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Revised (10-12)

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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.

1. ENGINE EXTERNAL VIEWS

1. EXTERNAL VIEW (LH)

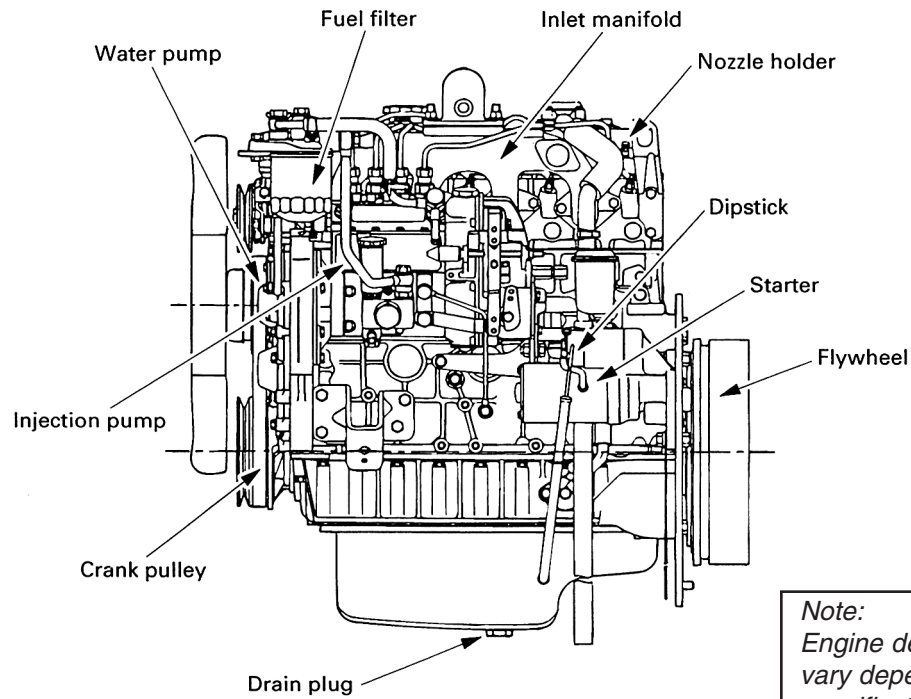


Fig. 1

*Note:
Engine details may
vary depending on the
specifications*

2. EXTERNAL VIEW (RH)

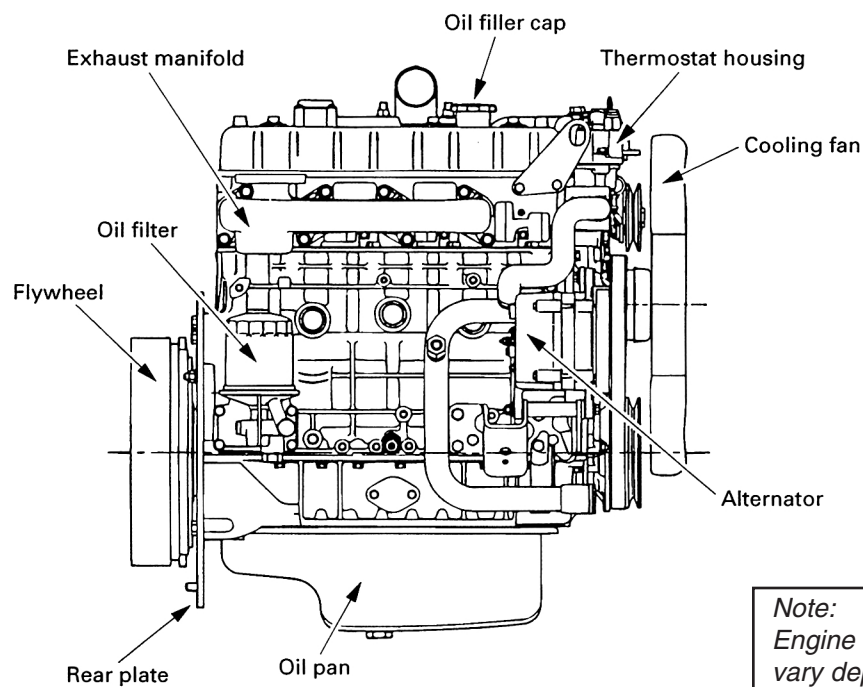


Fig. 2

*Note:
Engine details may
vary depending on the
specifications*

2. GENERAL INFORMATION

1. STANDARD ENGINE DATA AND SPECIFICATIONS

(1) Model 4IRJ7N (IN-LINE INJECTION PUMP TYPE)

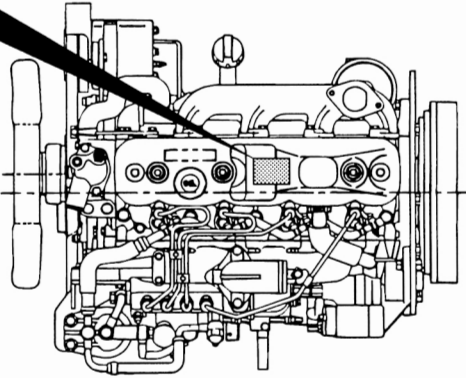
Ingersoll-Rand engine model name		4IRJ7N
Engine family		XSZXL03.1DNC
Engine code		31DNC
Engine type		Water-Cooled, four cycle, in-line overhead valve type
Combustion type		Direct Injection
No. of cylinders - bore x strokemm (in)		4 - 95.4 x 107 (3.76 x 4.21)
Engine displacement L (cid)		3.059 (186.7)
Compression ratio		18.6 to 1
Firing order		1 - 3 - 4 - 2
Max. rated power: SAE NET (hp)/min ⁻¹		65 / 2500
Exhaust emission control system		Engine modification
Injection pump		In-line, Mechanical
Governor		Variable speed, Mechanical type
Injection nozzles		Multi-hole type
Specified fuel		Diesel fuel (ASTM D975 No.2-D)
Starter (V-kW)		12 - 2.2
Alternator (V-A)		12 - 50
Specified engine oil (API grade)		CD
Lub. oil volume (Oil pan) L(qts)		9.6 - 7.6 (10.1 - 8.0)
Coolant volume (Engine only)lit (qts)		4.5 (4.8)
Engine dry weight kg (lb)		244 (538)
Engine dimensions	Overall length mm (in)	809 (31.8)
	Overall width mm (in)	606 (23.9)
	Overall height mm (in)	709 (27.9)
Valve clearance (cold) mm (in)		0.4 (0.0157)
Nozzle injection pressure MPa (psi)		18.1 (2.625)
Injection timing B.T.D.C. (Static)		12°
Maker and type of turbocharger		NA

EMISSION CONTROL LABEL: ENGINE LABEL (FOR EPA) - TYPE A

Emission control label is attached on the center, upper side of cylinder head cover. But the same emission control label is attached at a visible point on the equipment when the label that is attached to the engine is not visible due to the structure of the equipment.

The following is the sample of a label required for engine emission control information, along with location.

IMPORTANT ENGINE INFORMATION	
ENGINE FAMILY: XXXXXXXX.XXXX	★ ENGINE SPECIFICATION
ENGINE CODE: XXXX	ADVERTISED MAX.POWER.
MODEL : XXXX	SAE NET
ENGINE DISPLACEMENT : XXXXcm ³	(FAN DISENGAGED)
EXHAUST EMISSION : XXX IN ³	XXkW/XXXX min ⁻¹
CONTROL SYSTEM : EM	XXHP/XXXX RPM
DATE OF ENGINE	FUEL RATE
MANUFACTURE : XX / XX	XX mm ³ /st.
THIS ENGINE IS CERTIFIED TO	VALVE LASH (COLD)
OPERATE ON DIESEL FUEL.	IN : X.X mm.
THIS ENGINE CONFORMS TO U.S. EPA	EXH : X.X mm.
REGULATIONS APPLICABLE TO 1999	INITIAL INJECTION
MODEL YEAR LARGE NONROAD	TIMING : XX° BTDC
COMPRESSION-IGNITION ENGINES.	CURB IDLE : XXXmin ⁻¹ /RPM
	(★MODEL SPECIFICATION
	SEE SERVICE MANUAL)
	P.NO. X-XXXXX-XXX-X



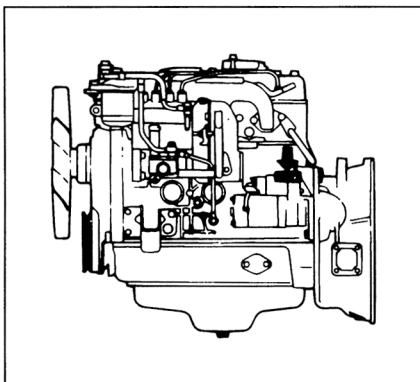


Fig. 3

2. ENGINE IDENTIFICATION

(1) Position of Display

The engine serial number is stamped on the rear left of cylinder body, near the upper starter. Engine model is described on an ID label on the left side of the cylinder head cover.

3. ENGINE AFTER SERVICE

(1) Ingersoll-Rand Engine After Service

Please feel free to contact your Ingersoll-Rand dealer for periodical inspection and maintenance.

(2) Ingersoll-Rand Genuine Parts

The Ingersoll-Rand genuine parts are identical with those of used in the engine production, and accordingly, they are warranted by Ingersoll-Rand.

The Ingersoll-Rand genuine parts are supplied by Ingersoll-Rand distributors. Please designate "Ingersoll-Rand Genuine Parts" when you need engine parts.

3. FUEL, LUBRICANT, AND COOLANT

1. FUEL

(1) Fuel Selection

The following specific advantages are required for the diesel fuel.

- 1) Must be free from minute dust particles.
- 2) Must have adequate viscosity.
- 3) Must have high cetane value.
- 4) Must have high fluidity at low temperature.
- 5) Must have low sulfur content.
- 6) Must have little residual carbon.

Diesel fuels

APPLICABLE STANDARD	RECOMMENDATION
JIS (JAPANESE INDUSTRIAL STANDARD)	NO.2
DIN (DEUTSCHE INDUSTRIE NORMEN)	DIN 51601
SAE (SOCIETY OF AUTOMOTIVE ENGINEERS) Based on SAE-J-313C	NO.2-D
BS (BRITISH STANDARD) Based on BS/2869-1970	Class A-1

If fuel other than the specified one is used, engine function will be affected.

(2) Fuel Requirements

NOTICE: The fuel injection pump, injector or other parts of the fuel system and engine can be damaged if you use any fuel or fuel additive other than those specifically recommended by Ingersoll-Rand.

Such damage is not Ingersoll-Rand's responsibility, and is not covered by the warranty. To help avoid fuel system or engine damage, please heed the following:

- Some service stations mix used engine oil with diesel fuel. Some manufacturers of large diesel engines allow this; however, for your diesel engine, do not use diesel fuel which has been contaminated with engine oil. Besides causing engine damage, such fuel can also affect emission control. Before using any diesel fuel, check with the service station operator to see if the fuel has been mixed with engine oil.

- Do not use any fuel additive (other than as recommended under "Biocide" in this section). At the time this manual was printed, no other fuel additive was recommended.

(See your authorized dealer to find out if this has changed.)

Your engine is designed to use either Number 1-D or Number 2-D diesel fuel. However, for better fuel economy, use Number 2-D diesel fuel whenever possible. At temperatures less than -7°C , (20°F), Number 2-D fuel may pose operating problems (see "Cold Weather Operation" which follows). At colder temperatures, use Number 1-D fuel (if available) or use a "winterized" Number 2-D (a blend of Number 1-D and Number 2-D). This blended fuel is usually called Number 2-D also, but can be used in colder temperatures than Number 2-D fuel which has not been "winterized." Check with the service station operator to be sure you get the properly blended fuel. Note that diesel fuel may foam during a fill-up. This can cause the automatic pump nozzle to shut off even though your tank is not full.

NOTICE: Do not use home heating oil or gasoline in your diesel engine; either may cause engine damage.

(3) Handling of the Fuel

Fuel containing dust particles or water will cause engine failure. Therefore;

- 1) Take care to prevent dust particles or water from contaminating the fuel when filling the fuel tank.
When fueling is done from an oil drum directly, allow the fuel to set long enough for contaminants to settle.
- 2) Always fully fill the fuel tank. Drain the fuel tank frequently.

(4) Water in Fuel

During refueling, it is possible for water (and other contaminants) to be pumped into your fuel tank along with the diesel fuel. This can happen if a service station does not regularly inspect and clean its fuel tanks, or if a service station receives contaminated fuel from its supplier(s). To protect your engine from contaminated fuel, there is a fuel filter system on the engine which allows you to drain excess water.

CAUTION: The water/diesel fuel mixture is flammable, and could be hot. To help avoid personal injury and/or property damage, do not touch the fuel coming from the drain valve, and do not expose the fuel to open flames or sparks. Be sure you do not overfill the container. Heat (such as from the engine) can cause the fuel to expand. If the container is too full, fuel could be forced out of the container. This could lead to a fire and the risk of personal injury and/or vehicle or equipment damage.

(5) Biocides

In warm or humid weather, fungus and/or bacteria may form in diesel fuel if there is water in the fuel.

NOTICE: *Fungus or bacteria can cause fuel system damage by plugging the fuel lines, fuel filters or injector. They can also cause fuel system corrosion.*

If fungus or bacteria has caused fuel system problems, you should have your authorized dealer correct these problems. Then, use a diesel fuel biocide to sterilize the fuel system (follow the biocide manufacturer's instructions). Biocides are available from your dealer, service stations, parts stores and other automotive places. See your authorized dealer for advice on using biocides in your area and for recommendations on which biocides you should use.

(6) Smoke Suppressants

Because of extensive testing of treated fuel versus untreated fuel, the use of a smoke suppressant additive is not recommended because of the greater possibility of stuck rings and valve failure, resulting from excessive ash deposits.

2. LUBRICANT

The quality of engine oil may affect engine performance, startability and engine life.

Use of unsuitable engine oil will result in piston ring, piston and cylinder seizure and accelerate the sliding surface wear causing increased oil consumption, lowered output and, finally engine failure. To avoid this, use the specified engine oil.

(1) Engine Oil Selection

API, CC or CD grade

(2) Oil Viscosity

Engine oil viscosity affects engine startability, performance, oil consumption, speed of wearing and occurrence of seizure, etc. Using lubricants whose viscosity selected according to the atmospheric temperature is important.

NOTICE: 1) *Using a mixture of different brand or quality oils will adversely affect the original oil quality; therefore, never mix different brand or different type oils.*

2) *Don't use API, CA, CB grade and reconstituted engine oil.*

3) *Engine damage due to improper maintenance, or using oil of the improper quality and/or viscosity, is not covered by the warranty.*

Must use Ingersoll-Rand Pro-Tee™ for optional Platinum Extended Engine Warranty.

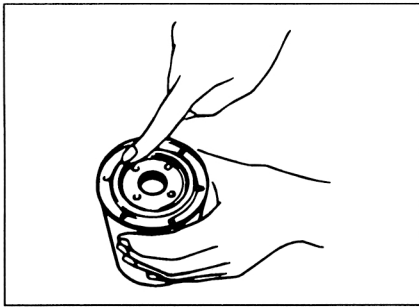
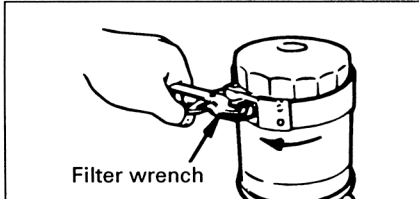


Fig. 16



Oil filter element installation

- 1) Apply lightly engine oil to the O-ring.
- 2) Turn in new cartridge until its sealed face comes in contact with the O-ring.
- 3) Use a filter wrench to further turn in the cartridge by 1 and 1/4 turns.

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

Recommended Fluid	1 Gal.	5 Gal.	45 Gal.
Pro-tec Engine Fluid (15W-40)	54480918	36875938	36866903

4. ENGINE OPERATION

Engine Exhaust Gas Caution (Carbon Monoxide)

CAUTION: Do not breathe exhaust gas because it contains carbon monoxide, which by itself has no color or odor. Carbon monoxide is a dangerous gas. It can cause unconsciousness and can be lethal. Do not run the engine in confined areas. Keep the exhaust tailpipe area clear of snow and other material to help reduce the buildup of exhaust gases.

1. CHECK BEFORE OPERATION

CAUTION: For Safety's sake, conduct the inspection before start-up with the engine stopped.

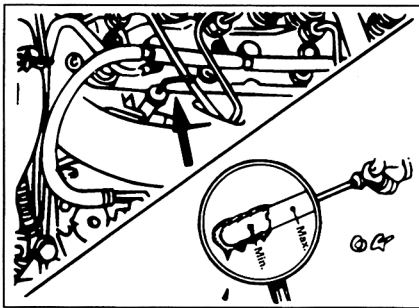


Fig. 6

(1) Engine Oil Level

Insert-type dipstick

- 1) Check with machine in level position.
- 2) Remove the dipstick from the crankcase, wipe it with a cloth. Insert fully and remove again. Check the oil level by the level marks on the dipstick. The oil level must be between the "Max" level mark and the "Min" level mark as illustrated.

Take care not to add too much engine oil.

- Drain oil to the max. oil level if oil level is above the max. level mark.
- Add oil to the max. oil level if oil level is below the min. level mark.

Engine oil replenishment

Oil is poured through the oil filler at the front of the cylinder head cover.

A certain period of time is required before the engine oil completely flows down from the oil filler to the crankcase.

Check the oil level ten or twenty minutes after oil replenishment.

NOTICE: If the engine oil is splashed on the fan drive belt, it causes belt slippage or slackness; therefore, take care to avoid it.

CAUTION: In adding oil, take care not to spill it. If you spill oil on engine or equipment, wipe it properly, or this could lead to a fire and the risk of personal injury and/or equipment damage.

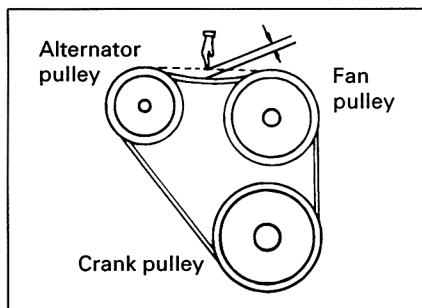


Fig. 8

(2) Fan Belt Check

Check the fan belt for tension and abnormalities.

- 1) When the belt is depressed **about 8 to 12 mm (0.31 to 0.47 in)** with the thumb [about 98 N (10 kgf/22 lb) pressure] at midway between the fan pulley and alternator pulley, the belt tension is correct.

When the belt tension is too high, it will result in alternator failure.

Contrarily, loose belt will cause belt slippage which may result in damaged belt and abnormal noise.

- 2) Check the belts. Replace them if any damage is found.

NOTICE: Replace all belts as a set even when one is not usable. Single belt of similar size must not be used as a substitute for a matched belt set. Otherwise, premature belt wear would result because of uneven belt length.

(3) Coolant Level Check

- 1) Remove the radiator filler cap, and check the coolant level

CAUTION: When removing the radiator filler cap while the engine is still hot, cover the cap with clothing, then turn it slowly to gradually release the internal steam pressure.

- 2) Use clean drinking water as coolant. When an anti-freeze solution is required, keep to the specified mixing ratio.

(4) Radiator Cap Condition

After adding coolant, install the radiator cap. Make sure the cap is securely installed.

(5) Battery Cable Connection

Check the battery cable connections for looseness or corrosion. The loosened cable connection will result in hard engine starting or insufficient battery charge.

The battery cables must be tightened securely.

Never reverse "+" and "-" terminals when reconnecting cables after disconnection.

Even a short period of reverse connection will damage the electrical parts.

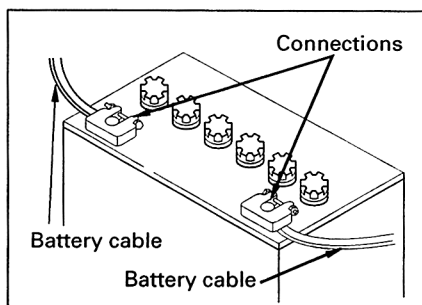


Fig. 9

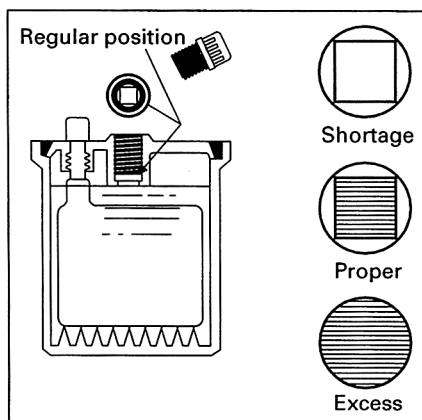


Fig. 10

(6) Battery Electrolyte Level

The amount of electrolyte in the batteries will be reduced after repeated discharge and recharge.

Check the electrolyte for the level in the batteries, replenish with a commercially available electrolyte such as distilled water, if necessary.

The battery electrolyte level checking procedure will vary with battery type. Follow the equipment manufacturer's instructions.

NOTICE: Do not replenish with dilute sulfuric acid in the daily service.

2. CHECK AND OPERATION AFTER THE ENGINE START-UP

(1) Warm-up Operation

Allow engine to warm about ten minutes after the engine has started.

(2) Check after the Engine Start-up

Check the following items in the engine warm-up operation.

Engine oil pressure (Gauge Optional)

Although the engine oil pressure gauge readings vary depending on ambient temperature or type of oil, the gauge registers around 392 to 490 kPa (4 to 5kgf/cm²/57 to 71 psi) during warm-up.

In the oil pressure warning lamp type, make sure that the lamp is off.

Charge Condition (Ammeter Optional)

Gauge should read in normal range shortly after starting.

Engine noise and exhaust smoke colour

Pay attention to engine noise and, if any abnormal noise is heard, check the engine to detect the cause.

Check the fuel combustion condition by exhaust smoke colour. The exhaust smoke colour after engine warming-up and at no-load operation:

{	Colourless or light blue.....	Normal (Perfect combustion)
{	Black colour	Abnormal (Imperfect combustion)
{	White colour.....	Abnormal (Imperfect combustion)

NOTICE: Engine noise after start-up might be noisy than that of warmed-up engine and, the exhaust smoke colour also being more blackish than the normal condition. However, it will be normalized after warming-up engine.

Leakage in the systems

Check the following items:

- Lube oil leakage
Check both sides and bottom of the engine assembly for lube oil leaks, paying particular attention to the lube oil pressure gauge pipe joint, lube oil filter and lube oil pipe joints.
- Fuel leakage
Check the fuel injection pump, fuel lines and fuel filter for leakage.
- Coolant leakage
Check the radiator and water pump hose connections also the water drain cocks on the radiator and cylinder body for leakage.
- Exhaust smoke or gas leakage

Checking coolant level

The coolant level could drop because air is expelled about 5 minutes after the engine started.

Stop the engine, remove radiator cap, and add coolant.

CAUTION: Hot steam will rush out and you could get burnt, if the radiator cap is removed when the engine is hot.
Cover the radiator cap with a thick cloth and loosen the cap slowly to reduce the pressure, then remove the cap.

3. CARE IN THE ENGINE OPERATION

In the engine operation, always pay attention to the following items if the engine indicates any sign of abnormalities.

(1) Engine Oil Pressure

Engine oil pressure is normal when the oil pressure gauge shows 294 to 392 kPa (3 to 4 kgf/cm²/43 to 57 psi) in the engine warmed-up condition.

In the continuous engine operation, engine oil pressure is slightly lower than the pressure at start-up time.

When the engine oil pressure gauge shows the following abnormal conditions, stop the engine immediately and check the engine oil amount in the oil sump and look for oil leakage:

- The engine oil pressure gauge shows below 196 kPa (2 kgf/cm²/28 psi) though the engine speed is raised.
- The oil pressure gauge indicator oscillates greatly in the engine low speed range.

When no lack of engine oil or no oil leakage is found, contact your equipment supplier to determine the cause of the abnormal reading.

(2) Coolant Temperature

The engine performance will be adversely affected if engine coolant temperature is too hot or too cold.

The normal coolant temperature is 75 to 85°C (167 to 185°F).

Overheating

The engine cooling system may overheat if the engine coolant level is too low, if there is a sudden loss of engine coolant (such as hose splitting), or if other problems occur.

Overcooling

The engine operation at low coolant temperature will not only increase the oil and fuel consumption but also will lead to premature parts wear which may result in engine failure.

(3) Engine Hourmeter (Engine Operation Hour Indicating)

This meter indicates the engine operation hours. Make sure that the meter is always working during engine operation.

Periodical engine maintenance is scheduled on the operation hours indicated on the hourmeter.

(4) Liquid and Exhaust Smoke Leakage

Be careful with lubricant, fuel, coolant and exhaust smoke leakage.

(5) Abnormal Engine Noise

Pay attention to the noise from the engine or other related parts, checking if the noise is normal.

(6) State of the Exhaust Smoke

Be careful with exhaust smoke colour, check if it is whitish or blackish.

4. OPERATION AND CARE FOR NEW ENGINE

Your Ingersoll-Rand engine is carefully tested and adjusted in the factory, however, further, thorough run-in (i.e. break-in) operation is necessary.

If the new engine is harshly operated, lubricating oil film will be reduced leading to abnormal wear or seizure. Particularly, avoid a harsh engine operation within the initial 100 operation hours observing the following notice.

- (1) Do the warming-up operation continuously until the engine is warmed-up. In this operation, do not race the engine.
- (2) Also do not operate the engine with rapid acceleration, rapid machine starting and continuous high speed operation.

5. ENGINE CARE FOR OVER-COOLING

Engine over-cooling causes premature wear and increased fuel consumption. Maintain the coolant temperature 75 to 85°C(167 to 185°F).

6. STARTING THE ENGINE AFTER BEING LEFT UNUSED FOR A LONG PERIOD OF TIME

When the vehicle or equipment is left unused for “more than three months” without running the engine (warming up), conduct a thorough inspection of the vehicle before starting the engine. After starting the engine, be sure to warm it up for more than ten minutes.

5. PERIODICAL INSPECTION AND MAINTENANCE

1. LUBRICATING SYSTEM

Servicing of the engine oil or the oil filter element will affect on the engine performance as well as the engine life.

Change the engine oil and the oil filter element periodically with the specified ones.

(1) Engine Oil and Oil Filter Element Change

Engine oil change and oil filter element change must be made according to the following change schedule.

Change interval

Engine Oil.....	Initial 50 and thereafter every 500 operating hours
Oil Filter Element.....	Initial 50 and therefore every 500 operating hours

Engine oil draining

CAUTION: To help avoid the damage of being burned, do not drain oil while the engine is still hot.

- 1) Wipe the oil filler cap taking care to remove foreign particles. Remove the filler cap.

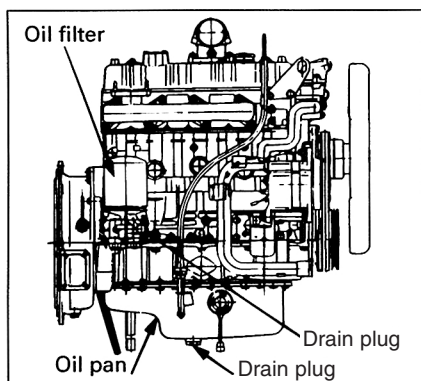


Fig. 14

Remove the following drain plugs to drain the engine oil completely.

- a. Drain plug at the oil pan.
- b. Drain plug at the main oil filter.

It is advisable that draining be done while the engine is warm, to minimize the draining time.

Oil filter element removal

- 1) Warm the engine to or near normal operating temperature.
- 2) Loosen the oil drain bolt (see arrow) one full turn to allow the oil to drain out of the filter and down to the crankcase. (The time it takes to drain the oil from the oil pan is sufficient to thoroughly drain the filter.
- 3) Once drained, remove the drain bolt entirely and replace the O-ring on the bolt (which is supplied with each Genuine IR oil filter).
- 4) Install the oil drain bolt. Tighten to 14 - 22 lb. ft. (20-30 Nm).

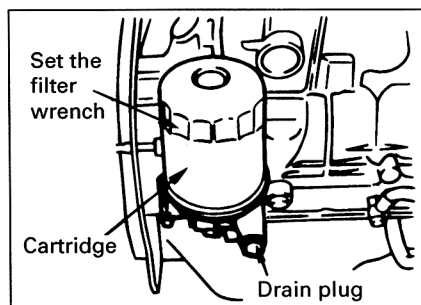


Fig. 15

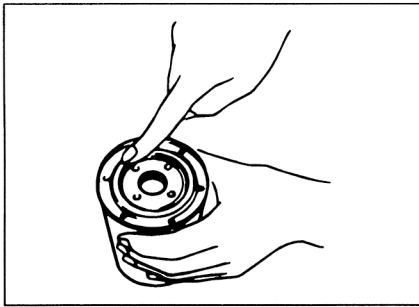


Fig. 16

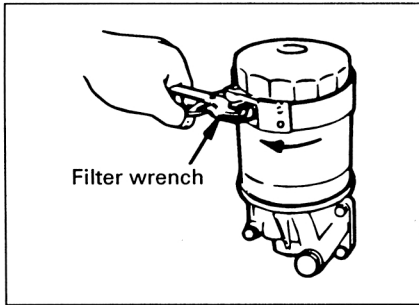


Fig. 17

Oil filter element installation

- 1) Apply engine oil to the O-ring.
- 2) Rotate new cartridge until its sealed face comes in contact with the O-ring.
- 3) Use a filter wrench, tighten the cartridge 1 1/4 turns.

Engine oil refilling

- 1) Reinstall the drain plugs.
- 2) Fill with new engine oil at the oil filler port.
Wait about fifteen minutes until the oil gets down to the oil pan.
Then check the oil level.

(2) Check after Oil and Filter Changes

Oil leakage check

Idle the engine to raise the oil pressure, then check for oil leakage.

Oil level recheck

Stop the engine. Use the dipstick to recheck the oil level.
Replenish with engine oil, if necessary, to the specified level.

NOTICE: When the engine is started, the oil level will drop slightly from the initial level as the oil fills the entire oil circuit.

(3) Engine Oil Additives

Engine oils contain a variety of additives. Your engine should not need any extra additives if you use the recommended oil quality and change intervals.

(4) Used Oil Disposal

Do not dispose of used engine oil (or any other oil) in a careless manner such as pouring it on the ground, into sewers, or into streams or bodies of water. Instead, recycle it by taking it to a used oil collection facility which may be found in your community. If you have a problem disposing of your used oil, it is suggested that you contact your dealer or service station.

(5) Used Engine Oil

CAUTION: *Used engine oil contains harmful contaminants that have caused skin cancer in laboratory animals. Avoid prolonged skin contact. Clean skin and nails thoroughly using soap and water - not mineral oil, fuels, or solvents. Launder or discard clothing, shoes, or rags containing used engine oil.*

Discard used engine oil and other oil properly.

2. COOLING SYSTEM

(1) Fan Belt Tension Adjustment

Adjust fan belt tension when belt slackness is greater than the specified amount and when the belts are replaced.

CAUTION: To help avoid being injury, check and adjust fan belt tension with engine stopped.

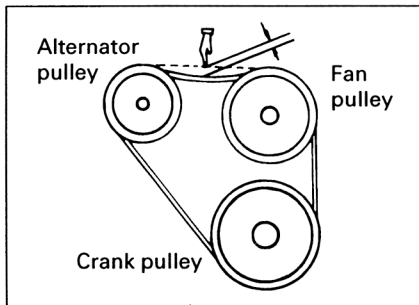


Fig. 18

Belt tension

Belt tension is normal when it is depressed 8 to 12 mm (0.31 to 0.47 in) with the thumb at the midway between the fan pulley and alternator pulley. [about 98 N (10 kgf/22 lb) depressing force.]

Fan belt slackness : **About 8 – 12 mm (0.31 – 0.47 in)**

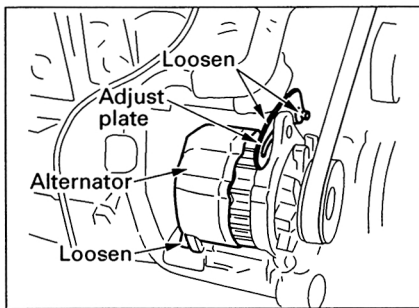


Fig. 19

Adjusting procedure

Belt tension adjustment is made by pivoting the alternator at the alternator mounting bolt.

- 1) Loosen the alternator adjusting plate bolt and the alternator mounting bolt.
- 2) Pivot the alternator at the mounting bolt toward the engine left or right hand side as required.
- 3) Tighten the mounting bolt and the adjusting bolt.

NOTICE: Belt tension may vary slightly after the alternator is fixed. Therefore, recheck the belt tension after tightening the bolts.

- 4) After the adjustment, operate the engine about five minutes at a low idle speed and recheck the belt tension. Particularly, pay attention to this matter when installing new belts. Belt tension may vary due to the initial belt conforming.

(2) Fan Belt Change

Use of fan belt with poor quality will result in premature belt wear or belt elongation leading to engine damage such as overheat. Therefore use of the Ingersoll-Rand genuine fan belts are recommended.

(3) Coolant Change

The coolant must be changed at intervals of **six months**.

If the coolant is being fouled greatly, it will lead to engine overheating or coolant blow-off from the radiator.

Coolant draining

- 1) Remove the radiator cap.
Open the drain cock on the radiator to drain the coolant in the radiator.

CAUTION: When removing the radiator filler cap while the engine is still hot, cover the cap with a rag, then turn it slowly to release the internal steam pressure. This will prevent a person from scalding with hot steam spouted out from the filler port.

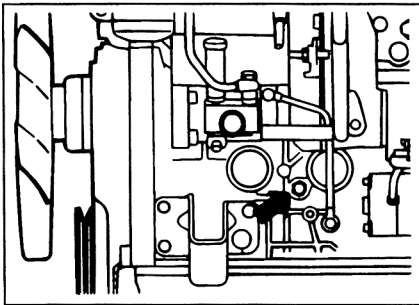


Fig. 20

- 2) Drain away the coolant from the engine by loosening the water drain plug under the injection pump on the left side of cylinder body.

Filling with coolant

- 1) Close or tighten the coolant drain plug.
- 2) Use clean drinking water as a coolant. Fill up the radiator with the coolant until the level comes up to the filler port neck.
Fill gradually to prevent air entry.
Coolant volume (Engine only) :
Refer to "Main Data Specifications"
- 3) Operate the engine about five minutes at a low idle speed, then the air contained in the coolant circuit is bled. The coolant level will drop.
Stop the engine to replenish with the coolant.

(4) Cleaning outside of Radiator

Mud or dried grass caught between radiator fins will block the air flow, resulting in lower cooling efficiency.
Clean the radiator fins with steam or compressed water.

(5) Cooling System Circuit Cleaning

When the cooling system circuit is fouled with water scales or sludge particles, cooling efficiency will be lowered.
Periodically clean the circuit interior with a cleaner.
Refer to the "Engine Maintenance Schedule".

3. FUEL SYSTEM

The fuel injection pump and fuel injection nozzles are precisely manufactured, and therefore, using the fuel which contains water or dust particles will result in either injection pump plunger seizure or injection nozzle seizure, and the fouled fuel filter element with sludge or dust particles lead to decreased engine output.

In addition, clogged filter element can cause low output or automatic air bleeding failure.

Perform inspection and maintenance periodically as follows:

(1) Removal of Water from the Fuel

The fuel system with the water sedimentor.

The water sedimentor is provided to separate the water contained in the fuel.

The sedimentor housing contains a float which moves up and down in accordance with level change of the sedimented water. Be sure to drain the sedimented water when the float has come up to the warning level line marked on the transparent sedimentor housing.

Draining procedure:

Loosen the drain plug and drain the sedimented water.

Be sure to tighten the drain plug on completion of draining.

A packing of the "plug" which is provided at the upper portion of the water sedimentor is not reusable. When the "plug" is loosened, be sure to replace the packing with a new one.

The fuel system without the water sedimentor

Drain the sedimented water in the fuel filter body every 250 operating hours

- 1) Loosen the cartridge
 - 2) Drain the fuel in the cartridge with the mixed water.
 - 3) Installation the cartridge.
- (Refer to fuel filter element change)

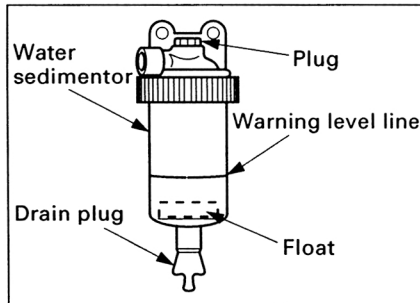


Fig. 21

NOTICE: 1. The cartridge and cup contains fuel. Take care not to spill it during disassembly.
2. Perform the "fuel system air bleeding" after the water in the fuel is drained.

(2) Fuel System Air Bleeding

The entry of air into the fuel system will cause hard engine starting or engine malfunction.

When servicing the fuel system, be sure to perform air bleeding procedure.

Air bleeding procedure:

- 1) Loosen the bleeding screws on the fuel injection pump.
- 2) Turn the feed pump knob counter clockwise until the pump knob is forced up by spring.
- 3) Depressing the pump knob will cause air mixed fuel to drain from the loosened bleeding screws.
- 4) Repeat the pumping action until no bubbles are visible in the flowing fuel.
No more bubble in the fuel indicates that air bleeding is completed.
Tighten the bleeding screws and the feed pump knob.
- 5) Start the engine and check the fuel system for fuel leaks.

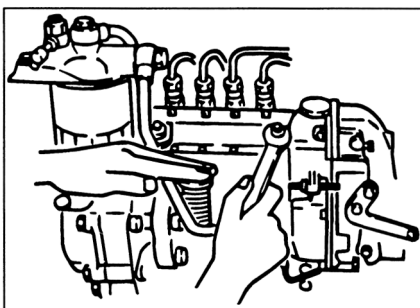


Fig. 22

(3) Fuel Filter Element Change

Change interval

Every 500 operating hours

Change Procedure

NOTICE: 1. Be careful not to spill out the fuel remaining in the fuel filter when the filter is removed.
2. After draining the water from the fuel, conduct fuel air bleeding.

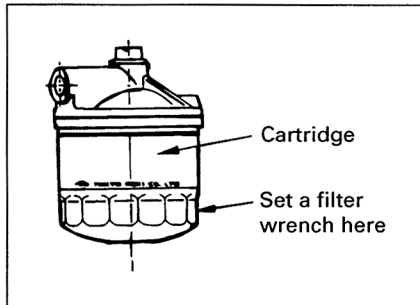


Fig. 23

- 1) Loosen the fuel filter turning it counterclockwise with a filter wrench. Discard the used fuel filter.
- 2) Clean the fitting face on the upper cover, so that new fuel filter can be seated properly.
- 3) Lightly oil the O-ring. To reinstall, turn the filter assembly clockwise carefully to prevent the fuel from spilling until the O-ring is fitted against the sealing face of the filter cover. Turn 2/3 turn further with the filter wrench.

Air bleeding

Do air bleeding on completion of fuel filter element change referring the description Fuel System Air Bleeding.

Feed Pump Strainer Cleaning

Clean the feed pump strainer every 1000 operating hours. The strainer is incorporated in the feed pump inlet side joint bolt. Clean the strainer with compressed air and rinse it in fuel oil.

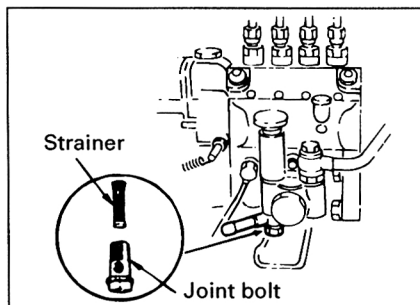


Fig. 24

(4) Fuel Injection Pump Control Seals

As the fuel injection pump is precisely adjusted, most of the controls are sealed, do not break them. When adjustment is necessary, contact your Ingersoll-Rand dealer.

NOTICE: The manufacturer does not warrant the engine with the broken governor seals.

4. AIR INTAKE SYSTEM

(1) Air Cleaner

Engine performance and life vary with the air intake conditions. A dirty air cleaner element reduces the amount of intake air, causing reduced engine output.

A damaged element leads to abrasion of cylinders and valves, resulting in increased oil consumption, reduced output and shortened engine life.

NOTICE: 1. Shorten the cleaning or change interval when the equipment is used in dusty areas.
2. Change the element, if element damage is found during air cleaner cleaning.

5. ENGINE ELECTRICAL

The engines uses a 12 volt negative ground electrical system.

(1) Battery Servicing

Gravity of the batteries

The battery charge condition is judged by the electrolyte gravity measurement.

Periodically measure the electrolyte gravity of the batteries.

For the internal check follow the equipment manufacturer's standard.

The relationship between the electrolyte specific gravity and the battery conditions are as follows:

Electrolyte Specific Gravity	Battery Conditions
Over 1.300	Over 100% (Over charged)
1.290 – 1.270	100%
1.260 – 1.240	75%
Below 1.230	Below 50% (Insufficiently charged)

Fig. 27

NOTICE: The battery electrolyte is dilute sulfuric acid. So, be careful not to stain your body and clothes with it. If stained, rinse portion in clean water.

Gravity conversion

The specified electrolyte temperature for the gravity measurement is 20°C (68°F).

Measure the electrolyte temperature and do the conversion in accordance with the following formula when the temperature does not fall to the specified temperature.

$$S_{20} = S_t + 0.0007 (t - 20)$$

S_{20} ; gravity at 20°C
 S_t ; gravity measured
 t ; electrolyte temperature whe measured

Battery terminal connections

Periodically, check the battery terminals for loose connection and corrosion.

For the check interval, follow the machine manufacturer's standard. Loose connection will cause hard engine starting or deficient battery charging.

If the terminals are excessively corroded, disconnect the battery cables and polish them with a wire brush or sandpaper.

Never reverse the "+" and "-" terminals when reconnecting the cables. Even a short period of reverse connection could damage the electrical parts.

Cleaning of Battery

When the battery is fouled clean it with clean water or tepid water and wipe them with a dry cloth to remove the water.

Apply a light coat of vaseline or a grease to the battery post.

(2) Alternator Servicing

- 1) The polarity of the alternator is negative grounding type. When an inverted circuit connection take place, the circuit will be in short circuit instantaneously resulting in alternator failure.
- 2) Do not put water directly on the alternator. Entry of water into the alternator leads an electrolyte corrosion causing a alternator failure.
Pay attention particularly when cleaning the engine.
- 3) When the battery is charged with a external electric source, be sure to disconnect the battery cables.

(3) Wiring Connections

Check all of the electric wiring connections for looseness and damage.

6. ENGINE ASSEMBLY AND OTHERS

To continue trouble free engine operation over a long period of time, the servicing items need a skilled maintenance technican, therefore, consult your machine supply source on the following items when necessary.

(1) Fuel Injection Nozzle

Use an injection nozzle tester to check the static injection starting pressure and the fuel spray conditions.

Injection nozzle pressure test interval:

Every 500 operating hours.

When the injection starting pressure is too high or too low or the fuel spray pattern is improper, an abnormal fuel combustion take place in the engine causing lowered output and blackish exhaust smoke. Further, it causes a piston seizure or piston damage etc. In such cases, the injection nozzle test or the nozzle replacement is required.

Injection starting pressure.....18.1 MPa (2630 psi)

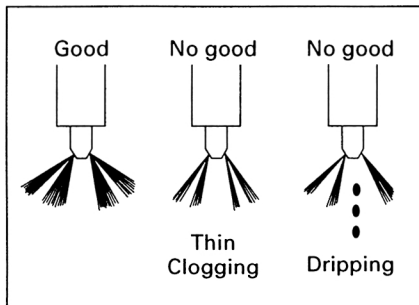


Fig. 28

NOTICE: While using a nozzle tester, it may happen that high pressure blow off the light oil and injure the worker. Keep off the nozzle end.

(2) Valve Clearance Adjustment

The valve clearance must be adjusted every 1500 operating hours, or whenever the valve rocker is abnormally noisy.

Valve clearance : 0.40 mm (0.0157 in) (When the engine is cold.)

Adjustment Procedure

- 1) In order to bring No.1 or No. 4 cylinder to the top dead center in the compression stroke, align the TDC mark on the crank pulley with the pointer on the timing gear case.
- 2) Do the adjustment on the circle marked valves in the below table where No. 1 cylinder is in the top dead center in the compression stroke.
After the above steps, do the adjustment on the double circle marked valves where No. 4 cylinder is on the top dead center in the compression stroke.

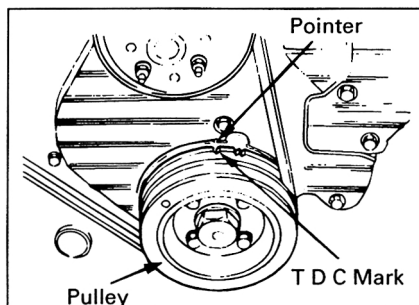


Fig. 29

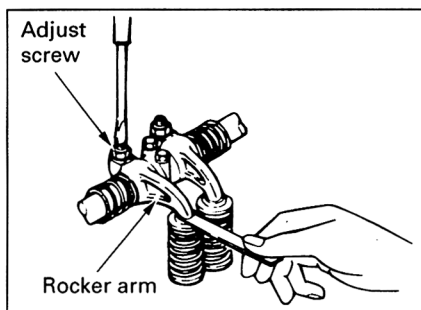


Fig. 30

	I ; Inlet E ; Exhaust							
Cylinder No.	1		2		3		4	
Valve arrangement	I	E	I	E	I	E	I	E
When No. 1 cylinder is at TDC in the compression stroke	○	○	○			○		
When No. 4 cylinder is at TDC in the compression stroke				⊙	⊙		⊙	⊙

Fig. 31

- 3) After the adjustment started from either piston top dead center, turn the crankshaft 360° to align the TDC mark and the pointer to do the adjustment again on the remaining valve.

(3) Injection Timing Check and Adjust

Improper injection timing causes serious engine failure such as blackish exhaust smoke, poor engine output and engine breakage etc.

In normal servicing, this check and adjustment is unnecessary, however, it might be necessary in conjunction with a related works.

Check procedure

- 1) Rotate the crankshaft clockwise to align the camshaft gear timing mark "0" (B) with the timing gear case pointer (A). If A and B are in alignment, the No. 1 cylinder will now be at the point where the fuel injection starts nearly.

Next, inspect the crankangle position of the injection starting.

- 2) Remove No. 1 injection pipe from the engine.
- 3) Remove the injection pump No. 1 delivery valve holder, delivery valve and spring and reinstall the delivery valve holder on the original place.

Delivery valve holder tightening torque : 39 – 44 Nm (28.9 – 32.5 lb.ft)

- 4) Slowly turn the crankshaft pulley clockwise and at the same time, continue to feed the fuel with pumping the feed pump. When the fuel stop to flow out from No. 1 delivery valve holder, stop the pumping instantaneously.
- 5) Observe and make sure that which mark (injection starting angle line) on the crankshaft pulley is aligning with the pointer.

The timing line shows the injection starting crank angle of the engine.

The injection starting crank angle differs depending on the engine model.
Refer to the main data and specifications on the injection timing angle for the respective model engine. If the timing is incorrect, do the following adjustment.

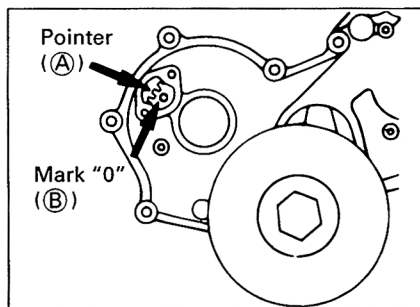


Fig. 32

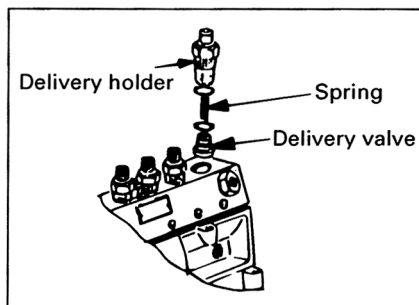


Fig. 33

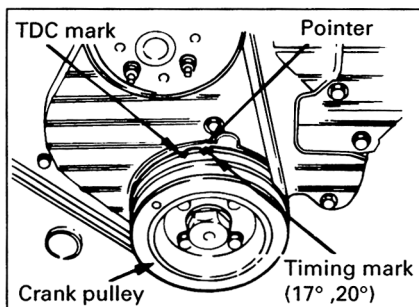


Fig. 34

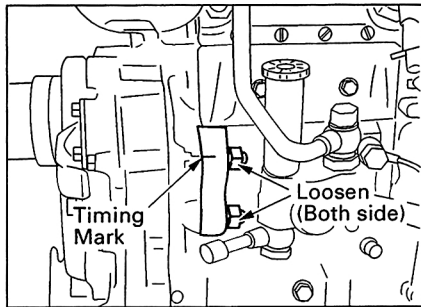


Fig. 35

Adjustment procedures

- 1) Align the pointer and the specified timing mark on the crankshaft pulley.
(Refer to the injection timing angle shown in the main data and specifications.)
- 2) Loosen the four injection pump fixing nuts.
- 3) To advance the timing.
Pivot the injection pump at the pump drive shaft toward out.
To retard the timing.
Pivot the injection pump at the pump drive shaft toward in (toward the cylinder block).
The 1 mm (0.039 in) misalignment between the two setting mark lines corresponds to about 2° in crank angle.
- 4) Do a fine injection pump position adjustment, while continuing the pumping operation to feed the fuel, and stop to pivot the injection pump when the fuel stop to flow out from No. 1 delivery valve holder.
- 5) Tighten the four injection pump fixing nuts.
- 6) Once remove No. 1 delivery valve holder, and reinstall the delivery valve, spring and the valve holder.
Delivery valve holder tightening torque : 39 ~ 44 Nm (28.9 ~ 32.5 ft.lb)
- 7) Install No. 1 injection pipe.

NOTICE: Take care to prevent entry of dust or foreign particles into the pump interior when timing adjustment is made.

(4) Cylinder Compression Pressure Measurement

The cylinder compression pressure measurement must be done **every 1200** operation hours, or whenever the engine output is reduced.

Compression pressure 3.04 MPa (441 psi)
Test condition: Cranking speed 200 rpm
 Coolant temperature 75°C (167°F)

Repair the engine and/or replace some parts of engine if compression pressure is lower than 2.15 MPa (313 psi)

(5) Starter and Alternator Servicing

Do the starter and the alternator servicing every 1500 operating hours on the following items.

- Starter commutator cleaning.
- Alternator slip ring cleaning.
- Carbon brushes and the brush contact check.

(6) Radiator Pressurization Valve Check

A pressurization valve is incorporated in the radiator cap assembly. Check the valve actuating pressure with a radiator compression tester. For the pressurization valve actuating pressure and the check interval, follow the equipment manufacturer's standards.

(7) Water Pump Grease Replacement

Grease packed in the water pump must be replaced every 1500 operating hours, (BESCO GREASE L-2).

6. ENGINE CARE IN COLD SEASON

1. FUEL

(1) Fuel Selection

In the cold zone, the fuel might be frozen resulting in hard engine starting; therefore, select a suitable fuel for such engine operation.

Use ASTM 975 No. 2-D fuel if you expect temperature above -7°C (20°F).

Use Number 1-D if you expect temperatures below -7°C (20°F).

If Number 1-D is not available, a "winterized" blend of 1-D and 2-D is available in some areas during the winter months.

Check with the service station operator to be sure you get the properly blended fuel.

2. COOLANT

Where the atmospheric temperature falls below freezing point, the cooling system should be drained after engine operation, but to eliminate the need for repeated draining and refilling, the use of anti-freeze solution is highly recommended.

A 50/50 Ethylene glycol base antifreeze/water mix.

Concentrations over 65% adversely affect freeze protection, heat transfer rates, and silicate stability which may cause water pump leakage.

Never exceed a 60/40 antifreeze/water mix.

(which provides protection to about -50°C (-58°F)).

CAUTION: *Under some conditions the ethylene glycol in the engine coolant is combustible. To help avoid being burned when adding engine coolant, do not spill it on the exhaust system or engine parts that may be hot. If there is any question, have this service performed by a qualified technician.*

NOTICE: 1. Methyl alcohol base antifreeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point.
2. High silicate antifreeze is not recommended because of causing serious silica gelation problems.
3. Usage and mixing ratio etc. should be followed to the antifreeze manufacture's recommendations.

3. ENGINE OIL

Engine oil viscosity largely affects engine startability, so the use of lubricant with selected viscosity according to the atmospheric temperature is important.

At low atmospheric temperature, engine oil viscosity will increase to cause hard engine starting.

4. BATTERY

- 1) Always pay attention to charging the batteries completely in cold season.

As the discharge current from the battery is large in cold engine starting, it takes a comparatively long while to recharge the batteries than the recharge after the normal engine starting.

Particularly, as the gravity of the insufficiently charged battery's electrolyte is low, it will easily be frozen.

Pay attention to keep the batteries warm in the cold season.

- 2) To replenish the battery with distilled water, do it immediately before the engine operation.

If the work is done after the engine has already been in an operation, the distilled water replenished will not be mixed with the original electrolyte, allowing the danger of freezing the not mixed distilled water staying in the battery cell upper part.

NOTICE: Do not use starting "aids" in the air intake system. Such aids can cause immediate engine damage.

7. ENGINE MAINTENANCE SCHEDULE

(2). Applicable Engine Model : 4IRJT

When performing the following items, the daily inspection items should also be carried out.

NO.	Description of check and maintenance		Daily	(operation hours)						Remark	
				50	250	500	750	1000	1250		1500
1.	Oil level and oil fouling		○							See "EXPLANATION OF MAINTENANCE SCHEDULE"	
2.	Oil leakage check		○								
3.	Oil pressure gauge registration		○								
4.	Oil pressure warning lamp		○								
5.	Engine oil change			(○)		○		○			○
6.	Oil filter element replacement			(○)		○		○			○
7.	Water pump grease change										○
8.	Fuel leakage check		○								
9.	Draining water in fuel filter	w/water sedimentor	○								
		w/o water sedimentor			○	○	○	○	○		○
10.	Fuel filter element replacement					○		○			○
11.	Feed Pump Strainer Cleaning							○			

NO.	Description of check and maintenance		Daily	(operation hours)							Remark
				50	250	500	750	1000	1250	1500	
12.	Injection nozzle check (*)					○★		○★		○★	See "EXPLANATION OF MAINTENANCE SCHEDULE"
13.	Coolant level and fouling check		○								
14.	Coolant leakage check		○								
15.	Radiator filler cap fitting condition		○								
16.	Fan belt tension check (Replace if necessary.)		○								
17.	Coolant temperature registration		○								
18.	Coolant replacement										
19.	Radiator external face cleaning					○		○		○	
20.	Cooling system circuit cleaning									○	
21.	Radiator filler cap function check (*)										
22.	Electrolyte level check		○								
23.	Battery cleaning		○								
24.	Battery charge condition	Ammeter registration	○								
		Charge warning lamp	○								
25.	Electrolyte gravity check										
26.	Starter and alternator check and cleaning (*)									○	
27.	Wiring and connection check										
28.	Preheating condition check		○								
29.	Air cleaner element replacement										

★ This is a recommended maintenance. The failure to perform this maintenance item will not nullify the emission warranty or Limit recall liability prior to the completion engine useful life. However, it is recommended that maintenance service is performed at the indicated intervals.

NO.	Description of check and maintenance	Daily	(operation hours)							Remark
			50	250	500	750	1000	1250	1500	
30.	Engine starting conditions and noise conditions	○								See "EXPLANATION OF MAINTENANCE SCHEDULE"
31.	Exhaust smoke condition	○								
32.	Cylinder compression pressure (*)								○	
33.	Valve clearance check (*)								○	

Note:

1. The service intervals after 1500 operation hours should also be made every 250 operation hours in accordance with this check and maintenance schedule.
2. When the servicing on the asterisked (*) items are necessary, consult the equipment supplier.

EXPLANATION OF MAINTENANCE SCHEDULE

The following is a brief explanation of the services listed in the preceding Engine Maintenance schedule.

1. **Oil level and oil fouling** Check that the oil level is between the max. level mark and the min. level mark. Drain oil to the max. level mark if oil level is above the max. level mark. Add oil to the max. level mark if oil is below the min. level mark.
2. **Oil leakage check** Replace any damaged or malfunctioning parts which could cause leakage.
3. **Oil pressure gauge registration** Engine oil pressure is normal at about 294 to 490 kPa (3 to 5 kgf/cm²/43 to 71 psi) in warmed-up condition. Check and repair the lubrication oil system, if it is abnormal.
4. **Oil pressure warning lamp** Warning lamp is off while engine running. If it stays on, check and repair the lubrication system.
5. **Engine oil change** Refer to the previous maintenance schedule.
6. **Oil filter element replacement** Refer to the previous maintenance schedule.
7. **Water pump grease change** Refer to the previous maintenance schedule.
8. **Fuel leakage check** Inspect the fuel lines for damage which could cause leakage. Replace any damaged or malfunctioning parts.
9. **Draining water in fuel filter** Drain water in fuel filter if water reaches the fuel element. In the fuel system without water sedimentor, drain the sedimented water in fuel filter every specified operating hours.
10. **Fuel filter element replacement** Refer to the previous maintenance schedule.
11. **Feed pump strainer cleaning** Refer to the previous maintenance schedule.
12. **Injection nozzle check** Check and adjust injection opening pressure and spray condition. (This is a recommended maintenance)
13. **Coolant level and fouling check** Check coolant level and add coolant if necessary.
14. **Coolant leakage check** Repair part for coolant leakage.
15. **Radiator filler cap fitting condition** The radiator cap must be installed tightly.
16. **Fan belt tension check** Check and adjust fan belt deflection. Look for cracks, fraying and wear.

17. Coolant temperature registration	Coolant temperature is normal at about 75 to 85°C (167 to 185°F). Check and repair the cooling system if coolant temperature is abnormal.
18. Coolant replacement	Change coolant at intervals of 6 months or 12 months respectively if coolant is plain water, or long life coolant (LLC).
19. Radiator external face cleaning	According to the equipment manufacturer's specification.
20. Cooling system circuit cleaning	Refer to the previous maintenance schedule.
21. Radiator filling cap function check	Check radiator pressure cap periodically for proper operation according to the equipment manufacturer's specifications.
22. Electrolyte level check	Replenish with distilled water if necessary.
23. Battery cleaning	Clean the terminals.
24. Battery charge condition	Ammeter registration goes to plus (+) side while engine running. In the lamp type, the lamp is completely being off while engine running. Check charging circuit if the lamp is not off.
25. Electrolyte gravity check	Check according to the equipment manufacturer's specifications.
26. Starter and alternator check and cleaning	Check wear condition of brush and commutator.
27. Wiring and connection check	Check according to the equipment specifications.
28. Preheating condition check	Check preheating condition of the system.
29. Air cleaner element replacement	Change element according to the manufacturer's specifications.
30. Engine starting condition and noise condition	Check engine stability and noise.
31. Exhaust smoke condition	Check exhaust smoke color.
32. Cylinder compression pressure	Refer to the previous maintenance schedule.
33. Valve clearance check	Incorrect valve clearance will result in increased engine noise and lower engine output. Thereby adversely affecting engine performance.

8. SIMPLE ENGINE TROUBLESHOOTING

This item contains a simple troubleshooting. When a failure takes place on your Ingersoll-Rand engine, diagnose the cause referring this troubleshooting. Should the cause of failure cannot be detected or you are unable to manage the failure consult to your machine supply source or nearest Ingersoll-Rand engine service outlet.

