenance Schedules are developed for clock hours or fuel consumption. For most users, clock hours are the standard interval for maintenance and SMU's can be roughly equal to clock hours. However, Caterpillar recommends that fuel consumption be used as the preferred method of determining intervals rather than SMU's or clock hours.

Interval Categories

Engine components can generally be grouped into speed sensitive and load sensitive categories. The maintenance interval for each item listed in the Maintenance Schedule is based on either engine speed or load.

Speed sensitive items such as water pumps and air compressors are not primarily affected by the operating load on your engine. The load on an engine will not significantly accelerate the repair or replacement cycle for speed sensitive items.

The maintenance intervals established for speed sensitive items are based on service hours.

Load sensitive items such as piston rings and cylinder liners are affected by the operating load on your engine. Generally speaking, the lower the load, the longer the engine life. Conversely, the higher the load, the shorter the engine life. A heavy load on an engine will accelerate the repair or replacement cycle for load sensitive items.

Load sensitive items are normally internal engine components. The amount of fuel consumed is directly related to the load on your engine.

The maintenance interval for load sensitive items includes fuel consumption, since the amount of fuel consumed is directly related to the load on your engine.

Caterpillar recommends performing maintenance on load sensitive items at maintenance intervals based on the quantity of fuel consumed.

Lubricant Viscosity Recommendations & Refill Capacity

Lubricant Viscosity Recommendations

See chart for recommended viscosity and temperature range. The required performance criteria for the oil is defined in the previous Lubricant Specification section.

The minimum temperature for the viscosity grade provides guidelines for the lowest starting temperature with a "cold soaked" engine. Base stocks for blending the oil formulations do differ, and variations can exist within a viscosity grade on low temperature characteristics. Therefore, a particular oil may allow lower starting temperatures than given in the chart. Your oil supplier can provide additional information on oil properties.

The recommendation is to use the highest viscosity oil possible. Even though the ambient temperature may be low, operating engines can still be subjected to normal oil temperatures because of regulated temperature components. Higher viscosity fluids provide better protection to all components contacted during the full day work cycle.

Multi-viscosity oils are preferred because of full protection through a wider temperature range. See chart for recommended viscosity and temperature range.

To determine if the oil in the crankcase will flow in cold weather, remove the oil dipstick before starting the engine. If the oil flows off, the oil is fluid enough to circulate properly.

Lubricant Viscosity Chart

LUBRICANT VISCOSITIES FOR AMBIENT (OUTSIDE) TEMPERATURES					
Compartment or System	Oil[1] Viscosities	°C		°F	
		Min	Max	Min	Max
Engine Crankcase	SAE 10W30[2]	-20	+40	-4	+104
	SAE 15W40[2]	-15	+50	+5	+122
	SAE 30	0	+40	+32	+104
	SAE 40	+5	+50	+41	+122

[1] Select oil viscosity based on maximum expected operating temperature. Engine start-up at lower than specified ambient temperature requires caution. Start-up at very low ambient temperatures may require auxiliary oil heaters or other methods to increase the engine crankcase and surrounding temperatures.

[2] Oil viscosity grades which meet the API CE or CF-4 performance category are limited somewhat to multi-grades (SAE 15W40 and 10W30). If single viscosity grades are selected, confirm with your oil supplier that the oil does meet the API CE or CF-4 rating requirement.

Refill Capacities

These refill capacities reflect the crankcase capacity plus filter. Auxiliary oil filter systems will require additional oil. For all auxiliary oil filter system information consult the OEM or auxiliary oil filter system manufacturer.

In order to properly maintain the cooling system, Total Cooling System capacity must be known. This capacity information will be needed to determine the amount of antifreeze and coolant additive (conditioner) required for the cooling system.

REFILL CAPACITIES - (APPROXIMATE)			
Compartment or System	Liters	U.S. Quarts	Imperial Quarts
3304B ENGINE CRANKCASE with Filters[1]	22.0	23.3	19.4
3304B JACKET WATER COOLING SYSTEM (Engine Only)	13.0	14.0	11.5
STANDARD RADIATOR (w/ hoses)[2]	10.7	11.2	9.2
C-SIZE RADIATOR (w/ hoses)[2]	32.0	34.0	28.2
TOTAL COOLING SYSTEM [3]			
3306B ENGINE CRANKCASE with Filters[1]	27.5	29.0	24.0
3306B JACKET WATER COOLING SYSTEM (T Engine Only)	18.0	19.0	16.0
3306B JACKET WATER COOLING SYSTEM (TA Engine Only)	20.0	21.0	17.5
3306B JACKET WATER COOLING SYSTEM (ATAAC Engine Only)	16.0	17.0	14.0
STANDARD RADIATOR (w/ hoses)[2]	10.7	11.2	9.2
C-SIZE RADIATOR (w/ hoses)[2]	32.0	34.0	28.2
TOTAL COOLING SYSTEM [3]			

[1] Optional bypass filters supplied by Caterpillar require additional oil. Additional oil is required with the use of auxiliary filters. Make sure to add enough oil to fill auxiliary oil circuit. Refer to OEM's specifications regarding auxiliary filter capacity.

[2] Refer to the OEM's specifications regarding cooling equipment capacity if radiator is not a Caterpillar radiator.

[3] The Total Cooling System capacity will vary, depending on the radiator type and capacity provided by Caterpillar or the OEM. In order to properly maintain the cooling system, Total Cooling System capacity must be known. The chart is blank and should be filled in by the customer to determine the Total Cooling System Capacity for this engine and application. Add ENGINE ONLY and appropriate RADIATOR capacity for TOTAL COOLING SYSTEM capacity for your engine and application.

Maintenance Schedule–3304B Engines

Use fuel consumption, service hours, or calendar time, whichever occurs first, to determine maintenance intervals.

NOTE: Experience has shown that maintenance intervals are most accurately scheduled on the basis of fuel consumed rather than service hours.

Daily

Every 1,100 L (300 gal) of Fuel or 50 Hours*

Every 2,800 L (750 gal) of Fuel 125 Hours*

Every 5,600 L (1,500 gal) of Fuel or 250 Hours*

[1] These maintenance requirements are to be performed at the 250 Hour interval for Turbocharged (T) Engines ONLY. Refer to 500 Hour interval for Naturally Aspirated (NA) Engines.

Every 11,250 L (3,000 gal) of Fuel or 500 Hours (NA Only)*

Every 22,500 L (6,000 gal) of Fuel or 1000 Hours*

Every 45,000 L (12,000 gal) of Fuel 2000 Hours*

Every 68,220 L (18,000 gal) of Fuel or 3000 Hours or Two Years*

Every 90,000 L (24,000 gal) of Fuel or 4000 Hours*

Every 135,000 L (36,000 gal) of fuel or 6,000 Hours or Four Years

*Perform previous maintenance interval items first.

Maintenance Schedule–3306B Engines

Use fuel consumption or service hours, whichever occurs first, to determine maintenance intervals.

NOTE: Experience has shown that maintenance intervals are most accurately scheduled on the basis of fuel consumed rather than service hours.

Daily

Every 1,900 L (500 gal) of Fuel or 50 Hours*

Every 4,250 L (1,100 gal) of Fuel or 125 Hours*

Every 8,500 L (2,200 gal) of Fuel or 250 Hours*

[1] These maintenance requirements are to be performed at the 250 Hour interval for engines equipped with turbochargers (T, TA & ATAAC) ONLY. Refer to 500 Hour interval for Naturally Aspirated (NA) Engines.

Every 17,000 L (4,500 gal) of Fuel or 500 Hours (NA Only)*

Every 34,000 L (9,000 gal) of Fuel or 1000 Hours*

Every 67,000 L (18,000 gal) of Fuel or 2000 Hours*

Every 91,000 L (24,000 gal) of Fuel or 3000 Hours or Two Years*

Every 136,000 L (36,000 gal) of Fuel or 4000 Hours*

Every 204,000 L (54,000 gal) of Fuel or 6,000 Hours or Four Years

*Perform previous maintenance interval items first.

Daily

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Walk-Around Inspection

Inspect Engine for Leaks and Loose Connections

A walk-around inspection should only take a few minutes of your time. By taking the time to make these checks, costly repairs and accidents can be avoided and your equipment will be ready to run should the need arise.

For maximum engine service life, make a thorough inspection before starting the engine. Look for items such as oil or coolant leaks, loose bolts, worn fan belts, loose connections and trash build-up. Remove trash build-up and have repairs made as needed.

Keep a close watch for leaks. If leaking is observed, find the source and correct the leak. If leaking is suspected: check the fluid levels more frequently than the recommended maintenance intervals and continue to monitor fluid levels until any leak is found and fixed.

- Wipe all fittings, caps and plugs before servicing to reduce the chance of system contamination.

Inspect:

- Radiator core for leaks and trash build-up.
- Radiator and air intake system hoses and elbows for cracks and loose clamps.
- air-to-air aftercooler for insects, dirt and other debris. Clean as necessary. Clean the front of the aftercooler with a stainless steel brush and soapy water.

Depending on your findings and operating environment, the maintenance interval for cleaning the air-to-air aftercooler can be extended from a Daily to an as needed basis.

- Fan and accessory drive belts for cracks, breaks or other damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt of a two or three belt set is replaced, it will carry more of a load than the belts not replaced since the older belts are stretched. The additional load on the new belt could cause it to break.

- Water pump for coolant leaks at weep hole. Check weep hole for water pump breather filter blockage. Replace the filter if necessary.

NOTE: The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and parts contract.

If leaks are found, check the coolant level frequently and continue to monitor the level until the water pump is repaired. Excessive coolant leakage may indicate the need to replace the water pump seal. For removal and installation of water pumps and/or seals, see the Service Manual for this engine or consult your Caterpillar dealer.

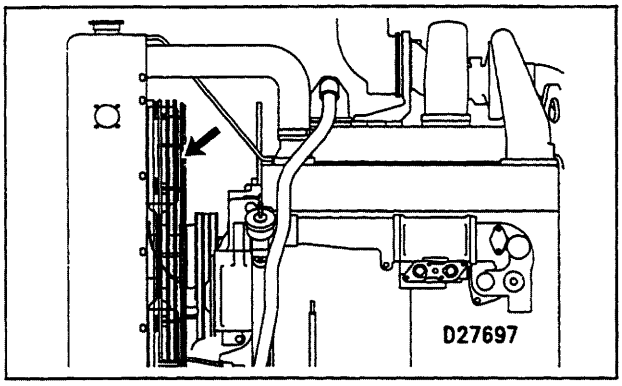
- Lube system for leaks, such as front and rear crankshaft seals, oil pan, oil filters and valve covers.
- Fuel system for leaks, loose fuel line clamps and fittings and loose or worn hoses.

NOTICE

Fuel line clamps should not be over torqued. Over torqueing causes the clamps to butterfly, which results in low clamping force, fuel line vibration and eventual failure. Refer to the Torque Specifications in this manual.

- Drain water and sediment from fuel storage and day tanks on a daily basis to ensure only clean fuel enters the fuel system.

- Inspect wiring and wiring harnesses for loose connections and worn or frayed wires.



- All guards must be in place. Repair or replace missing or damaged guards.
- Disconnect any battery chargers that are not protected against the starter current drain. Check the condition and the electrolyte level of batteries, unless equipped with a maintenance free battery.
- Inspect the engine-to-frame ground strap for good connection and condition.

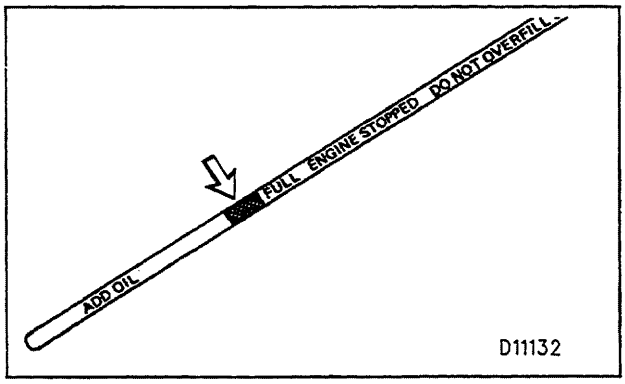
Engine Crankcase

NOTICE

Make sure you read and understand the information in the Lubricant Specifications section of this manual before you proceed with maintenance of the crankcase lube oil system.

The engine must be on a level surface to properly perform this maintenance procedure.

Check Oil Level



1. Check the oil level with the engine stopped.

Ensure that the engine when the oil level is not above the FULL RANGE zone on the dipstick.

2. Maintain the oil level between the ADD and FULL marks on the ENGINE STOPPED side of the dipstick. Do not fill the crankcase above the mark in FULL RANGE zone.

NOTE: Operating your engine when the oil level is above the FULL RANGE zone could cause your crankshaft to dip into the oil. The air bubbles created from the crankshaft dipping into the oil reduces the oil's lubricating characteristics and could result in the loss of power.

If the dipstick does not have a FULL mark in the FULL RANGE zone: refer to calibrating the oil level gauge in the Dipsticks topic of this manual or consult your Caterpillar dealer before operating the engine.

3. Remove the oil filler cap and add oil if necessary. See Refill Capacities and Lubricant Specifications for the size of your engine crankcase and recommended oil to use.

NOTE: Remote mounted or auxiliary oil filters require more oil than the Refill Capacities chart states. For all information pertaining to auxiliary oil filters, refer to the OEM or filter manufacturer's instructions.

Cooling System

NOTICE

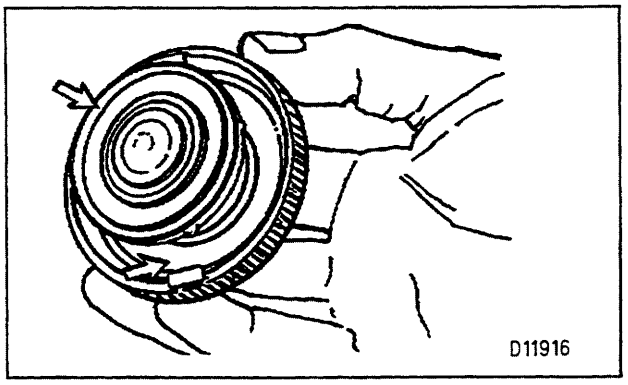
Make sure you read and understand the information in the Cooling System Specifications section of this manual before you proceed with maintenance of the cooling system.

Check Coolant Level

1. Check the coolant level with the engine stopped and cool.

2. The filler cap covers the fill pipe. Remove the filler cap slowly to relieve any pressure.

3. Maintain the coolant level within 13 mm (½ inch) below the bottom of the fill pipe or to the proper level on the sight glass (if equipped).



4. Inspect the filler cap. Replace the cap if gaskets are damaged. Install the filler cap.

5. Inspect the radiator fins for dirt and debris and clean the fins if necessary.

Clutch

Check/Adjust/Lubricate

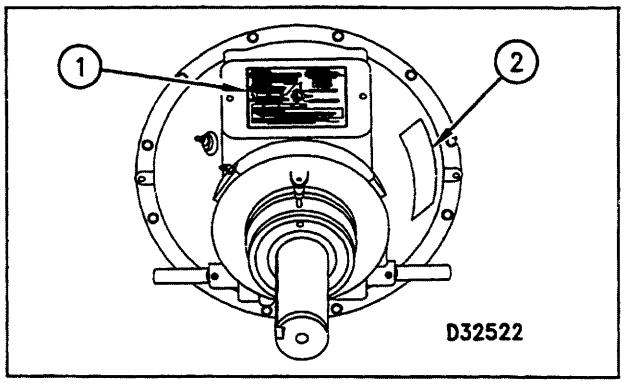
Check/Adjust

NOTICE

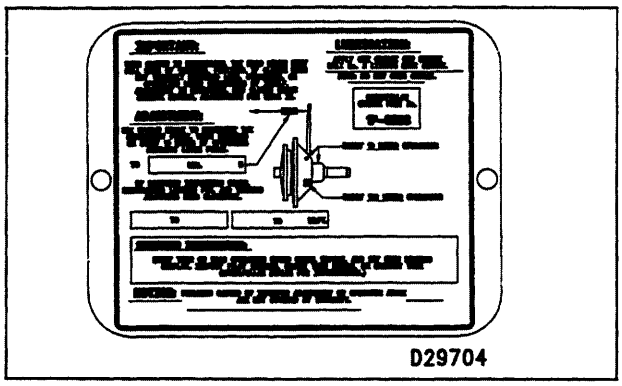
New power take-offs should have clutch adjustment checked before being placed in service. Clutch adjustment should be checked again after the first ten hours of operation. New clutch plates have a "wear in" period, and the clutch may require several adjustments until the new plates are "worn in."

Clutch adjustment should be checked regularly after "wear in." Heavy duty applications which have frequent engagements and relatively long periods of clutch slip require more frequent adjustment than light duty applications. Operating torque should be measured to determine if clutch adjustment is required.

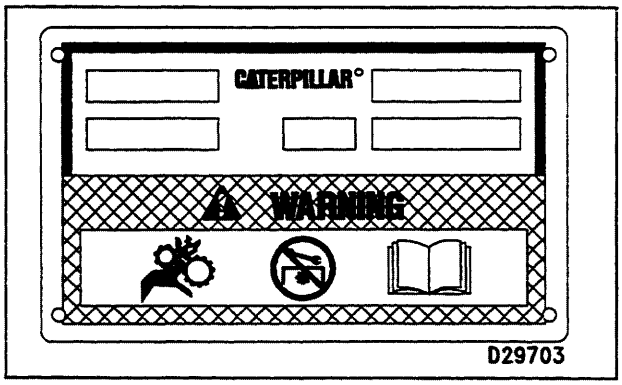
Refer to the clutch OEM service instructions and the clutch instruction plate for adjustment and other service recommendations. Perform the maintenance specified on the instruction plate.



Typical Clutch Instruction Plate (1) and Serial Number Plate (2) locations.



Instruction Plate.



Serial Number Plate.

⚠ WARNING

Rotating gears– finger or hand entanglement. Do not service until reading the operator's manual.

Do Not operate the engine with Instruction Plate cover removed from the clutch. Personal injury may result.

If the clutch is damaged to the point of burst failure, expelled pieces can cause personal injury to anyone in the immediate area. Proper safeguards must be followed to prevent accidents.

Lubricate

Refer to the clutch OEM service recommendations and the clutch instruction plate for lubrication instructions. Perform the maintenance specified on the instruction plate.

Air Starter & Air Tank (If Equipped)

Check Lubricator Level

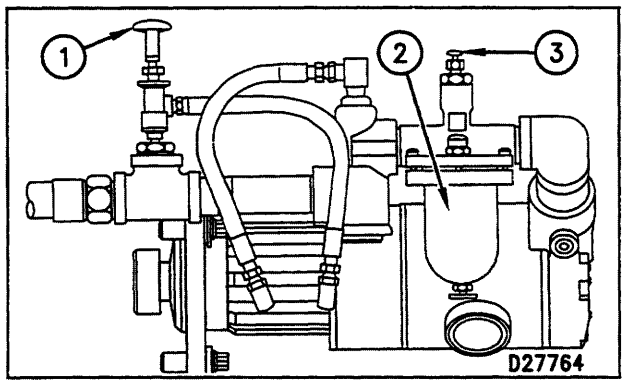
NOTICE
Never allow the lubricator bowl (if equipped) to become empty. The starting motor will be damaged by lack of proper lubrication.

The vanes of the starting motor are lubricated with a fine mist of oil from the motor lubricator. Check the level of oil in the lubricator bowl. If the bowl is less than half full, add lubricant. Use non detergent 10W engine oil for temperatures that are greater than 0°C (32°F). Use air tool oil for temperatures below 0°C (32°F).

Oiler Feed Adjustment

If necessary, adjust the lubricator to release approximately four drops of fluid per minute into the starting motor air stream.

Be sure there is NO fuel supply to the engine.



1. Push on the air start control lever (1) to crank the engine.

2. Count the drops of fluid per minute that are released into the air stream. Turn the needle valve knob (3) counterclockwise to increase the flow and clockwise to decrease the flow of fluid into the air stream.

Collector Bowl

Some air starters may be equipped with a collector bowl. The bowl collects used oil after the oil has lubricated the vanes. The bowl also collects moisture condensation from the compressed air. When the collector bowl becomes half full, drain the used lubricant. Never fill the lubricator bowl with oil from the collector bowl- use clean lubricant.

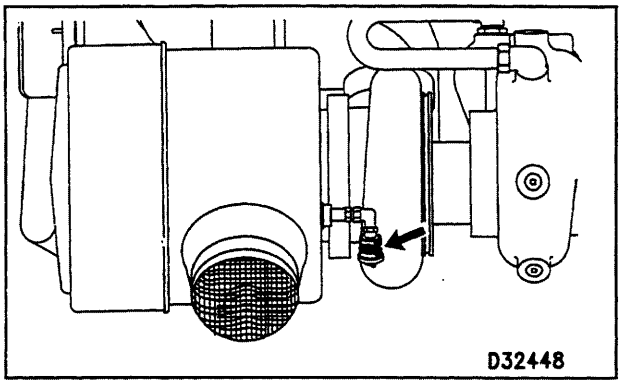
Air Tank (If Equipped)

For good life of the air starting motor, the air supply must be free of dirt and water. The air starter requires adequate air pressure in order to operate.

- Drain water from the air tank (if equipped). Open the drain valve on the bottom of the air tank to drain the condensation and oil carryover.
- Check the air supply pressure. The air starting motor requires a minimum of 620 kPa (90 psi) of air pressure to operate properly. The maximum air pressure must not exceed 1550 kPa (225 psi). The normal air pressure will be 758 kPa (110 psi) to 965 kPa (140 psi).

Engine Air Cleaner

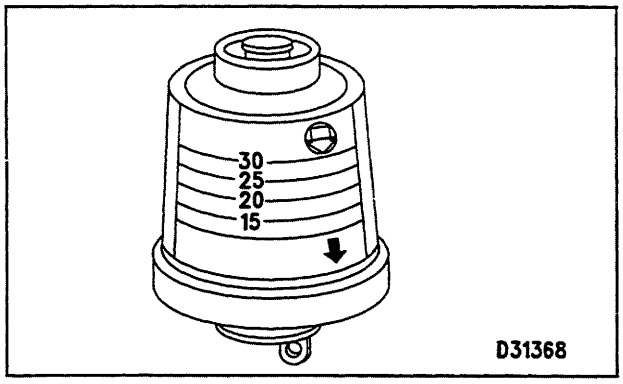
Check Air Cleaner Service Indicator



Typical air cleaner indicator, mounted on the air cleaner housing.

Your engine may be equipped with a different indicator.

A service indicator (if equipped) may be mounted on the air cleaner or in a remote location. A colored piston showing in the window indicates the need for servicing the air cleaner.



Observe the air cleaner service indicator. Clean or replace the air cleaner element when the yellow diaphragm enters the red zone or the red piston locks in the visible position. If the air cleaner indicator shows red at any time, clean the filter element or install a new air cleaner element.

NOTICE

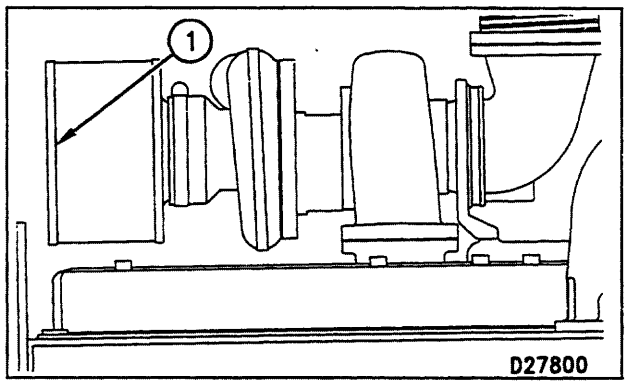
Never service the air cleaner with the engine running since this will allow dirt to enter the engine.

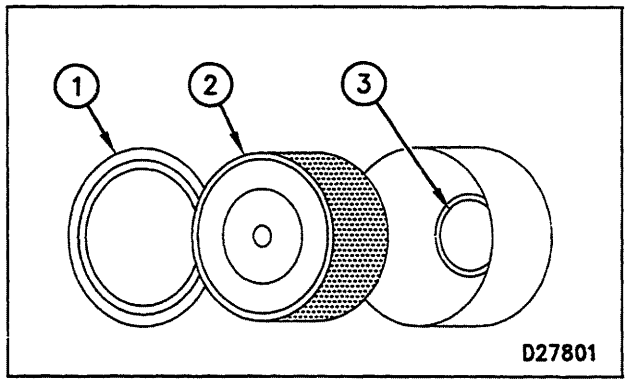
If your air cleaner element becomes plugged, the air can split the element filter material. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has air filter elements to service this unit. Contact your Caterpillar dealer for the correct filter element.

If equipped with a Light Duty air cleaner element, refer to the 50 Hour interval for information.

Single Stage Air Cleaner Elements

Remove and Install Air Cleaner Elements





1. Remove the air cleaner cover (1) and element (2).

2. Seal the turbocharger air inlet (3) so that debris can not enter the inlet. Use tape, or secure a clean cloth over the opening.

3. Clean the inside of the air cleaner cover and body.

4. Inspect the replacement element for damage, dirt or debris.

5. Remove the seal from the turbocharger inlet.

6. Install a clean, undamaged element.

7. Install the air cleaner cover.

8. Reset the service indicator.

Two Stage Air Cleaners

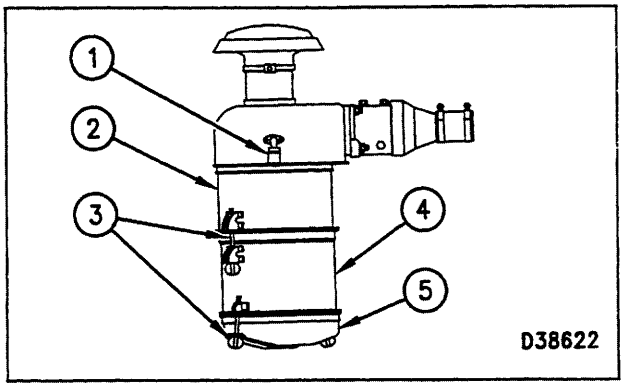
If equipped with a two stage air cleaner, refer to the Every 50 Hour interval for information regarding cleaning the dust collector/precleaner.

Heavy Duty Air Cleaners Only

Generator set engines equipped with heavy duty air cleaners have a serviceable air cleaner element. The element may be cleaned up to six times, but must be replaced Every Year. Refer to the Cleaning Air Filter Elements topic in this section.

Observe the service indicator to determine the condition of the elements. If an element becomes plugged, but does not split, engine performance will deteriorate and output power will be reduced. Keep spare filter elements on hand for replacement.

Remove and Install Air Cleaner Elements



Heavy duty air cleaner: service indicator (1), upper body (air filter element housing) (2), clamps (3), lower body (tube element) (4), and dust collector cup (5).

1. Loosen clamps (3) between lower body (4) and dust collector cup (5). Remove the cup.

2. Loosen the clamps between the lower body and the upper body (2). Remove the tube element.

3. Clean the tubes from both sides with water or air.

4. Remove the air filter element from the upper body (2). Wipe the inside of the upper body clean.

5. Inspect a clean air filter element. Install a clean or new element.

6. Inspect the gasket between the upper body and lower body. Inspect the seal between the lower body and the dust collector cup. Install a new gasket and seal if necessary.

7. Install the cleaned, dry tube element. Tighten the retaining clamps attaching the lower body to the upper body.

8. Wipe the dust collector cup clean. Install the cup and tighten the retaining clamps.

9. Reset the service indicator (1).

Cleaning Air Filter Elements

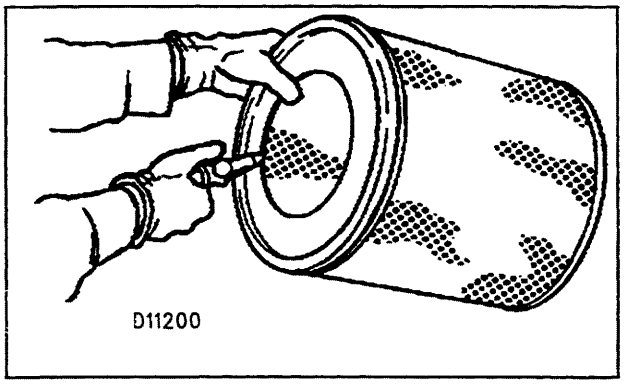
The primary element (Caterpillar air filters) can be cleaned several times before replacement. The element, when cleaned, should be thoroughly checked for rips or tears in the filter material.

Replace the primary element at least Every Year regardless of operating hours it has accumulated.

NOTICE

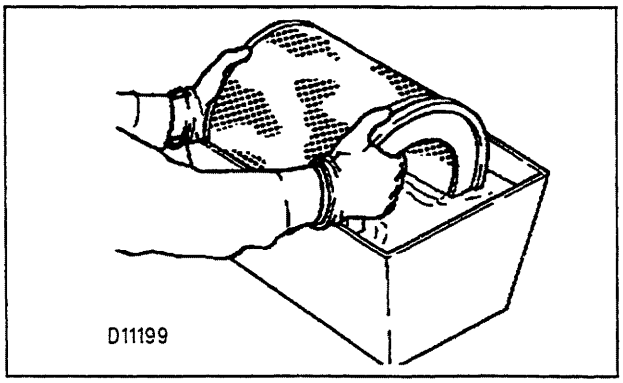
Do not clean filter elements by bumping or tapping.

Do not use filter elements with damaged pleats, gaskets or seals. Engine damage could result.

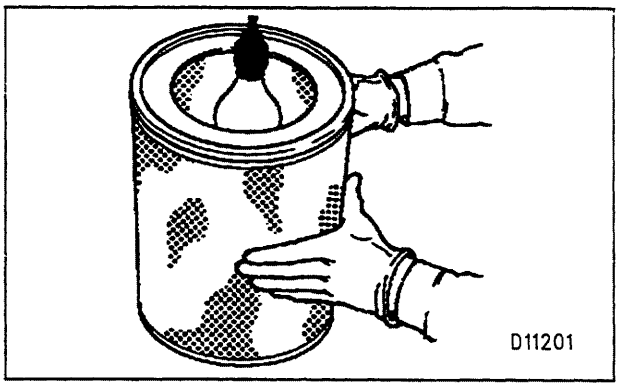


Filter elements can be cleaned with air pressure, 205 kPa (30 psi) maximum, or water pressure, 280 kPa (40 psi) maximum, or detergent washing. Have spare elements on hand to use while cleaning used elements.

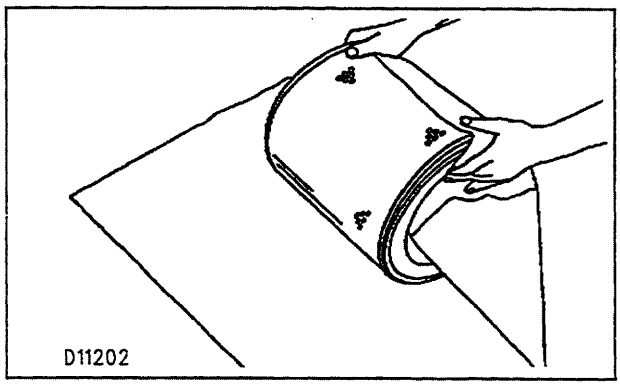
- Direct air or water along the length of the pleats inside and outside of filter element.



The element can be washed in warm water and nonsudsing household detergent, such as automatic dishwasher detergent. Rinse inside and outside the pleats. The filter should then be thoroughly air dried and inspected.



- Inspect the filter elements after cleaning for any rips, tears or damage. Insert a light inside of the clean, dry element. Do not use a filter element with damaged pleats, gaskets or seals. Discard the element if damaged.



- Wrap and store the clean filter elements in a clean, dry place.
- Reset the service indicator by pushing the piston plunger in.

For more information on air cleaner element cleaning, refer to Guideline for Reusable Parts-Cleaning and Inspection of Air Filters, SEBF8062.

SR4 Generator (If Equipped)

Inspect/Check

Inspect the generator for moisture, dust, oils, greases, and debris on the main stator, excitor, and PMG. Clean as needed.

Check for proper voltage and frequency settings and stability.

Every 50 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

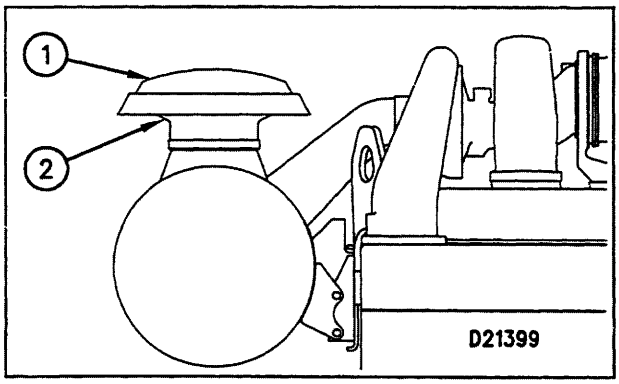
Before proceeding with Every 50 Hour maintenance, perform all Daily maintenance requirements.

Dust Collector

NOTICE

Never run the engine without an air cleaner installed. Never run the engine with a damaged air cleaner. Do not use filter elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaners prevent airborne debris from entering the engine through the air inlet.

Clean



Typical two stage air cleaner. Individual applications may be different.

1. Remove the air cleaner cap (1). Remove the dust collector cup (2).

2. Wipe dust collector cup with a clean, dry cloth.

3. Install the cup. Install and secure the cap.

NOTE: If equipped with a heavy duty air cleaner: refer to the Heavy Duty Air Cleaner topic in the Daily section of this manual for information about cleaning the dust collector cup.

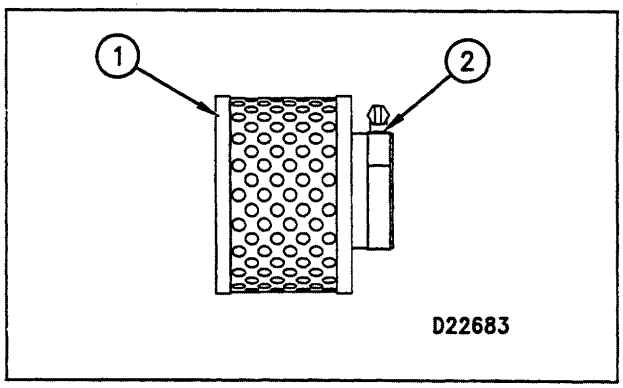
Light Duty Air Cleaner (If Equipped)

Light duty air cleaners are not serviceable (washable). Light duty air cleaners are intended for a 50 service hours of maximum use, or one year, whichever occurs first. However, engines operating in a severe environment may require more frequent air cleaner replacement.

Dust conditions vary for different operating environments. Service the air cleaner at regular intervals as determined by the operating environment. Check the air cleaner service indicator (if equipped) daily.

Check the air cleaner for cleanliness and damage such as rips and tears. Replace the air cleaner element at the required service interval, or more often as determined by the operating environmental dust conditions.

To Replace the Light Duty Air Cleaner Element:



1. Loosen the clamp (2) fastening the air cleaner element (1) to the air intake, and remove the dirty element and clamp.

2. Install the clamp on a new element.

3. Install the new element to the air intake and tighten the clamp.

Every 125 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Clutch (If Equipped)

Check/Adjust

Refer to the clutch OEM service instructions and the clutch instruction plate for adjustment and other service recommendations. Perform the maintenance specified on the instruction plate.

Lubricate

Refer to the clutch OEM service recommendations and the clutch instruction plate for lubrication instructions. Perform the maintenance specified on the instruction plate.

Generator Space Heaters (If Equipped)

Check

The SR4 generator can operate in high humidity conditions without problems. However, problems can occur when the generator is idle and the surrounding air is warmer than the generator. Moisture can form on the windings and result in poor performance and even result in damage to the windings. Whenever the generator is not in use, insure that the space heaters are in operation.

Every 250 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

NOTE: Naturally Aspirated engines need the following maintenance performed at Every 500 Hours under normal operating conditions instead of 250 Hours.

- Scheduled Oil Sampling (S•O•S)
- Engine Oil and Filter Change
- Clean Crankcase Breather
- Initial Valve Lash Adjustment

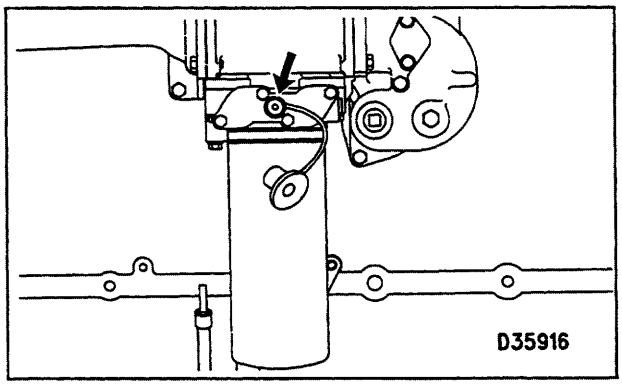
Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Scheduled Oil Sampling (S•O•S) Analysis

To compliment a good preventive maintenance program, Caterpillar recommends using S•O•S analysis at regular scheduled intervals to monitor the condition of the engine oil and maintenance requirements of your engine.

Obtain Sample

Each oil sample should be taken when the oil is warm and well mixed to ensure that the sample is representative of the oil in the crankcase. There are two methods recommended to obtain S•O•S samples from the engine crankcase.



Oil Sampling Valve

- Use the sampling valve.
- Use a sampling gun inserted into the sump.

NOTE: Refer to How to Take a Good Oil Sample, PEHP6001 for a step-by-step explanation if using this method of sampling crankcase oil.

Caterpillar recommends using one of the above methods. If either of these methods are not possible, then use a drain stream method when changing oil.

NOTE: When using the drain stream to obtain the oil sample, do not sample from the beginning or end of drain stream. The oil at the beginning or end of the drain stream is not mixed well enough to be representative of the oil in the crankcase.

S•O•S INTERVAL CHART	
Compartment	**Interval**
Engine Crankcase	Every 250 Hours (T & TA Only)
Engine Crankcase	Every 500 Hours (NA Only)

Consult your Caterpillar dealer for complete information and assistance in establishing an S•O•S program for your engine.

Oil Drain Intervals

The Maintenance Schedule assumes the use of SUPERIOR QUALITY API CF-4 (minimum) performance oil, which has sufficient TBN for fuels with less than 0.5 percent sulfur.

Many conditions exist that can affect the selection of an optimum oil change period. The fundamental requirement in this decision must be to maintain the lube oil in an acceptable condition that provides continual engine protection. The quality and amount of oil available is balanced against oil ability to absorb combustion by-products. It is essential to include an S•O•S analysis of oil condition before oil change period adjustment is considered.

All oils do not perform equally. A lower quality lube oil would require that the oil change intervals be reduced accordingly. If the sulfur content in the fuel is greater than 1.5 percent by weight, use an oil with a TBN of 30 and reduce oil change interval by one half the interval recommended in the Maintenance Schedule.

If the engine crankcase oil has reached its condemning limits as established by the oil analysis program, refer to the topic, Engine Oil and Filter(s), in this publication for the procedure to change the crankcase oil and oil filters.

Due to manufacturing tolerances, engine application and maintenance variation, all engines do not consume fuel and oil at the same rate. The amount of fuel consumed is in direct relation to the **maximum** oil change interval selected. Some history of fuel and oil consumed for each engine (or group of engines) in a similar application must be established.

For a group of engines, average fuel consumption and add oil rate may be determined by multiplying the total quantity of fuel consumed by the operating (service) hours of the engines.

For more information on adjusting or extending oil change intervals for specific applications, see your Caterpillar dealer.

Engine Oil and Filter(s)

NOTE: The engine must be on a level surface to perform this maintenance procedure.

Refer to the Lubricant Specifications section of this manual for the recommended oil to use for this engine.

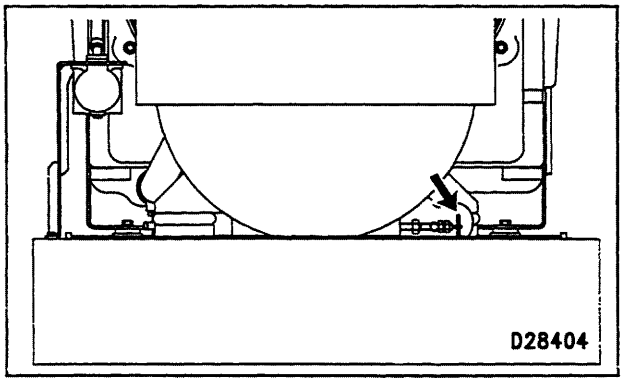
Do not drain oil when the engine is cold. As oil cools, suspended waste particles settle on the bottom of the crankcase or oil pan. The waste particles are not removed with the draining cold oil. Drain the crankcase with the engine stopped and the oil warm. This allows for the draining of the waste particles that are suspended in the oil.

Failure to follow this recommended procedure would result in these waste particles being recirculated through your engine lubrication system with the new oil.

Change Oil

Obtain an oil sample for S•O•S (Scheduled Oil Sampling) analysis at this time.

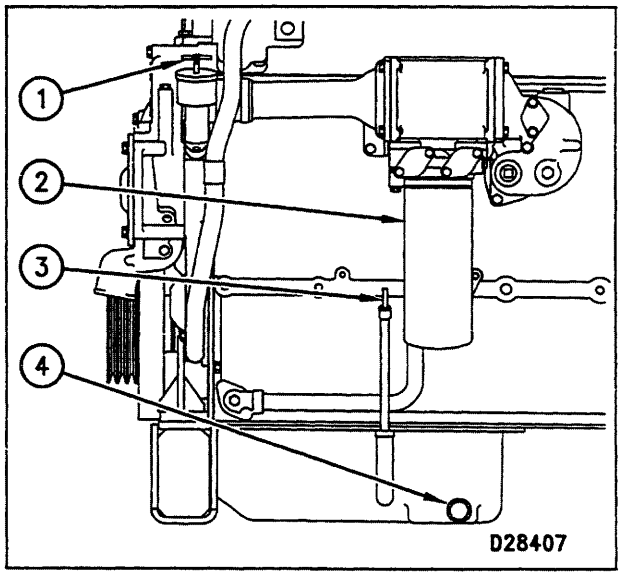
1. After the engine has been run at normal operating water temperature, STOP the engine. Remove the crankcase oil drain plug(s) and allow the oil to drain. If equipped with drain lines, turn knob on valve counterclockwise (CCW) to drain the oil.



Oil Drain Valve

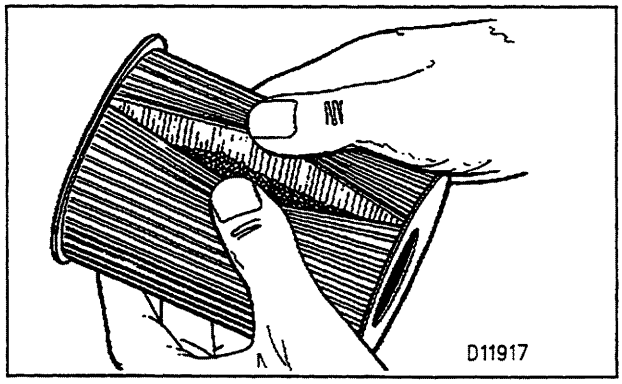
2. Install the oil drain plug(s). Tighten the plug(s) to 70 ± 14 N•m (50 ± 10 lb ft). If equipped with a drain line valve, turn the valve knob clockwise (CW) to shut the drain.

Change Filter(s)



Oil Filler Cap (1), Oil Filter (2), Oil Level Gauge (dipstick) (3), and Oil Drain Plug (4).

1. Use a 2P8250 Filter Wrench to remove the oil filter (2) and optional bypass oil filter, if equipped.



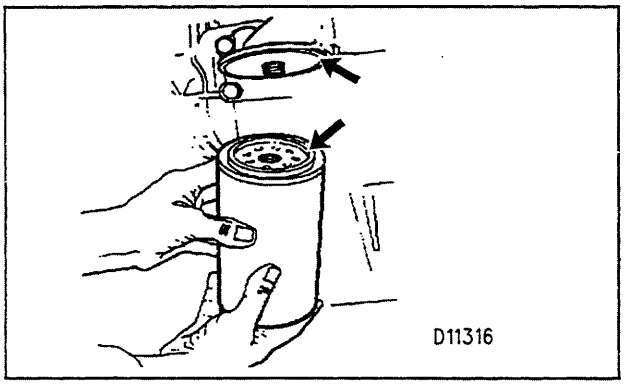
Element with debris.

2. Use a 4C5084 Oil Filter Cutter (which replaced the former 6V7905 Service Tool) to cut the oil filter open. Spread the pleats apart and inspect the element for metal debris. An excessive amount of debris in the oil filter element may be indicative of early wear or a pending failure.

Use a magnet to differentiate between the ferrous and non-ferrous metals found in your oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of your engine.

Non-ferrous metals may indicate wear on the aluminum, brass or bronze parts of your engine, such as main and rod bearings, turbocharger bearings and cylinder head wear.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter element. Consult your Caterpillar dealer to arrange for further analysis if an excessive amount of debris is found in your oil filter element.

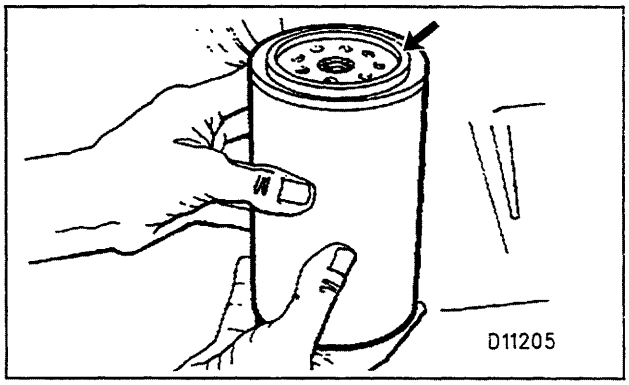


3. Wipe the sealing surface of the filter mounting base. Make sure all of the old gasket is removed.

NOTE: Change oil filter(s) at every oil change. Make sure to use the correct Caterpillar oil filter(s) for your engine arrangement.

NOTICE

Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to your engine bearings, crankshaft, etc., as a result of the larger debris particles from unfiltered oil entering your engine lubricating system. Only use oil filters recommended by Caterpillar.



4. Apply a small amount of clean engine oil to the new filter gasket.

NOTICE

Do NOT fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil will cause accelerated wear to engine components.

5. Install the new filter(s) until the gasket contacts the base. Tighten the filter ¾ of a turn more by hand. Do not over tighten.

- Replace the bypass filter (if equipped) as instructed in Steps 3, 4 and 5. The Caterpillar bypass filter will require an additional 2.5 L (2.6 U.S. qts) of oil.

Fill Crankcase

6. Remove the oil filler cap (1). Refer to Lubricant Specifications, Lubricant Viscosities and Refill Capacities chart for the proper oil and quantity to use for this engine. Fill the crankcase with the proper amount of oil. Under Filling or overfilling of engine crankcase oil can cause engine damage. Before starting the engine, ensure your oil level is within the correct operating range on the ENGINE STOPPED side of the dipstick (3).

NOTICE

If equipped with an auxiliary oil filter or system, extra oil must be added when filling the crankcase. Follow the OEM or filter manufacturer's recommendations. If the extra oil is not added, the engine may starve for oil.

To prevent crankshaft or bearing damage, crank engine to fill all filters BEFORE starting. Do Not crank engine for more than 30 seconds.

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7. Start and run the engine at LOW IDLE for two minutes to ensure the lube system (including auxiliary filters, etc.) has oil and the oil filter(s) are filled. Inspect for oil leaks.

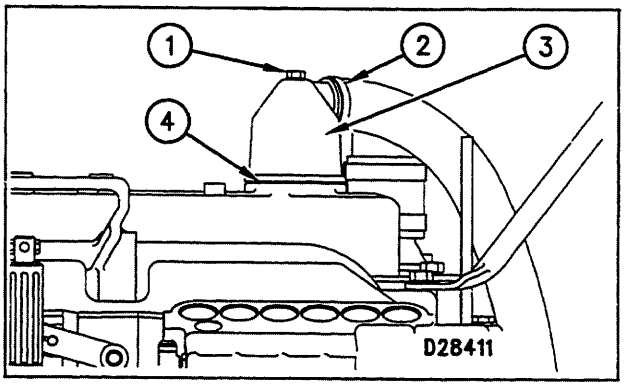
8. Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes.

9. Remove the dipstick to check the oil level. Maintain the oil level to the FULL mark in the FULL RANGE zone on the ENGINE STOPPED side of the dipstick.

Crankcase Breather

If the crankcase breather is not maintained on a regular basis, it will become plugged. A plugged crankcase breather would result in excessive crankcase pressure that may cause crankshaft seal leakage.

Clean



1. Loosen breather retaining bolt (1).

2. Loosen hose clamp(s) (2) and remove breather assembly (3) and seal (4).

3. Wash the breather in clean, nonflammable solvent. Allow the breather assembly to dry.

4. Install a new seal.

5. Assemble the breather. Install the breather in reverse order of removal.

6. Tighten the hose clamp(s) (2).

Refer to the Torque Specifications section of this manual for Torque for Standard Hose Clamps-Worm Drive Band Type hose clamps.

Engine Valve Lash

Check/Adjust

⚠ WARNING

To prevent possible injury, do not use the starter motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before adjusting valve lash.

Initial valve lash adjustment on new, rebuilt or remanufactured engines is recommended at the first scheduled oil change interval (250 hours for Turbocharged engines and 500 hours for Naturally Aspirated engines) due to initial wear and seating of valve train components. Subsequent adjustments should be made at Every 2000 Hour interval.

This maintenance is recommended by Caterpillar as part of a lubrication and preventive maintenance schedule to provide maximum engine life.

See the valve lash topics in the Service Manual or contact your Caterpillar dealer for the complete valve adjustment procedure.

Cooling System

NOTICE
Make sure you read and understand the information in the Cooling System Specifications section of this manual before you proceed with maintenance of the cooling system.

To prevent engine damage, never add coolant to an overheated engine. Allow the engine to cool first.

Test for Supplemental Coolant Additive (SCA) Concentration (Conventional Coolant/Antifreeze Only)

Use the 8T5296 Coolant Additive (Conditioner) Test Kit to check for a three to six percent SCA concentration.

Clean/Flush the cooling system before the recommended maintenance interval if:

- Coolant is heavily contaminated.
- The engine overheats frequently.
- Foaming is observed in the radiator.
- The oil cooler has failed allowing oil in the cooling system and contaminated the coolant.
- Fuel has entered the cooling system and contaminated the coolant.

Caterpillar Antifreeze contains the necessary SCA. Add SCA after flushing the system only if Caterpillar Antifreeze is NOT being used.

Add Supplemental Coolant Additive (SCA)

NOTICE
Excessive and continuous over concentration of SCA (greater than the recommended 6 percent initial fill), together with antifreeze concentrations greater than 60 percent, can result in deposits on the higher temperature surfaces of the cooling system, accelerated water pump seal wear, and radiator tube blockage, forming a barrier that reduces the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components.

1. Loosen the radiator filler cap slowly to relieve pressure. Remove the cap.

2. It may be necessary to drain enough coolant from the radiator to allow for the addition of the SCA.

3. Add 0.25 liter (½ pt) of Caterpillar SCA for every 20 liter (5 US gal) of cooling system capacity.

Refer to the Refill Capacities chart in this publication for the cooling system capacity for your engine.

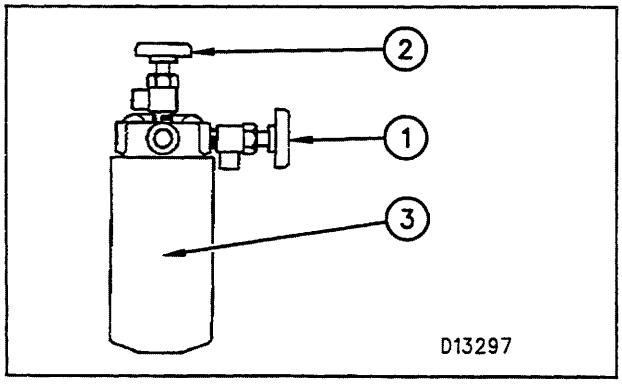
4. Inspect the radiator filler cap gaskets. Replace the cap if the gaskets are damaged.

5. Install the filler cap.

Replace Coolant Additive Element (If Equipped)

NOTICE

DO NOT use SCA and coolant additive elements together. Doing so would result in an over concentration of additive. Use one method or the other exclusively.



1. Close the coolant additive element inlet valve (1) and outlet valve (2). Remove and discard the coolant additive element (3).

2. Clean the element mounting base. Make sure all of the old gasket is removed.

3. Install a new Caterpillar coolant additive element.

4. Coat the gasket of the new element with a thin film of engine oil.

5. Install the element. Spin the element until the seal contacts the base, then tighten ¾ turn more by hand. Do not over tighten.

6. Open the inlet valve (1) and the outlet valve (2).

7. Remove the radiator filler cap.

8. Start the engine and check for leaks. Allow the coolant level to stabilize.

9. Add premixed coolant water, if necessary, to bring the coolant to within 13 mm (½ inch) below the bottom of the fill pipe or to the proper level on the sight glass, if equipped.

10. Replace the radiator filler cap.

Refer to Know Your Cooling System, SEBD0518, Coolant and Your Engine, SEBD0970 or your Caterpillar dealer for more detailed information.

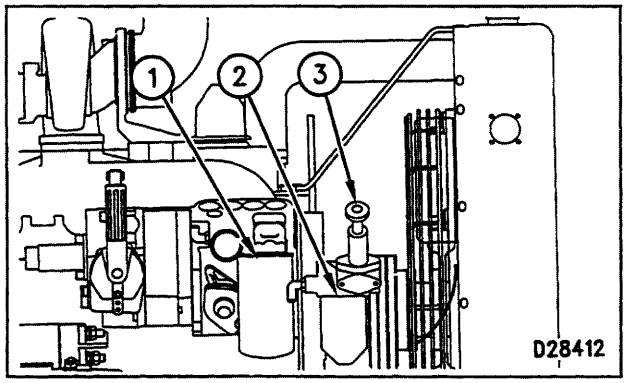
Fuel System

Fuel Tank Maintenance

Fuel tanks should have some provision for draining water and sediment from the bottom. Some fuel tanks use piping that allow water and sediment to settle. This water and sediment should be drained at each oil change.

Drain the water and sediment from any fuel storage tanks weekly, at the oil change period, and before it is refilled. This will help prevent water and/or sediment from being pumped from the fuel storage tank into the engine fuel tank.

Clean/Replace Filters

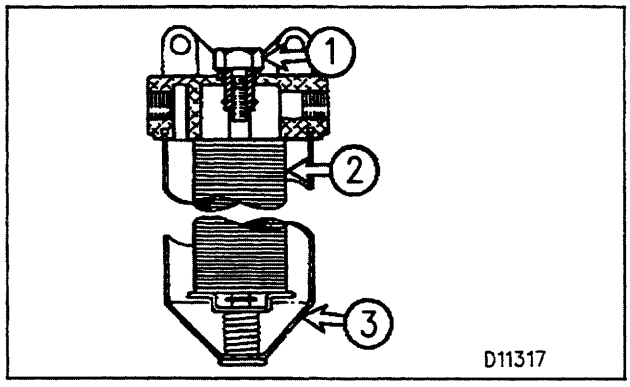


Final Fuel Filter (1), Primary Fuel Filter (2), and Fuel Priming Pump (3).

- Stop the engine.
- Turn the ECS switch OFF or disconnect the battery (or starting motor) when performing maintenance on fuel filters.
- Shut off the fuel tank supply valve to the engine. Drain water and sediment from the primary fuel filter.

Clean Primary Filter (If Equipped)

Use the following procedure to clean the primary fuel filter (if equipped).



Typical primary fuel filter section view: bolt (1), element (2), and case (3).

1. Loosen the bolt (1) on the primary filter housing and remove the filter case (3).

2. Remove the element (2) and wash it in clean, nonflammable solvent.

3. Install the element (2) and case (3). Tighten bolt (1) to a torque of 24 ± 4 N•m (18 ± 3 lb ft).

Replace Final Fuel Filter

1. Remove and discard the final fuel filter.

2. Clean the gasket sealing surface of the filter base. Make sure all of the old gasket is removed.

3. Apply clean diesel fuel to the new fuel filter gasket.

NOTICE

Do NOT fill the fuel filters with fuel before installing them. This fuel would not be filtered and could be contaminated. Contaminated fuel will cause accelerated wear to fuel system parts.

4. Install new filter. Spin filter until gasket contacts the filter base. Tighten the filter ¾ turn more by hand. Do not over tighten.

5. Prime the fuel system.

Priming the Fuel System

Prime the fuel system to fill dry fuel filters and purge trapped air. The fuel system requires priming after:

- being run dry.
- storage.
- fuel filter cleaning/replacement.

All engines:

NOTE: If the engine does not have a fuel priming pump, go to step 4.

1. Unlock and operate the priming pump plunger until a resistance is felt. Seventy five or more pump strokes may be required.

2. Push in and hand-tighten the plunger.

3. Crank the engine. If the engine starts, but runs rough, continue running the engine at low idle until the engine runs smoothly.

NOTICE

Do not crank the engine for more than 30 seconds. If the engine does not start, allow the starter motor to cool for two minutes before cranking again.

NOTE: If the engine will not start, or once started, continues to misfire or smoke, further priming is necessary. Repeat steps one through three. If operating problems persist after repeating steps one through three, further priming is necessary.

4. Open the vent valve (if equipped) on the fuel injection pump housing.

NOTICE

DO NOT remove the plug in the fuel filter base (for the fuel pressure sending unit [if equipped]) to purge air from the fuel system. Periodic removal of the plug will result in increased wear of the threads in the fuel filter base and lead to fuel leakage.

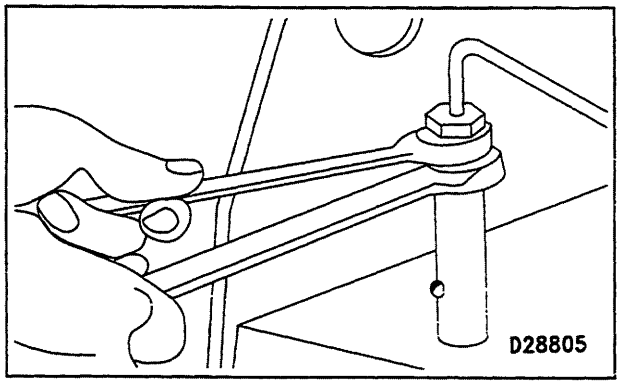
5. Operate the priming pump until the flow of fuel from the vent valve is continuous and free of air bubbles. If the engine does not have a fuel priming pump, crank the engine until the fuel flows free of air bubbles. Do not crank the engine for more than 30 seconds. Allow the starter to cool for two minutes before cranking again.

6. Close the vent valve. Push in and hand-tighten the plunger.

7. Crank the engine. If the engine starts, but runs rough, continue running the engine at low idle until the engine runs smoothly.

NOTE: If the engine will not start, or once started, continues to misfire or smoke, further priming is necessary.

8. Loosen the fuel line nuts, one at a time, at the fuel injection nozzle.



NOTICE

A fuel injection nozzle will be damaged if the top of the nozzle turns in the body. The engine will be damaged if a defective fuel injection nozzle is used because the fuel spray pattern that comes out of the nozzle will be incorrect. Fuel injection nozzles can be permanently damaged by twisting if only one wrench is used to loosen or tighten the fuel line nuts. Do NOT let the tops of the fuel nozzles turn when the fuel lines are loosened. Use one wrench to hold the nozzle and another to loosen the fuel line nut.

Loosen one fuel line nut. Operate the priming pump plunger until the flow of fuel from the fuel line is continuous and free of air bubbles. Push the plunger in and tighten by hand. If the engine does not have a fuel priming pump, crank the engine.

Tighten each fuel line nut before the next fuel line nut is loosened. Tighten the fuel line nuts to 40 ± 7 N•m (30 ± 5 lb ft). Continue the procedure until all of the fuel lines have been cleared of air. Make sure the fuel line nuts are tightened and the priming pump is locked before starting the engine.

Radiator Fins, Aftercooler,Belts, and Hoses

Inspect/Check Radiator Fins

Check the radiator fins for debris. High pressure water is an excellent way to clean the debris out of the radiator fins. If necessary, use a light bulb behind the radiator fins to see if they are completely clean.

Refer to Know Your Cooling System, SEBD0518, for more detailed information on cleaning your radiator fins.

Inspect/Check Aftercooler System

NOTICE

A hose failure or significant system leak will cause a large drop in boost pressure and power. The engine can be operated at this power level long enough to reach a safe stop or repair area. Sustained operation under this condition should be avoided.

Inspect the front of the air-to-air aftercooler. Examine core fins for external damage, insects, dirt, debris, salt, corrosion, etc. Use a firm stainless steel brush and soapy water to remove dirt, debris, salt, etc. Depending on your findings and operating environment, the maintenance interval for cleaning the air-to-air aftercooler may be more frequent.

A slight reduction in power or response, or a small increase in exhaust temperature, may indicate a small air leak in the charge air cooler core or piping. Inspect all air ducting and gasket connections at each oil change. Constant torque hose clamps should be secure. Tighten these clamps until the spring is at least partially compressed.

Inspect all welds for cracks. Check the mounting brackets to ensure they are secure and in good condition.

NOTE: Whenever air-to-air aftercooler parts are repaired and/or replaced, a leak test is highly recommended. Refer to the service manual or consult your Caterpillar dealer for the correct procedure to use when performing a leak test.

Inspect/Adjust Belts

Inspect the condition and adjustment of alternator belts and fan drive belts.

Inspect all drive belts for wear and replace if they show any signs of wear.

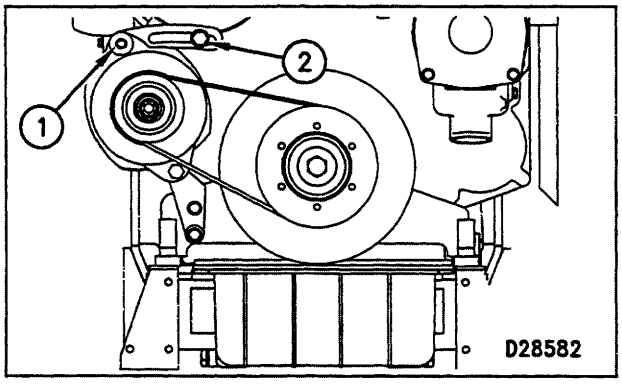
If one belt in a set requires replacement, always install a new matched set of belts. Never replace just the worn belt. If only the worn belt is replaced, the new belt will carry all the load, as it will not be stretched as much as the older belts. All the belts will fail in rapid succession.

If belts are too loose, they vibrate enough to cause unnecessary wear on the belts and pulleys. If belts are too tight, unnecessary stresses are placed upon the pulley bearings and belts which might shorten the life of both.

1. Inspect the condition and adjustment of alternator belts and fan drive belts.

2. To check the belt tension, apply 110 N (25 lbs) of force midway between the pulleys. Correctly adjusted belts will deflect 13 to 19 mm (½ to ¾ inch).

Adjust Alternator Belts



3. To adjust the alternator drive belts, loosen mounting nut (1) and adjusting bracket nut(s) (2).

4. Adjust the alternator in or out by either tightening or loosening adjusting nut(s) (2), as required, to obtain the correct adjustment.

5. Tighten nuts (1) and (2).

6. If new belts are installed, check belt adjustment again after 30 minutes of engine operation. Replace belts in matched sets only.

Adjust Fan Drive Belts

1. To adjust the fan drive belts, loosen mounting bolts and adjust with adjusting bolt.

2. Move the fan drive up or down as required to obtain the correct adjustment. Tighten mounting bolts.

3. If new belts are installed, check belt adjustment again after 30 minutes of engine operation.

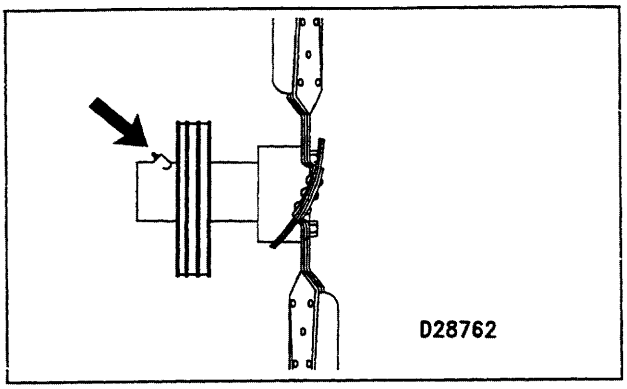
Inspect Hoses

Hose replacement prior to failure is a cost effective preventive maintenance practice. Replacing a hose before it fails saves you money and reduces the chances for unscheduled downtime. By replacing a hose that is cracked, soft, or leaking, you will avoid major repairs that could result in a severe engine overheating problem.
Inspect all hoses for leaks due to cracking, softness and loose clamps. Replace hoses that are cracked or soft and tighten loose clamps.

- Inspect all hoses for leaks due to cracking and softness. Inspect for loose clamps.
- Replace hoses that are cracked or soft and tighten loose clamps. Refer to the Replace Hoses topic in this publication.

Fan Drive Bearing

Lubricate Fitting



Lubricate one fitting.

Use Caterpillar Bearing Lubricant Special Purpose Grease, part number 2S3230, to service ball and roller bearings which operate at high speeds and temperatures. NLGI No. 2 Grade is acceptable for temperatures from −34 to 163°C (−20 to 325°F).

Inspect the fan drive pulley assembly. It should be difficult to detect movement of the shaft in the bearing. The bearing end play should be 0.03 to 0.23 mm (.001 to .009 inch). The radial play should be no greater than 0.13 mm (.005 inch).

If the shaft is loose, an inspection of the internal components should be made. If the assembly should require disassembly, refer to the Special Instruction, SMHS7001 or the Service Manual for the procedure.

Batteries

Clean/Check Electrolyte Level (if required)

BATTERY ELECTROLYTE CHART	
Battery	**Interval**
Conventional	100 Hour
Low Maintenance	250 Hours
Maintenance Free	None Required

1. Remove fill caps. Maintain electrolyte level to bottom on fill plug openings

If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

At proper charging rate, batteries should not require more than 30 cc (1 oz) water per cell per week.

2. Keep batteries clean.

3. Loosen and remove cable clamps from all battery terminals.

4. Clean all battery terminals.

5. Clean all cable clamps.

6. Install and tighten cable clamps to battery terminals.

7. Coat cable clamps and terminals with 5N5561 Silicone Lubricant, petroleum jelly or MPGM grease.

Check Battery Charger (if equipped)

- Check the battery charger for proper operation. If batteries are properly charged, ammeter reading should be very near zero. All batteries should be kept charged to a corrected specific gravity of 1.250 or above.

- The batteries should be kept warm, if possible. The battery temperature affects the cranking power. If the battery is too cold, it will not crank the engine, even if the engine is warm.

- When the engine is not run for long periods of time or is run for short periods, the batteries may not fully recharge. Ensure a full charge to help prevent the battery from freezing.

Battery or Battery Cable Replacement

NOTE: When replacing batteries or battery cables, use the following procedure.

1. Turn off the START switch or the ECS switch to the OFF/RESET position. Turn off (open) the ignition switch (if equipped) and remove the key and all electrical loads.

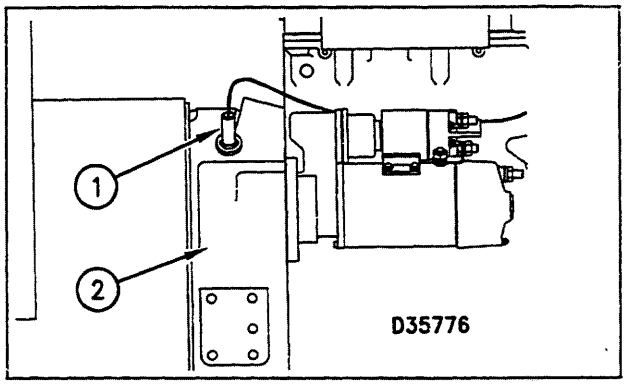
2. Disconnect the cable from ground (one cable connects to frame and one to battery negative). Be sure the cable cannot contact where it was just removed.

3. Disconnect the negative battery cable terminal at the battery(s) that goes to the control panel switch. Where four 12 volt batteries are involved, the negative side of two batteries must be disconnected.

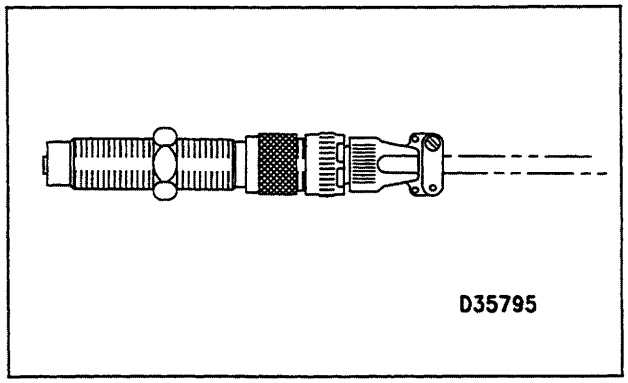
4. Proceed with necessary system repairs. Reverse steps to reconnect all cables.

Magnetic Pickup

Inspect/Clean



1. Remove the magnetic pickup (1) from the flywheel housing (2) and check the magnet condition.



Magnetic Pickup

2. Clean the metal shavings and other debris from the face of the magnet.

3. Install the magnetic pickup into the flywheel housing by turning pickup clockwise (CW) until the magnet comes in contact with the flywheel ring gear tooth.

4. Back out the pickup thread counterclockwise (CCW) ½ of a turn (180 ± 15 degrees) to maintain a clearance between the magnetic pickup and the flywheel ring gear tooth. Tighten the locknut 45 ± 7 N•m (33 ± 5 lb ft).

For additional information on the magnetic pickup(s) for your engine, refer to the Service Manual.

Every 500 Hours (NA Only)*

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

This maintenance interval applies to Naturally Aspirated (NA) Engines only. For information regarding all topics in this section, refer to the Every 250 Hour maintenance interval.

*Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Scheduled Oil Sampling (S•O•S) Analysis

Obtain Sample

Refer to the Scheduled Oil Sampling topic in the Every 250 Hour maintenance interval in this publication.

Engine Oil and Filter(s)

Replace

Refer to the Engine Oil and Filters topic in the Every 250 Hour maintenance interval in this publication.

Crankcase Breather

Clean

Refer to the Crankcase Breather topic in the Every 250 Hour maintenance interval in this publication.

Engine Valve Lash (First Oil Change Only)

Check/Adjust

Refer to the Engine Valve Lash topic in the Every 250 Hour maintenance interval in this publication.

Every 1000 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Before proceeding with Every 1000 Hour maintenance, perform all previous maintenance interval requirements.

Engine Protection Devices

Inspect for Proper Operation

Refer to the Service Manual for the procedure. All engine protective devices must be checked and maintained to provide the engine with proper protection if a component malfunction or failure should occur. Check all engine protective devices.

NOTE: Never use the Emergency Shutdown controls for a normal stopping procedure.

SR4 Generator and Control Panel (If Equipped)

SR4 Generator

⚠ WARNING

Before working inside the generator, make sure that the starting motor can not be activated by any automatic or manual signal.

When the engine-generator is operating, voltages up to 600V are present in these areas near or on the regulator:

1. the regulator terminal strip
2. the excitation transformer terminal strip (self-excited generator only)

Do not short these terminals to ground with any part of the body or any conductive material. Loss of life or injury could result from electrical shock or injury from molten metal.

NOTICE
Electronic components in the regulator can be damaged during generator operation if contact is made between the part and ground.

Clean/Inspect Voltage Regulator

If moisture is allowed to remain in contact with an electrical winding, some of the moisture will eventually be absorbed. This will lower the resistance of the winding insulation. The insulation used on the windings of Caterpillar generators is moisture resistant, but constant exposure to moisture will gradually lower the insulation's resistance.

Dirt can make the problem worse because it can hold the moisture in contact with the insulation. Salt (from coastal location sea air) can also make the problem much worse. This is because salt tends to absorb moisture from the air. When the salt and moisture combine, they make a good electrical conductor.

- Clean the voltage regulator and generator of dirt and debris. Use a brush to loosen accumulations of dirt and a vacuum system for removal. Use of compressed air is not recommended, because of moisture present in the form of condensate.

Carbon tracking on insulators can be caused by dirt or loose connections. These carbon paths must be cleaned or the insulators replaced. Failure to correct a carbon tracking problem will eventually result in a short in the electrical circuit.

- Visually check for loose or broken wires and connections. Check the wires and connections on the regulator assembly. Check all wires and connections in the generator. Make any necessary repairs to the wiring as required.

Visually inspect the generator and control panel. Check for loose, broken, or damaged wiring or components. The inspection only takes a few minutes and could avert a potential problem that could cause your generator set to fail.

Operational Checks

Start the engine. Use the starting procedure found in the SR4 Generators and Control Panels Operation and Maintenance Manual, SEBU6150.

The following operational checks include:

- generator operation and engine starting
- lubricating and fuel systems
- overall operation

The checks should take no longer than five minutes to complete. A more thorough Performance Analysis should be performed every 3000 hours with the engine operating under load.

While operating, frequently observe all readings, especially the engine oil pressure and the water temperature.

Check and Record Readings from Frequency (rpm) and Generated Voltage

NOTE: The operating voltage of a cold (just started) generator will be slightly higher than the operating voltage of a generator that has been under load and warm. The full load voltage of an SR4 Generator will decrease a maximum of one percent when this generator temperature stabilizes at 100°C (212°F).

Most of the voltage decrease occurs in about 30 minutes. Generally, voltages stabilize within two hours.

Recommended Periodic Insulation Resistance Checks

Use a megohmmeter to check generator winding insulation resistance periodically. The frequency of the megohmmeter test is determined by the generator's environment and by previous megohmmeter test indications.

The megohmmeter test is described in Service Manual for SR4 Generators, SENR3985 or Special Instruction, SEHS9124, Cleaning and Drying of Caterpillar Electric Set Generators, or contact your Caterpillar dealer.

Your Caterpillar dealer has the trained personnel and equipment to provide this service for you.

The shutoff controls must be checked so that they function properly when they are required. To prevent damage to the engine while performing the test, only authorized personnel or your Caterpillar dealer should perform the checks.

Control Panel

Check Gauges

Check the condition of all readings on the Control Panel. Check the condition of all gauges. Repair or replace any broken gauge before it becomes a problem.

- Water Temperature - Check for proper operating coolant temperature. It should normally indicate between 79°C (175°F) and 98°C (208°F). Maximum allowable temperature is 99°C (210°F) with the cooling system pressurized. Somewhat higher temperatures may occur under certain conditions.

- Oil Pressure - Check for proper operating oil pressure. The pressure will be greatest after starting a cold engine. Oil pressure will decrease as the engine warms while idling. As the engine speed is increased to full load speed, oil pressure will increase and stabilize. Minimum oil pressure is 240 kPa (35 psi) at rated speed.

NOTE: If oil pressure fails to rise within 15 seconds after the engine starts, stop the engine and make necessary repairs.

- Fuel Pressure - Check for proper operating fuel pressure. Minimum fuel pressure is 140 kPa (20 psi) at rated speed.

While operating, frequently observe all readings, especially the engine oil pressure and the water temperature.

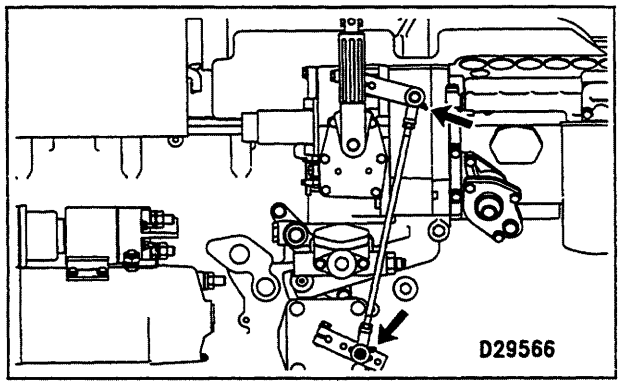
Automatic Operation

Check that all switches are in proper position for automatic start. Refer to the Engine Protection Devices section of this publication for additional information.

Fuel Control Linkage

Check/Lubricate Linkages

Check and adjust if necessary, all fuel control linkages. Refer to the Service Manual for check/adjust procedure.



Fuel Control Linkage Grease Fittings

Lubricate the grease fittings on the fuel control linkage. Caterpillar recommends Multipurpose Lithium Grease, part no. 1P0808, suitable for light duty applications where a high temperature up to 175°C (350°F) is required.

Every 2000 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Engine Valve Lash, Valve Rotators, Fuel Ratio Control, Set Point, and Low Idle

Check/Adjust

⚠ WARNING

Be sure the engine cannot be started while this maintenance is being performed. To prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

Operation of Caterpillar engines with improper valve adjustments will reduce engine efficiency. This reduced efficiency could result in excessive fuel usage and/or shortened engine component life.

To prevent possible injury, do not use the starter motor to turn the flywheel.

⚠ WARNING

When inspecting the valve rotators, protective glasses or face shield and protective clothing must be worn, to prevent being burned by hot oil or spray.

NOTICE

If a damaged rotator is not replaced, valve face guttering could result in pieces of the valve to fall into the cylinder. This can cause piston and cylinder head damage.

Measure the valve lash with the engine stopped. To obtain an accurate measurement, allow at least 20 minutes for the valves to cool to engine cylinder head and block temperature.

For the complete engine valve lash, fuel ratio control, set point, and low idle check/adjust procedures, refer to the Service Manual or contact your Caterpillar dealer.

Fuel Injection Nozzles

Test/Clean/Replace

NOTICE
The engine will be damaged if a defective fuel injection nozzle is used because of the shape of fuel (spray pattern) that comes out of the nozzles will not be correct.

Fuel injection nozzles are subject to tip wear as a result of fuel contamination. This damage can cause an increase in fuel consumption, the engine to emit black smoke, misfire or run rough. Inspect, test and replace if necessary.

Whenever the engine performs in such a manner that a fuel injection nozzle is suspected of causing irregular running, smoking or knocking, each fuel injection nozzle must be isolated, one at a time, to determine the malfunctioning nozzle. Special tooling is required to remove fuel injection nozzles.

NOTE: Refer to the Service Manual or contact your Caterpillar dealer for fuel injection nozzle testing and cleaning procedures.

Turbocharger

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side) and the aftercooler core. Since the crankcase fumes are ingested through the inlet air system, oil and combustion by-products may collect in these two areas.

This buildup, over time, can contribute to loss of engine power, increased black smoke, and overall loss of engine efficiency. This buildup is only a possible contributor to these conditions.

Operating the engine until the turbocharger fails can severely damage the turbocharger's compressor wheel and/or the engine. Damage to the turbocharger compressor wheel could allow parts from the compressor wheel to enter the engine cylinder, causing additional damage to the piston, valve, and cylinder head.

NOTICE
Turbocharger bearing failures can cause large quantities of oil to enter the air intake and exhaust systems. Loss of engine lubricant can result in serious engine damage.
When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine speed up at no load), DO NOT continue engine operation until the turbocharger is repaired or replaced.

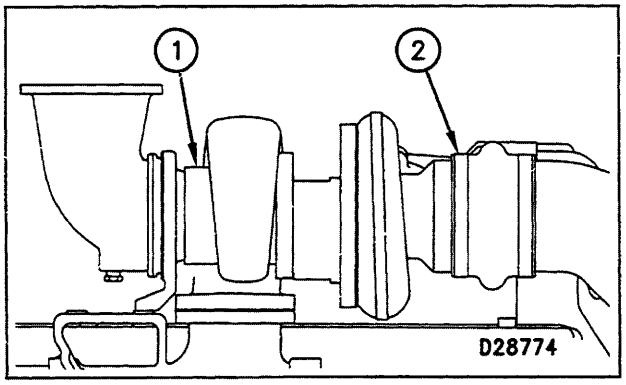
Minor leakage of a turbocharger housing under extended low idle operation will not cause problems as long as no turbocharger bearing failure occurred.

Inspect for Proper Operation

Turbocharger components require precision clearances and balancing due to operation at high rotational speeds. Severe Service Applications can accelerate component wear and may suggest the need to Inspect/Repair/Replace the cartridge at reduced intervals to ensure maximum reliability and retention of full core value.

The following conditions can indicate severe service operation.

- Frequent high altitude operation above 5,000 ft (1525 m).
- Arctic operation (regular cold starts at temperatures below 0°C [32°F]).
- Extending lubrication and intake air system maintenance intervals.



1. Remove the exhaust outlet piping (1) and inlet piping (2) from the turbocharger. Visually check for oil leaks.

2. Turn the compressor wheel and turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and turbine wheel for contact with the turbocharger housing. There should NOT be any visible signs of contact between the turbine or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating wheel(s) and the housing, the turbocharger should be reconditioned or replaced.

3. Use a dial indicator to check end clearance on the shaft. Attach the dial indicator point on the end of turbocharger shaft. Push and pull the other end of the shaft. Note the total dial indicator reading. If the measured end play is greater than the Service Manual specifications, repair or replace the turbocharger. Measured end play less than the minimum Service Manual specifications could indicate carbon build up on the turbine wheel. The turbocharger should be disassembled for cleaning and inspection if the measured end play is less than the minimum Service Manual specifications.

4. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system properly. If oil is found only on the back side of the wheel, an oil seal leak is indicated. The leak may be the result of extended engine operation at low idle, or an intake air line restriction (plugged air filter).

5. Inspect the turbine housing bore for corrosion.

6. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.

7. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing. Refer to the Torque Specification section in this manual for correct fastener torques.

Severe Service Operation

Turbocharger components require precision clearances and balancing due to operation at high rotation speeds. Severe Service Applications can accelerate component wear. Engines operating under severe conditions may need more frequent Inspect/Repair/Replace the cartridge intervals to ensure maximum reliability and retention of full core value.

The following conditions can indicate severe service operation:

- Extended operation at low idle.
- Extending lube and air system maintenance intervals.
- Frequent hot shutdowns (minimum cool down periods after high load factor operation).

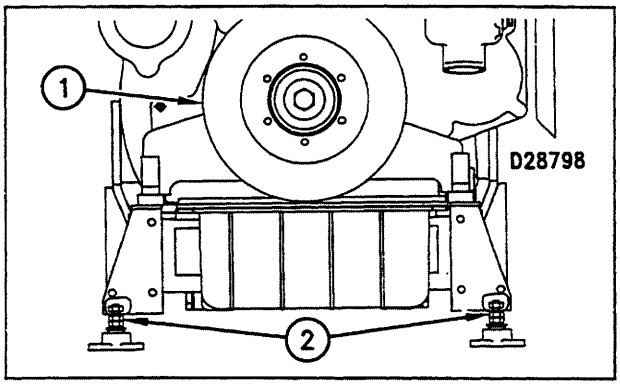
Removal and Installation

For removal and installation, or repair/replacement options of turbochargers, see your Caterpillar dealer.

Refer to the Service Manual for this engine or consult your Caterpillar dealer for the procedure and specifications.

Engine Mounts

Inspect



Crankshaft Vibration Damper (1) and Engine Mounts (2).

Caterpillar recommends checking the engine mounts for deterioration and proper bolt torque. This will prevent excessive engine vibration caused from improper mounting. See your Service Manual or Caterpillar dealer for recommended torque values.

Crankshaft Vibration Damper

Inspect

Damage to, or failure of, the damper will increase torsional vibrations and result in damage to the crankshaft and other engine components. A deteriorating vibration damper will cause excessive gear train noise at variable points in the speed range.

The vibration damper can have a visual wobble (movement to the front and rear when in rotation) on the outer ring. This does not mean a replacement is necessary since some wobble of the outer ring is normal.

If your engine is equipped with a rubber damper, inspect the damper for:

- rubber deterioration, cracking.
- movement of the rubber from the original location.

Visconic Damper

Your engine may be equipped with a visconic damper. The visconic damper has a weight, located inside a fluid filled case. The weight moves in the case to limit torsional vibration. Inspect the dampers for evidence of dents, cracks or leaks of the fluid.

NOTE: To see if the amount of wobble is acceptable, or replacement is necessary, check the damper with the procedure in the Testing and Adjusting section of the Service Manual.

SR4 Generator (If Equipped)

Lubricate Bearings

For all information regarding lubrication and maintenance of SR4 Generators supplied by Caterpillar, refer to the SR4 Generator and Control Panel Operation and Maintenance Manual, SEBU6150. If further assistance is required, contact your Caterpillar dealer.

Note: Some engines equipped with generators may be equipped with a sealed prelubed bearing. These generator set bearings will not require lubrication every 2000 service hours.

- Lubricate small frame generators with a hand held grease gun using two pumps of grease.
- Wipe fittings of excess grease. Start the engine and run at low idle. Engage driven equipment and allow the grease to expand.

Use Special Purpose Grease (SPG) 2S3230. NLGI No. 2 Grade is suitable for most temperatures. Use NLGI No. 1 or 0 Grade for extremely low temperatures.

Perform the SR4 Generator bearings lubrication instructions as per SEBU6150, SR4 Generators and Control Panels Operation and Maintenance Manual.

Every 3000 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Before proceeding with this maintenance, perform all previous maintenance requirements.

Cooling System

NOTICE
Do not perform this maintenance until you read and understand the material in the Safety and Cooling System Specifications sections of this publication.

Add Extender (Long Life Coolant/Antifreeze Only)

Caterpillar Long Life Coolant/Antifreeze (LLCA) does not require the frequent Supplemental Coolant Additive (SCA) additions associated with the present conventional coolants. Only a "one time" coolant Extender is required.

Extender should be added to LLCA after 3,000 service hours or two years, whichever comes first. The cooling system should be treated with .95 L (1 qt) of Extender for every 46 L (12 US gal) of cooling system capacity. A 15 percent over or under treatment will not create any cooling system problems.

For more Extender information, refer to the Cooling System Specifications LLCA Extender topic in this manual.

Drain/Clean/Replace Coolant (Conventional Antifreeze Only)

NOTICE
Do not perform this maintenance until you read and understand the material in the Safety and Cooling System Specifications sections of this publication.

Clean/Flush the cooling system before the recommended maintenance interval if:

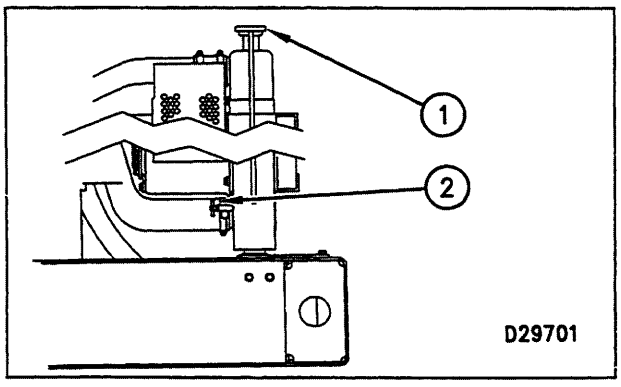
- Coolant is heavily contaminated.
- The engine overheats frequently.
- Foaming is observed in the radiator.
- The oil cooler has failed, allowing oil to contaminate the coolant.
- Fuel has entered the cooling system and contaminated the coolant.
- Commercial cooling system products other than Caterpillar products are used.

NOTICE
When using commercial antifreeze/coolant products from a manufacturer other than Caterpillar, drain, clean, and refill the cooling system every year or 1,500 service hours, whichever comes first.

Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

NOTE: A good time to inspect the water pump, replace the thermostat, and replace hoses is when your engine's cooling system has been drained.

Drain



Filler Cap (1), Drain Valve (2).

1. Stop the engine and allow the engine to cool. Loosen the coolant filler cap slowly to relieve any pressure, and remove the cap.

2. Remove the cooling system drain plug(s) or open the drain valve. Remove the drain plug from the bottom of the water pump housing (if equipped) and/or radiator. Allow the coolant to drain.

NOTICE

Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding disposal and recycling of used coolant:

Contact Caterpillar Service Technology Group:
Outside Illinois: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL

Clean

3. Flush the cooling system with clean water to remove any debris.

4. Clean and install all drain plugs and/or close the drain valve(s).

NOTICE

Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

5. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of Cleaner per 15 L (4 US gal) of cooling system capacity. Install the radiator filler cap.

6. Start and run the engine for a minimum of 30 minutes with the coolant temperature at 82°C (180°F). Stop the engine and allow the engine to cool.

7. Loosen the filler cap slowly to relieve any pressure, and remove the cap. Remove the cooling system drain plug(s) or open the drain valve(s). Allow the cleaning solution to drain. Flush the cooling system with clean water until the draining water is clear. Clean and install all drain plugs and/or close the drain valve(s).

Fill

Refer to the Cooling System Specifications for all information regarding acceptable water, coolant/antifreeze, and supplemental coolant additive requirements. Refer to the Refill Capacities chart in this publication for the capacity of your engine's system.

8. Fill the system with the recommended coolant/antifreeze mixture.

9. Start and run the engine with the filler cap removed. Allow the coolant to warm, the thermostat to open and the coolant level to stabilize. Check the coolant level. Add coolant mixture if necessary to bring the coolant to within 13 mm (½ in) below the bottom of the fill tube or the correct level on the sight glass (if equipped).

10. Check the condition of the filler cap gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a 9S8140 Service Tool (available from your Caterpillar dealer) to pressure test the filler cap. The correct filler cap pressure is stamped on the face of the filler cap. If the filler cap does not hold the correct pressure, install a new filler cap.

11. Start the engine and inspect for coolant leaks and proper operating temperature. Check for coolant leaks at the oil cooler connections. Stop the engine.

Cooling Systems with Heavy Deposits or Plugging

NOTE: For the following procedure to be effective, there must be some active flow through the radiator and the other cooling system components.

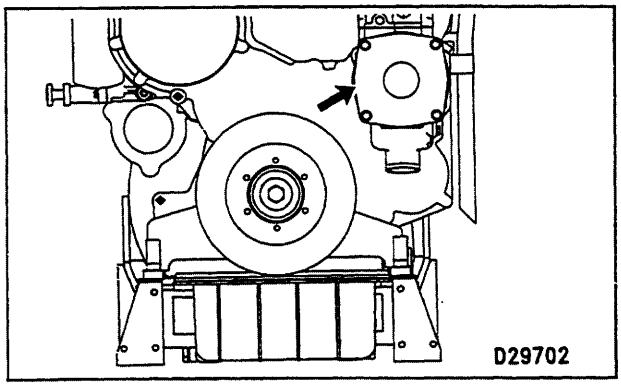
Follow the same steps as outlined above, with the following modifications to steps 5 and 6:

5. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pt) of Cleaner per 3.8 to 7.6 L (1 to 2 US gal) of cooling system capacity. Install the radiator filler cap.

6. Start and run the engine for a minimum of 90 minutes with the coolant temperature at 82°C (180°F). Stop the engine and allow the engine to cool.

Water Pump Seal

Inspect/Replace



Water Pump

Over concentration of coolant additive (Conditioner), mineral deposits from hard water or cooling system contamination can accelerate the wear on the water pump coolant seal. The cooling system maintenance interval provides an opportunity to inspect and replace the water pump seal if necessary to reduce coolant leakage.

Check the water pump breather filter for blockage or debris. Replace the filter if necessary. Refer to the Service Manual for the complete water pump inspection procedure.

Replace Hoses

Hose replacement prior to failure is a good preventive maintenance practice. Replacing a hose before it fails reduces the chances for unscheduled downtime. By replacing a hose that is cracked, soft or leaking, you will avoid major repairs that could result in a severe engine overheating problem.

1. Loosen the radiator filler cap slowly to relieve any pressure and remove the cap. Drain the coolant from the cooling system to a level below the hose being replaced.

2. Remove the hose clamps, disconnect the old hose. Install the new hose.

3. Install the hose clamps. See the Torque Specifications section of this publication for the appropriate torque.

4. Refill the cooling system with the recommended coolant/antifreeze mixture.

NOTE: Fill the cooling system with the coolant solution at 19 L (5 US gal) or less per minute to avoid air locks. See the Refill Capacities chart in this publication for the capacity of your cooling system.

5. Start and run the engine with the filler cap removed. Allow the coolant to warm, the thermostat to open and the coolant level to stabilize. Inspect for leaks and proper operating temperature. Check for coolant leaks at the oil cooler connections.

6. Check the coolant level. Add coolant mixture if necessary to bring the coolant to within 13 mm (½ inch) below the bottom of the fill tube, or the correct level on the sight glass (if equipped).

7. Check the condition of the filler cap gasket before installing the cap. If the gasket is damaged, discard the old filler cap and install a new filler cap.

Replace Thermostat

Replacing your thermostat prior to failure is a recommended preventive maintenance practice because it reduces the chances for unscheduled downtime.

NOTICE
Failure to replace your thermostat on a regularly scheduled basis could cause severe engine damage.

NOTICE
Caterpillar engines incorporate a shunt design cooling system and require operating the engine with a thermostat installed.

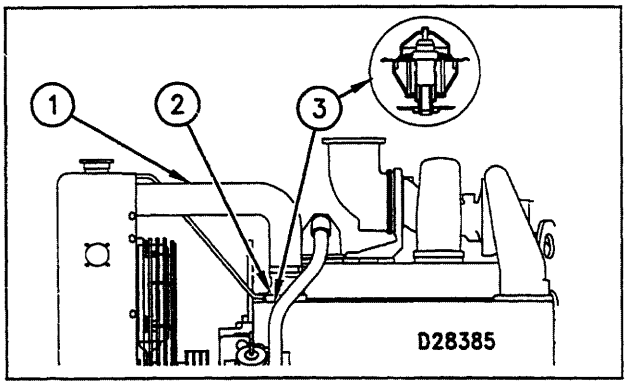
Depending on load, a thermostat that fails in a partially opened position will cause either an overheating or an over cooling condition.

If the thermostat fails in the closed position, it will cause excessive overheating. Excessive overheating could result in cylinder head cracking or piston seizure problems.

If the thermostat fails in the open position, it will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon build-up inside the cylinder. This excessive carbon build-up could result in accelerated ring and liner wear.

NOTE: Refer to the Service Manual for fully open and closed thermostat temperature ratings.

NOTE: If replacing thermostats ONLY, drain the coolant from the cooling system to a level below the thermostat housing.



1. Disconnect the hose assembly (1) from radiator inlet tube to engine water outlet pipe (2).

2. Remove the engine water outlet pipe (2) from the cylinder head.

3. Remove the thermostat (3) and gasket.

NOTE: DO NOT use liquid gasket material on the gasket or cylinder head surface.

NOTICE
If the thermostat is installed wrong, the engine may overheat, causing cylinder head damage. Ensure that the new thermostat is installed in the original position. Ensure that the thermostat vent hole is open.

4. Install a new thermostat and gasket in position on the cylinder head.

5. Install engine water outlet pipe (2) on the cylinder head. Connect the radiator inlet tube with the hose assembly (1).

Refer to the Cooling System Specifications in this publication for all information regarding acceptable water, antifreeze and supplemental coolant additive requirements, or contact your Caterpillar dealer for assistance.

6. Add the proper coolant/antifreeze mixture to the cooling system. Bring the coolant to within 13 mm (½ inch) below the bottom of the fill tube, or the correct level on the sight glass (if equipped).

NOTE: Fill the cooling system with the coolant solution at 19 L (5 US gal) or less per minute to avoid air locks. See the Refill Capacities chart in this publication for the capacity of your cooling system.

NOTICE
To prevent engine damage, never add coolant to an overheated engine. Allow the engine to cool first.

7. Start and run the engine with the filler cap removed. Allow the coolant to warm, the thermostat to open and the coolant level to stabilize. Inspect for leaks and proper operating temperature.

8. Check the coolant level. If the coolant level is low, add coolant the proper coolant mixture.

9. Check the condition of the filler cap gasket. If the gasket is damaged, discard the old cap and install a new cap.

Every 4000 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Magnetic Pickup

Inspect/Clean

Refer to the Magnetic Pickup topic in the Every 250 Hours interval in this manual.

SR4 Generator (If Equipped)

Inspect/Clean/Check/Lubricate

- Inspect and clean the voltage regulator. Refer to the SR4 topic in the Daily and Every 1000 Hours intervals in this manual.
- Check generator winding insulation resistance. Refer to the SR4 topic in the Every 1000 Hours interval in this manual.
- Lubricate generator components (if necessary). Perform the SR4 Generator bearings lubrication instructions as per SEBU6150, SR4 Generators and Control Panels Operation and Maintenance Manual.
- Check generator space heaters for proper operation. Refer to the Generator Space Heater topic in the Every 125 Hours interval in this manual.

Every 6,000 Hours

You must read and understand the warnings and instructions contained in the Safety section of this manual, before performing any operation or maintenance procedures.

Before proceeding with this maintenance, perform all previous maintenance interval requirements.

Cooling System

NOTICE
Do not perform this maintenance until you read and understand the material in the Safety and Cooling System Specifications sections of this publication.

Drain/Flush/Replace Coolant (Long Life Coolant/Antifreeze Only)

Caterpillar Long Life Coolant/Antifreeze should be replaced every 6,000 Service Hours or 4 Years, whichever comes first. Only clean water is needed to clean and flush the cooling system when LLCA is drained and replaced.

Drain

1. Stop the engine and allow the engine to cool. Loosen the coolant filler cap slowly to relieve any pressure, and remove the cap.

2. Remove the cooling system drain plug(s) or open the drain valve. Remove the drain plug from the bottom of the water pump housing (if equipped) and/or radiator. Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant. Contact your Caterpillar dealer for information regarding disposal and recycling of used coolant.

For information regarding disposal and recycling of used coolant:

Contact Caterpillar Service Technology Group:
Outside Illinois: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL

Flush

4. Flush the cooling system with clean water to remove any debris.

5. Clean and install all drain plugs and/or close the drain valve(s).

6. Fill the cooling system with clean water. Install the filler cap. Operate the engine until warm 49 to 66°C (150 to 120°F).

7. Stop the engine and allow the engine to cool. Loosen the coolant filler cap slowly to relieve any pressure, and remove the cap. Remove the cooling system drain plug(s) or open the drain valve. Allow the water to drain. Flush the cooling system with clean water.

8. Repeat steps 6 and 7.

Fill

9. Fill the cooling system with LLCA. Refer to the refill capacities chart in this manual for the amount of LLCA needed to refill your system.

10. Start and run the engine with the filler cap removed. Allow the LLCA to warm, the thermostat to open, and the coolant level to stabilize. Add LLCA if necessary to bring the coolant to the proper level.

11. Check the condition of the filler cap gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a 9S8140 Service Tool (available from your Caterpillar dealer) to pressure test the filler cap. The correct filler cap pressure is stamped on the face of the filler cap. If the filler cap does not hold the correct pressure, install a new filler cap.

12. Start the engine and inspect for coolant leaks and proper operating temperature. Stop the engine.

Standby Generator Preventive Maintenance Recommendations

Introduction

The objective of this topic is to assist users in establishing a Preventive Maintenance Program for Standby Generator Sets or as an aid in evaluating their present programs.

Standby Generator Sets may not be needed very often, but when they are, it is usually under emergency conditions. Maintenance of these standby units is very important. They must always be in excellent operating condition, ready to work under load at any time.

Establishing a Preventive Maintenance Program will provide maximum availability of a standby generator set when needed, longer engine and generator life, and a minimum of expensive repairs.

The recommended WEEKLY maintenance checks can be performed by an operator. The checks consist of basic maintenance requirements to ensure the standby generator set will be ready for immediate use should the need arise.

All YEARLY and THREE YEAR maintenance should be performed by an authorized mechanic or your Caterpillar dealer. These checks and maintenance requirements will require that the standby generator be run under load conditions, and may require special test equipment.

These guidelines are to be used with the information contained in the Operation and Maintenance sections of this manual. The Operation and Maintenance sections of the manual will provide the necessary information on how to perform the checks and routine maintenance.

Refer to the Generator and Engine Service Manuals and Recommended Preventive Maintenance Schedules for Standby Generator Sets, SEBU6042 for additional information, or contact your Caterpillar dealer for assistance.

Inspection and Maintenance Agreements

Your Caterpillar dealer can establish an Inspection and Preventive Maintenance Program for your generator set to provide maximum reliability, increased engine and generator life, and minimize expensive repairs. Contact your Caterpillar dealer for details.

General Recommendations

Safety

⚠ WARNING

The stop-manual-automatic switch on the cranking panel must be set at STOP position when performing maintenance or repair work on a standby generator set. This prevents the unit from starting if a power failure or voltage drop should occur while working on the unit.

To prevent personal injury due to accidental starting of the engine, disconnect the batteries or disable the starting system before doing maintenance or repair work.

Lock out all switch gear and automatic transfer switches associated with the generator while performing any generator maintenance or repairs. Make sure no shock hazard exists.

Failure to comply could result in personal injury or death.

Always make repairs with the engine stopped and the starting system disabled. When servicing the generator, make sure that switch gear and automatic transfer switches will not present a shock hazard. Lock them out on the generator being serviced.

Record Keeping

Maintain a log or record keeping system to document all gauge readings, problems, repairs, and maintenance performed on the equipment.

Space Heaters

Moisture is a natural enemy of generators and all electrical equipment. Every effort must be made to keep the generator as dry as possible. Space heaters should be operated inside the generator when it is not in use to maintain the integrity of the generator windings.

Maintenance Schedule for Standby Generator Set Engines

NOTE: Refer to the topics in the Operation & Maintenance Manual, SEBU6150, SR4 Generators and Control Panels, and the Maintenance Schedules in this manual for page numbers and information to perform the maintenance specified in the following schedules.

Weekly (Before Starting Engine)
Walk-Around Inspection – Inspect engine for leaks and loose connections
Engine Crankcase – Check oil level
Cooling System – Check coolant level
Battery Charger – Check for proper operation
Batteries – Clean/Check electrolyte level
Air Starter System (if equipped) – Check lubricator oil level, air pressure and drain condensation
Engine Air Cleaner – Check service indicator
Block Heater – Check for proper operation, maintain 32°C (90°F) temperature
Aftercooler – Inspect ATAAC
Belts – Inspect/Replace
Engine Protection Devices – Inspect system and gauges for proper operation
Generator and Control Panel – Inspect components

Weekly (With Engine Running)*
Walk-Around Inspection – Inspect engine for leaks and loose connections and generator louvers for proper operation
Engine Crankcase – Check oil level
Oil Pressure – Check gauge reading
Generator – Check frequency (rpm) and generated voltage

Weekly (After Stopping Engine)*
Walk-Around Inspection – Inspect engine and report malfunction and make necessary repairs
Automatic Switches – Check for proper position to execute auto-start
Battery Charger – Record charging amperage reading

Yearly (Before Starting Engine)*
Cooling System – Check coolant level, Test for concentration of supplemental coolant additive
Crankcase Breather – Clean
Valve Lash – Check/Adjust
Governor – Inspect for leaks
Governor Linkage – Check/Adjust and Lubricate
Air Inlet Piping – Inspect
Engine Air Cleaner – Check service indicator, Replace element if necessary
Generator – Lubricate bearing

Yearly (With Engine Running)*
Engine Protection Devices – Inspect system and gauges for proper operation;/bs/, Record gauge readings
Radiator (If Equipped) – Inspect for leaks and loose connections and louvers for proper operation
Load Test – Operate the engine at a minimum of 30% of rated load for minimum of two hours
Engine Mounts – Inspect

Yearly (After Stopping Engine)*
Scheduled Oil Sampling (S•O•S) Analysis – Obtain
Engine Oil and Filters – Replace

Every Three Years (Before Starting Engine)*
Turbocharger – Inspect/Check bearing end play and radial clearance
Governor – Inspect for leaks
Thermostat – Replace
Coolant Hoses – Replace
Cooling System – Clean/Flush coolant
Batteries – Replace

Every Three Years (With Engine Running)*
Walk-Around Inspection – Inspect engine for leaks and loose connections
Engine Protection Devices – Inspect system and gauges for proper operation, Record gauge readings
Engine Crankcase – Check oil level
Radiator (If Equipped) – Inspect for leaks and loose connections and louvers for proper operation
Load Test – Operate at a minimum of 30% of rated load for minimum of two hours
Exhaust System – Check for leaks

Every Three Years (After Stopping Engine)*
Walk-Around Inspection – Inspect engine and report malfunction and make necessary repairs
Scheduled Oil Sampling (S•O•S) Analysis – Obtain
Engine Oil and Filters – Replace
Battery Charger – Record charging amp reading
Automatic Switches – Check for proper position to execute auto-start
Coolant Analysis – Obtain

Every Four Years – Drain/Replace Engine Coolant (Long Life Coolant/Antifreeze Only)

*First Perform Previous Maintenance Items

Troubleshooting

Troubleshooting a failure on an engine can be a difficult procedure. For a troubleshooting manual, see the Service Manual for your engine. All repairs should be made by a properly trained mechanic. Your Caterpillar dealer has the personnel and special tools needed to troubleshoot and make repairs to your engine.

See the Service Manual for a troubleshooting manual. The list of problems, causes and corrections given in the Service Manual, will only give an indication of where a possible problem can be, and what repairs may be needed.

Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts.

The Service Manual can not give all possible problems and corrections. The serviceman must find the problem and its source, then make the necessary repairs.

Your Caterpillar dealer is equipped with the necessary tools and personnel to provide assistance when necessary.

Performance Analysis

Obtain at Every 3000 Hour Interval

Approximately 85 percent of your engine's operation and maintenance cost is the cost of the fuel. Therefore, substantial cost reductions can be achieved by keeping your engine operating at peak efficiency. The fuel economy and performance of the engine is affected by the application and specifications, how it is operated and the condition of the engine. Each plays an important part in minimizing your overall owning and operating cost.

Caterpillar recommends a regularly scheduled analysis to monitor the condition and maintenance requirements of your engine and to ensure your engine is operating at peak efficiency.

Potential problems can be identified early, thus preventing unnecessary repair costs and unscheduled downtime. Consult your Caterpillar dealer for complete information and assistance in conducting a performance analysis of your engine.

Tests normally conducted by your Caterpillar dealer can:

- confirm your engine is operating efficiently and within specification.
- identify potential problems.
- determine components or systems that should be adjusted, replaced, etc.

Fuel rate and boost are the primary indicators of your engine's performance and the analysis of this data will help pinpoint potential problems faster.

Regular performance testing of your engine can be cost effective to help lower fuel costs and lower costs associated with maintenance, repairs and overhauls.

Value Planned Repair (Repair Before Failure)

Until recently, engine maintenance and repair management involved changing the oil when it was convenient and repairing the engine when it was damaged. This seemed to be the accepted way of managing a maintenance operation.

However, due to a variety of circumstances, increasing competition have caused users to look for ways to prolong equipment life and lower operating costs so that they could be competitive.

To assist Caterpillar engine users in prolonging engine life and reducing operating costs, the Value Planned Repair approach to engine maintenance was developed.

The Value Planned Repair approach can be tailored for any engine. This approach, when properly structured, outlines every maintenance and repair service required to support an engine from the day it enters service until the day it is retired.

To ensure the repair is performed efficiently and expediently, the Value Planned Repair concept approaches a given repair in three basic steps:

1. Repair determination
2. Evaluation of repair options
3. Selection of the most appropriate option

The Value Planned Repair approach addresses:

- Services required to maintain an engine at optimum efficiency.
- Scheduled maintenance, repairs and overhauls to minimize unscheduled downtime.
- Preplanned repairs and overhauls that can be flat-rated, putting you in charge of costs.
- Repair or overhaul options designed to restore the engine to proper operating condition.
- Repair or overhaul options designed to renew the engine if a failure has occurred.

Part of the Value Planned Repair approach is the repair before failure concept. The objective of the repair before failure concept is to repair the engine before a failure takes place.

The fact that a failure has not taken place makes the repair before failure concept more economical since a high degree of parts such as pistons, liners, valves, etc., and major castings such as cylinder blocks, cylinder heads, etc., can be reused.

Also, an extensive internal cleaning of the engine, which is labor intensive, is eliminated because a generating failure has not taken place.

The best part of the repair before failure concept is that unscheduled downtime is minimized and in most cases eliminated. Because the repair or overhaul can be scheduled, it allows the user to adjust his operation accordingly.

The overall benefit to a customer who repairs an engine before failure is that the customer, and not the engine, is in control of the repairs required.

To stress the importance of the Value Planned Repair approach, please consider the following example that reflects the difference in the cost of a before failure repair versus the cost of an after failure repair.

The cost to repair a turbocharger after it fails is approximately five times more than the cost of repairing a turbocharger before it fails.

However, if parts from a damaged turbocharger enters the engine, then the cost to repair your engine could be as high as ten times or more the cost of repairing a turbocharger before it fails.

By subscribing to the Value Planned Repair approach, you can avoid spending money on costly repairs that should have been prevented and utilize the money more profitably elsewhere.

Caterpillar strongly recommends the Value Planned Repair approach for maintaining and overhauling your engine.

To better illustrate what the Value Planned Repair approach means to you in terms of dollars and cents, please refer to the Engine Operating Cost Analysis section following in this publication.

Engine Operating Cost Analysis

Operating Cost Information

The term "Life Cycle Costs" can be defined as the sum of the individual costs experienced by an engine from the day of purchase until the day of retirement. In other words, the total Owning and Operating Costs.

Owning Costs are fixed costs such as initial purchase price, interest on borrowed money, depreciation and taxes.

Operating Costs are a combination of fixed and variable costs such as fuel, oil, operator expenses, equipment maintenance and repair, engine maintenance and repair, and downtime

The difference between revenues generated and Life Cycle Costs (total Owning and Operating Costs) is profit.

Caterpillar and your Caterpillar dealer cannot guarantee that you will make a profit. However, Caterpillar and your Caterpillar dealer can provide you with a variety of services that can help you reduce the costs that impact your profits.

An Engine Operating Cost Analysis is a service provided by your dealer that was developed by Caterpillar to help you reduce the Life Cycle Cost of your engine. More specifically, an Engine Operating Cost Analysis is a computerized program that examines current and prospective oil, fuel, maintenance, minor repair, overhaul and downtime costs for the period of time you expect to own the engine. It also calculates the operating cost per hour.

This useful tool provides your dealer with the specific information needed to develop a customized Maintenance Management program for your operation which will minimize your engine's operating costs.

Before a cost analysis can be performed, your dealer needs to gather as much information as possible about your operation. He will need to know the length of time you plan to keep your engine, your average cost of fuel and oil as well as a variety of other ownership and cost related facts and figures.

Once this information is obtained, your dealer will enter the data into an established computerized program to produce an Engine Operating Cost Analysis printout reflecting your current and projected operating costs per hour. Current and expected cost information is reflected in the data provided by you. These are the costs that affect your engine's operating cost.

The General Information section contains basic user data such as name, business, location, ownership, usage per year, etc., information.

The Engine Operating Information section is divided into eight subsections that address fuel consumption, oil consumption, preventive maintenance, component repairs such as water pumps, turbochargers, air compressors, etc., before failure repairs, after failure repairs, user's revenue rate per hour and lastly, miscellaneous costs such as operator wages, insurance premiums, etc.

Engine Operating Cost Summary

The Operating Cost Summary is exactly what it implies, a summary. Here the total dollar expense and percentage of the total operating expense is calculated for each subsection. The individual elements are then totaled and divided by the ownership period to yield the cost per hour. Similar calculations are also made for only the maintenance and repair portion of the total operating cost.

An Engine Operating Cost Analysis is a useful tool that can be used to:

- Project the expected operating cost of a Caterpillar engine.
- Identify the impact of individual elements on engine operating costs.
- Determine expected operating costs if Caterpillar service and overhaul recommendations are followed.
- Determine the cost per hour figures that you can obtain by having your dealer perform various levels of preventive maintenance as recommended by Caterpillar.
- Determine the savings to be realized if Caterpillar repair kits, exchange components, etc., are used by those of you who elect to perform your own maintenance.
- Determine the proper way to realize full value of your Caterpillar Engine by utilizing genuine Caterpillar parts and following Caterpillar recommended guidelines for preventive maintenance and before failure repairs.

In conclusion, an Engine Operating Cost Analysis is a tool that was designed to identify costly problem areas for the purpose of helping you reduce your operating costs.

Maintenance Records

Caterpillar recommends that accurate maintenance records be maintained. Accurate maintenance records can be used for determining operating costs, establishing maintenance schedules for other engines being operated in the same environment and for a variety of other related business decisions.

Accurate maintenance records can also be used to show compliance with the required maintenance practices and intervals. Maintenance records are a key element of a well managed maintenance program. With accurate maintenance records your Caterpillar dealer can help you fine tune the recommended maintenance intervals to meet your specific operating situation. This should result in a lower engine operating cost.

The key elements to keep records on are:

- Fuel Consumption

This is essential for determining when load-sensitive items should be inspected or repaired and for determining overhaul intervals.

- Service Hours

This is essential for determining when revolution-sensitive items should be inspected or repaired.

- Documents

The following types of documents should be kept as proof of maintenance or repair for warranty and should not be difficult to obtain and keep in the engine history file. All documents should show date, service hours, liters (gallons) of fuel consumed, unit number and engine serial number. If the engine is sold, transfer the records with the engine.

The following types of documents should be kept as proof of maintenance or repair for warranty and should not be difficult to obtain and keep in the engine history file.

1. Dealer work orders and itemized bills.
2. Owner's repair orders.
3. Owner's receipts.
4. Maintenance log (see following example).

Maintenance Log

Engine Model ______________________ **Customer Identifier** ______________________

Serial Number ______________________ **Arrangement Number** ______________________

Service Hours	Quantity Of Fuel	Item Serviced	Date	By Initials

Reference Materials

Caterpillar Reference Material

The following literature can be obtained through any Caterpillar dealer.

Oil

SEBD0640: Oil and Your Engine

PEDP7122: Question & Answer Booklet

PEDP1129: Listen To Your Oil

PEHP6001: How to Take a Good Oil Sample

SEBU6251: Lubricant Recommendations

PEHP1020: Product Data Sheet for Cat Diesel Engine Oil (CF-4) (N. America & Selected Int'l)

PEHP1026: Product Data Sheet for Cat Diesel Engine Oil (CF-4)(international Only)

PEHP1027: Product Data Sheet for Cat Diesel Engine Oil (CD)

PEHP0002: Product Data Sheet for Cat Molybdenum Grease (MPGM)

PEHP0003: Product Data Sheet for Cat Lithium Grease (MPGL)

PEHP0017: Product Data Sheet for Cat Special Purpose Grease (SPG)

PEWP9733: Cat Fluids Selector

PEDP7105: Scheduled Oil Sampling

Fuel

SEBD0717: Diesel Fuels and Your Engine

Coolant

SEBD0518: Know Your Cooling System

SEBD0970: Coolant and Your Engine

Miscellaneous

SEBF8029: Index to Guidelines for Reusable Parts and Salvage Operations

SEBF8062: Guideline for Reusable Parts - Cleaning and Inspection of Air Filters

SEHS9031: Storage Procedure for Caterpillar Products

SENR5226: Service Manual (EMCP)

SEBU6150: SR4 Generators and Control Panels Operation and Maintenance Manual

SENR2380: Service Manual (4XB, 7JB, 64Z, 83Z & 10E300-up)

SENR2793: Service Manual (85Z, 2AJ & 2TM)

SEBP1805: Parts Manual (2AJ)

SEBP2273: Parts Manual (2TM)

SEBP1451: Parts Manual (7JB)

SEBP1452: Parts Manual (4XB)

SEBP1406: Parts Manual (85Z)

SEBP1411: Parts Manual (83Z)

SEBP1435: Parts Manual (64Z)

SEBP1400: Parts Manual (10E300-up)

SEHS7654: Alignment-General Instructions

SEHS9124: Cleaning and Drying of Caterpillar Electric Set Generators

LEBH9324: Agricultural and Material Handling Application and Installation Guide

SEHS7292: Use of 5P4150 Nozzle Testing Group

SEHS8622: Using the FT1984 Air-To-Air Aftercooler Leak Test Group

SEHS7795: Use of Pump & Governor Tool Group

SEHS8024: Governor Adjusting Tool Group

SEHS8094: Use of Nozzle Puller Group

Additional Reference Material

ASTM D2896: TBN Measurements

ASTM D21768: Worked Penetration

ASTM D2982B

ASTM D3828A

ASTM D445

ASTM D893

ASTM 498589: GM-6038M Specification

ASTM Specs can normally be obtained from your local technological society, library or college.

SAE J313: Diesel Fuels

SAE J754: Nomenclature

SAE J183: Classification

Society of Automotive Engineers (SAE) Specs can be found in your SAE handbook or can be obtained from your local library, college or technological society.

- SAE handbooks can be obtained directly from:
  SAE International
  400 Commonwealth Drive
  Warrendale, PA USA 15096-0001

Engine Manufacturers Association (EMA) information for lube oil selection can be obtained from your local library, college or technological society, or contact:

- Engine Manufacturers Association
  Lubricating Oils Data Book
  401 N. Michigan Ave. Ste. 2400
  Chicago, IL 60611
  (312) 644-6610 ext. 3626

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