SAFETY.CAT.COM™

COLD WEATHER RECOMMENDATIONS FOR ALL CATERPILLAR MACHINES

Excerpted from Operation & Maintenance Manual (SEBU5898-11-01)

CATERPILLAR®

Important Safety Information

Most accidents that involve 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 to other persons.

The hazards are identified by the “Safety Alert Symbol” and followed by a “Signal Word” such as “DANGER”, “WARNING” or “CAUTION”. The Safety Alert “WARNING” label is 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 explains the hazard and 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 that is not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Caterpillar dealers have the most current information available.

⚠ WARNING

When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

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Foreword

Literature Information

This manual should be stored in the operator's compartment in the literature holder or seat back literature storage area.

The information contained in this document is the most current information available for coolant, fuels, and lubricants. Special lubricants are required for some machine compartments. Refer to the Operation and Maintenance Manual for your machine for any special lubrication requirements.

Whenever a question arises regarding the machine, this publication, or the Operation and Maintenance Manual, please consult any Caterpillar dealer for the latest available information.

Safety

Refer to the Operation and Maintenance Manual for your machine for all safety information. Read and understand the basic safety precautions listed in the Safety Section. In addition to safety precautions, this section identifies the text and locations of warning signs used on the machine.

Read and understand the basic precautions listed in the Safety Section before operating or performing lubrication, maintenance and repair on the machine.

Maintenance

Refer to the Operation and Maintenance Manual for your machine to determine all maintenance requirements.

Maintenance Interval Schedule

Use the Maintenance Interval Schedule in the Operation and Maintenance Manual for your machine to determine servicing 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.

Under extremely severe, dusty or wet operating conditions, more frequent lubrication than is specified in the Maintenance Interval Schedule might be necessary.

Extended Engine Oil Drains and Warranty

Failures that result from extended oil drain periods are not Caterpillar factory defects and therefore are not covered by Caterpillar's warranty. In addition, failures that result from not using the recommended oil type are not Caterpillar factory defects and therefore are not covered by Caterpillar's warranty.

Refer to the applicable Operation and Maintenance Manual for standard oil drain periods and to the Maintenance Section, "Lubricant Specifications" of this publication for engine oil type and viscosity grade recommendations.

To reduce the potential risk of failures associated with extended oil drain periods; it is recommended that oil drain intervals only be extended based on oil analysis, and subsequent engine inspections. Oil analysis alone does not provide an indication of the rate of formation of lacquer, varnish and/or carbon on pistons and other engine surfaces. The only accurate way to evaluate specific oil performance in a specific engine and application that utilizes extended oil drain periods is to observe the effects on the engine components. This involves tear-down inspections of engines that have run to their normal overhaul period with extended oil drain intervals. Following this recommendation will help ensure that excessive component wear does not take place in a given application.

NOTICE

Light loads, low hour accumulation, and excessive idling time can contribute to excessive water in the crankcase oil. Corrosive damage, piston deposits and increased oil consumption can also result. If oil analysis is not done or the results are ignored, the potential for corrosive damage and piston deposits increases. Refer to the appropriate Operation and Maintenance Manual for guidance.

Note: Failures that result from extended oil drain periods are not warrantable failures, regardless of use of this recommended procedure. Failures that result from extended engine oil drain periods are considered improper use under the warranty.

Aftermarket Products and Warranty

NOTICE

When auxiliary devices, accessories or consumables (filters, oil, additives, catalysts, fuel, etc.) made by other manufacturers are used on Caterpillar products, the Caterpillar warranty is not affected simply because of such use. Failures that result from the installation or usage of other manufacturers auxiliary devices, accessories or consumables, however, are not Caterpillar factory defects and therefore are NOT covered by Caterpillar's warranty.

Caterpillar is not in a position to evaluate the many auxiliary devices, accessories or consumables promoted by other manufacturers and their effect on Caterpillar products. Installation or use of such items is at the discretion of the customer who assumes ALL risks for the effects that result from this usage.

Furthermore, Caterpillar does not authorize the use of its trade name, trademark, or logo in a manner which implies our endorsement of these aftermarket products.

Information Section

Cold Weather Recommendations

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Cold Weather Information

SMCS Code: 1000; 7000

The information that is contained in this document is an aid to the operation and maintenance of your Caterpillar machine in cold weather. This information will cover operating your machine in temperatures from 9 °C (48 °F) to −40 °C (−40 °F).

When you operate the machine in temperatures above 9 °C (48 °F), refer to the Operation and Maintenance Manual for your machine.

It is difficult to outline the operation and maintenance of a machine that is used in freezing temperatures for a general publication. The difficulty in outlining the requirements is caused by the following conditions: the unlimited differences in weather conditions, applications, and the supplies that are available in your area. In order to provide the best possible guidelines, use the information in this document and the following criteria: varying factors, recommendations from your Caterpillar dealer, and past proven practices.

Hints for Cold Weather

Make sure that you read the information for selecting the lubricants to use in cold weather. Refer to Special Publication, SEBU6250, “Lubricant Viscosities” for more information.

Prepare the machine for the weather conditions. Use the following options to keep the machine warm: heaters, enclosures for compartments, and storage facilities.

- To assist in warm-up, block the radiator. Blocking the radiator will restrict air from the fan.
- Before the beginning of cold weather, install the correct lubricant in each compartment.
- Keep all starting fluid at room temperature. Inject starting fluid only while the engine is cranking.
- Provide cooling system protection for the lowest expected outside temperature.

Premix the antifreeze solution for the cooling system. At the minimum, the freeze protection that is provided by the solution should be equal to the system protection requirements.

- Check all rubber parts weekly: hoses, tires, and fan drive belts.
- Check all electrical wiring and connections for any fraying or for damaged insulation.
- Keep all batteries fully charged and warm.
- Fill the fuel tank at the end of each shift.
- Check the air cleaners and the air intake daily. If snow is present, check the air intake more frequently.

Steering response on equipment with hydraulic steering may become very slow at very low temperatures. This can happen even if the correct oils are used.

If the engine is started, run the engine until the engine reaches operating temperature. Achieving operating temperature will help prevent the intake valves and exhaust valves from sticking.

⚠ WARNING

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.

Do not store starting fluid or store alcohol in the operator’s compartment.

Inject alcohol into air compressors in order to prevent moisture from freezing in the air system.

The cooling system and the lubrication system for the engine do not lose heat immediately upon shutdown. The transmission and the hydraulic system lose heat more rapidly because of more exposed areas. Gear cases cool rapidly, since the gear cases do not operate as warm as other compartments.

This means that an engine can maintain the ability to start readily after being shut down for a few hours. The other systems will lose heat more rapidly. The equipment will require exercising upon starting. If the engine is shut down for at least sixteen hours, the engine will cool down to the outside temperature.

Running the engine at idle will keep the engine compartment warm. The compartment for the transmission will also be kept warm. However, running the engine will not keep hydraulic systems warm.

The outer wrapper on hydraulic hoses can crack when flexing occurs in cold temperatures. This does not mean that the hoses have failed. The hoses will still carry oil under pressure.

Condition the hydraulic hoses on the equipment before the temperatures decrease below −40°C (−40°F).

Perform the following steps in order to condition the hoses with the hoses on the machine: Operate at 66°C (150°F) hydraulic oil temperature for at least one hour. Use an oil that has a pour point of −54°C (−65°F).

Normal machine operation will condition the hoses if arctic fluids have been put into the system. However, the arctic fluid must be put into the system before cold weather begins.

Condition the hoses before installation if the ambient temperature is lower than −40°C (−40°F).

Perform the following steps in order to condition a hose before installation:

- Fill the hose assembly with kerosene or with a winter blend of diesel fuel. Leave the couplings attached.
- Keep the hoses filled for a minimum of eight hours at a temperature of 22°C (72°F).
- Hose assemblies should be installed within thirty days of conditioning.

Check the machine in order to be sure that the voltage of the electric heaters matches the power source.

Correct track tension is especially important during cold weather operation in snow. For adjustment procedures, refer to the Operation and Maintenance Manual for the machine.

Operation Section

Starting Recommendations

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Before Starting Engine

SMCS Code: 1000; 7000

NOTICE
Do not remove the air cleaner element when snow packing occurs. This could cause severe engine damage. Instead, rework the air intake so air is taken in under the hood.

Do not use a torch to heat a compartment. This causes fires, burns wiring, gaskets and seals, or melts the battery case.

When using canvas covers, do not install them near exhaust systems. This helps to prevent fires.

Check the air cleaner daily before starting the machine. If you operate the machine in heavy snow, attach a burlap sack loosely to the precleaner. By moving freely, the sack will prevent the snow from accumulating around the precleaner. Keep the burlap sack away from heated parts. The hot exhaust piping may ignite the burlap sack. Also, make sure that the burlap sack does not touch any moving parts.

In order to assist in warm-up, block the radiator. Blocking the radiator will restrict air from the fan. Additional items may be needed to assist in warm-up. The use of the following items may be required: coolant heaters, block heaters, tents, and additional batteries.

Before entering the operator's station, inspect the condition of the following parts: hydraulic hoses, tires, and fan drive belts. Carefully inspect these components for any of these conditions: cuts, cracks, and worn spots. Check all electrical wiring and check electrical connections for any fraying or for damaged insulation.

If the machine is equipped with a gasoline starting engine, check the gasoline tank and check the sediment bowl. At every fifty service hours, check for moisture and check for dirt.

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Engine Starting Information

SMCS Code: 1000; 7000

Categories

Table 1

Categories of Cold Weather	
Category	**Temperature Range**
Category 1	9 to −9.5 °C (48 to 15 °F)
Category 2	−9.5 to −18 °C (15 to 0 °F)
Category 3	−18 to −30 °C (0 to −22 °F)
Category 4	−30 to −40 °C (−22 to −40 °F)

The fluids in all compartments must have a pour point below the outside starting temperature.

Category 1

9 to −9.5 °C (48 to 15 °F)

At operating altitudes of 460 m (1500 ft) or less, a Caterpillar diesel engine will not normally require any starting aids for temperatures in "Category 1".

At operating altitudes of 460 m (1500 ft) or higher, a Caterpillar diesel engine may require a starting aid. The use of starting aids depends on the engine model and the altitude.

Table 2

Category 1 Starting Aids			
Altitude	**Engine Model**	**Recommended**	**Optional**
0 to 460 m (0 to 1500 ft)	All Models	None	None
above 460 m (1500 ft)	3126B,C-9,C7,C9	Continuous Flow Ether	None
	All Other Models	None	

Note: Continuous flow ether is controlled by the engine ECM. Manual operation during starting is not required.

Use only Caterpillar SAE 15W-40, 10W-30 oils or any commercial SAE multigrade oil that meets the ECF-1 requirements. Refer to the machine Operation and Maintenance Manual and Special Publication, SEBU6251 for more information.

Category 2

−9.5 to −18 °C (15 to 0 °F)

Table 3

Category 2 Starting Aids			
Altitude	**Engine Model**	**Recommended**	**Optional**
All Altitudes	All Models	Continuous Flow Ether	Coolant Heater
			Heavy Duty Battery and Starter Package(1)

(1) Contact your Caterpillar dealer for availability for your machine model.

Use only Caterpillar 10W-30 oil, or a lower viscosity multigrade oil, that meets ECF-1 requirements. Do not use SAE 15W multigrade oil in category 2 temperatures. Refer to the machine Operation and Maintenance Manual and Special Publication, SEBU6251 for more information.

Category 3

−18 to −30 °C (0 to −22 °F)

Table 4

Category 3 Starting Aids			
Altitude	**Engine Model**	**Recommended**	**Optional**
All Altitudes	All Models	Continuous Flow Ether	Oil Heater
		Coolant Heater	Fuel Heater
		Heavy Duty Battery and Starter(1)	Battery Warmer

(1) Contact your Caterpillar dealer for availability for your machine model.

Only use SAE 5W-40 or a lower viscosity multigrade oil. Do not use any SAE 15W or 10W multigrade oils in category 3 temperatures. Refer to the machine Operation and Maintenance Manual and Special Publication, SEBU6251 for more information.

Category 4

−30 to −40 °C (−22 to −40 °F)

Table 5

Category 3 Starting Aids			
Altitude	**Engine Model**	**Recommended**	**Optional**
All Altitudes	All Models	Continuous Flow Ether	Oil Heater
		Coolant Heater	Fuel Heater
		Heavy Duty Battery and Starter(1)	Battery Warmer

(1) Contact your Caterpillar dealer for availability for your machine model.

Use only SAE 0W-40 or a lower viscosity multigrade oil. Do not use any SAE 15W, SAE 10W or 5W multigrade oils in category 3 temperatures. Refer to the machine Operation and Maintenance Manual and Special Publication, SEBU6251 for more information.

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Engine Starting with Starting Aid

SMCS Code: 1000; 1090; 1456; 7000

Diesel Engines That Are Equipped With Gasoline Starting Engines

1. Place the lever that is used to release compression into the START position.
2. Move the engine governor control to the SHUTOFF position.
3. Shift the transmission for the gasoline starting engine into the LOW speed position. Start cranking the diesel engine with the gasoline starting engine.
4. After the diesel engine cranks freely, disengage the clutch for the gasoline starting engine. Shift the transmission for the gasoline starting engine to HIGH speed. Engage the clutch for the gasoline starting engine. Crank the diesel engine for several minutes in order to warm the engine. As a result of cranking the diesel engine, the oil pressure should attain the NORMAL range on the gauge. Also, the pressure of the diesel fuel should register NORMAL.
5. Place the lever that is used to release compression into the RUN position. Move the diesel engine's governor control lever to the HIGH IDLE position.

NOTICE
Start the diesel engine with the starting engine transmission in High only.

6. After the diesel engine starts, reduce the rpm of the diesel engine. Disengage the clutch for the gasoline starting engine. Turn off the fuel to the gasoline starting engine. Continue to run the gasoline starting engine until the gasoline starting engine's carburetor bowl is dry.

Diesel Engines That Are Equipped With Gasoline Starting Engines and Glow Plugs

1. Place the lever that is used to release compression into the START position.

2. Move the governor control lever to the SHUTOFF position.

3. Start cranking the diesel engine with the gasoline starting engine's transmission in LOW speed.

4. After the diesel engine cranks freely, disengage the clutch for the gasoline starting engine. Shift the transmission for the gasoline starting engine to HIGH speed. Engage the clutch for the gasoline starting engine. Crank the diesel engine for several minutes in order to warm the engine. Cranking the diesel engine will also bring the oil pressure to the NORMAL range on the gauges. Also, the pressure for the diesel fuel should register NORMAL.

5. Disengage the clutch for the gasoline starting engine, but allow the gasoline starting engine to run.

6. Turn the heat switch for the glow plug to the HEAT position. Allow the glow plug to operate for two to five minutes. Do not crank the diesel engine.

7. After warming the engine with the glow plug, move the lever that is used to release compression into the RUN position. Engage the clutch in order to crank the diesel engine.

8. With the heat switch in the ON position, allow the gasoline starting engine to crank the diesel engine. Continue cranking the diesel engine until normal cranking rpm is achieved.

NOTICE
Start the diesel engine with the starting engine transmission in High only.

9. While you crank the engine with the heat switch in the ON position, move the governor control lever to the HIGH IDLE position.

10. Keep the heat switch in the ON position until the engine starts and the engine runs smoothly. After the engine starts, reduce the rpm of the engine.

NOTICE
Do not turn the heat switch to the Heat position if the engine is warm and running. Engine damage could result.

11. Disengage the clutch for the gasoline starting engine. Turn off the fuel for the gasoline starting engine. Continue to run the gasoline starting engine until the engine's carburetor bowl is dry.

Diesel Engines That Are Equipped With Ether Starting Aid

Manual Metered Ether Injection System

⚠ WARNING

Ether is poisonous and flammable.

Breathing ether vapors or repeated contact of ether with skin can cause personal injury.

Use ether only in well ventilated areas.

Do not smoke while changing ether cylinders.

Use ether with care to avoid fires.

Do not store replacement ether cylinders in living areas or in the operator's compartment.

Do not store ether cylinders in direct sunlight or at temperatures above 49 °C (120 °F).

Discard cylinders in a safe place. Do not puncture or burn cylinders.

Keep ether cylinders out of the reach of unauthorized personnel.

To avoid possible injury, be sure the brakes are applied and all controls are in Hold or Neutral when starting the engine.

At temperatures above 0°C (32°F), the use of ether is not normally necessary. At temperatures between 0°C (32°F) and −18°C (0°F), one to six injections of ether may be required. The amount of ether that is required will depend on the type of engine and the cranking rpm.

When you start the engine below −18°C (0°F), use a new container of ether to make sure that there is adequate delivery pressure.

NOTICE
Inject starting aid (ether), only while cranking the engine.

At temperatures below −18°C (0°F), three to six injections of ether will be required to start the engine. After the engine starts, and cranking is stopped, continue to inject ether until the engine runs smoothly and/or the white smoke stops. This may require as many as ten to twelve injections of ether.

Continuous Flow Ether System

The continuous flow ether system that is used as a starting aid in cold weather is controlled by the engine ECM and engine software. The continuous flow ether system is dependent on coolant temperature and altitude. The starting procedure is not affected during ether injection.

Note: On machine engines that are equipped with an air inlet heater and continuous flow ether, the heater indicator light may not illuminate under certain conditions. The ECM and engine software insure that ether injection will not occur when the air inlet heater is in use.

Note: Check the ether bottle to insure that the bottle contains an adequate supply of ether in order to aid engine starting. This can be done by removing the bottle and shaking the bottle. Replace with a new bottle if the bottle is empty.

Note: Insure the continuous flow ether is turned on using electronic technician (ET). Consult your Caterpillar dealer for more information.

Automatic Metered Ether Injection System

Start the engine with the ether starting aid in the AUTOMATIC position.

After the engine starts, move the ether starting aid switch to the MANUAL position. Hold the switch in the MANUAL position until the engine runs smoothly and/or the white exhaust smoke stops.

Note: Regardless of the switch position, if the jacket water coolant temperature is at least 13°C (55°F), ether will not be injected.

Allow the engine to warm up at low idle for a minimum of five minutes before operating the machine.

Diesel Engines That Are Equipped With Glow Plugs

1. Move the engine governor control to the FULL THROTTLE position.

2. Turn the heat-start switch to the HEAT position. Maintain heat to the engine for the time that is indicated in table 6.

Table 6

Times For Glow Plug Starting Aid	
Starting Temperature	Glow Plug Heating Time
Above 16°C (60°F)	Zero minutes
16 to 0°C (60 to 32°F)	One minute
0 to −18°C (32 to 0°F)	Two minutes
Lower Than −18°C (0°F)	Three minutes

3. Turn the heat-start switch to the START position. Spray ether starting fluid into the air intake while you crank the engine.

Note: Ether starting fluid may not be required in all instances.

NOTICE
Never operate the starter for more than twenty seconds at a time without allowing two minutes for the engine to cool before attempting to start again.

Do not turn the heat start switch to the Heat position or the Start position with the engine warm or running. Engine damage could result.

Use ether sparingly. Spray ether into the air intake for approximately one second. Wait approximately two seconds before spraying again. Spray ether only while cranking the engine. Follow instructions on the container.

4. When the engine starts, return the engine governor control to the LOW IDLE position. Run the engine at the rpm that allows the engine to run smoothly. If necessary, return the heat-start switch to the HEAT position until the engine runs smoothly.

5. When the engine is stopped, turn the disconnect switch to the OFF position in order to prevent battery discharge.

Diesel Engines That Are Equipped With An Air Inlet Heater

⚠ WARNING

If your engine is equipped with an air inlet heater (AIH) for cold weather starting, only use an approved continuous flow ether system that is installed by Caterpillar or by a Caterpillar dealer. The engine software must be activated in order to insure that ether injection and AIH operation will not occure at the same time. Use of any other manually or automatically operated ether started aid system could cause an explosion resulting in injury or death.

⚠ WARNING

Explosion hazard! This machine is equipped with an air inlet heater. Do not spray aerosol starting aids such as ether manually into the intake. The use of ether without an ether attachment could result in an explosion or fires that could cause personal injury or death.

1. Engage the parking brake.
2. Unlock the steering column and the steering wheel. Adjust the steering column and the steering wheel to the desired position. Lock the steering column and the steering wheel.
3. Move the control levers to the HOLD position.
4. Push in the starting aid switch for the air inlet heater and release the starting aid switch.
5. The indicator light for the air inlet heater may come on during engine start-up. When the indicator light goes off, turn the engine start switch to the START position.
6. Depress the throttle pedal by 1/3 of the full pedal travel during engine cranking.
7. When the engine starts, release the engine start switch key and the throttle pedal. The throttle pedal will return to the low idle position.

After engine start-up, the air inlet heater can be activated for an extended postheat cycle. The air inlet heater will operate for an additional 30 seconds in order to smooth a rough running engine.

When you are starting the engine at temperatures below −9.5 °C (15 °F) or below 9 °C (48 °F) when above 460 m (1500 ft), the use of additional cold weather starting aids is recommended. A coolant heater, a fuel heater, an oil heater, or extra battery capacity may be required.

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Engine Starting with Jump Start Cables

SMCS Code: 1000; 7000

⚠ WARNING

Batteries give off flammable fumes that can explode resulting in personal injury.

Prevent sparks near the batteries. They could cause vapors to explode. Do not allow the jump start cable ends to contact each other or the machine.

Do not smoke when checking battery electrolyte levels.

Electrolyte is an acid and can cause personal injury if it contacts skin or eyes.

Always wear eye protection when starting a machine with jump start cables.

Improper jump start procedures can cause an explosion resulting in personal injury.

Always connect the battery positive (+) to battery positive (+) and the battery negative (−) to battery negative (−).

Jump start only with an energy source with the same voltage as the stalled machine.

Turn off all lights and accessories on the stalled machine. Otherwise, they will operate when the energy source is connected.

NOTICE

When starting from another machine, make sure that the machines do not touch. This could prevent damage to engine bearings and electrical circuits.

Turn on (close) the battery disconnect switch prior to the boost connection to prevent damage to electrical components on the stalled machine.

Severely discharged maintenance free batteries do not fully recharge from the alternator after jump starting. The batteries must be charged to proper voltage with a battery charger. Many batteries thought to be unusable are still rechargeable.

Use only equal voltage for starting. Check the battery and starter voltage rating of your machine. Use only the same voltage for jump starting. Use of a welder or higher voltage damages the electrical system.

Refer to Special Instruction, Battery Test Procedure, SEHS7633, available from your Caterpillar dealer, for complete testing and charging information.

Severely discharged maintenance free batteries will not fully recharge from the alternator alone after you jump start the machine. The batteries must be charged to the proper voltage with a battery charger. Many batteries that are considered to be unusable can still be recharged by this method.

Refer to Special Instruction, SEHS7633, “Battery Test Procedure” for complete information about testing and about charging. This document is available from your Caterpillar dealer.

When auxiliary starting receptacles are not available, use the following procedure.

1. Determine the reason that the engine will not crank. See Special Instruction, SEHS7768 for instructions about the use of a 6V-2150 Starting/Charging Analyzer. This is still a valid procedure if the machine does not have a diagnostic connector.

2. Engage the parking brake on the stalled machine. Place the transmission into neutral. Lower the equipment to the ground. Move all controls to the HOLD position.

3. Turn the start switch on the stalled machine to the OFF position. Turn off all accessories.

4. Turn the battery disconnect switch on the stalled machine to the ON position.

5. Move the machine that is being used as an electrical source near the stalled machine so that the jump start cables reach the stalled machine. **Do not allow the machines to contact each other.**

6. Stop the engine of the machine that is being used as an electrical source. If you are using an auxiliary power source, turn off the charging system.

7. Ensure that battery caps on both machines are tight and correctly placed. Ensure that batteries in the stalled machine are not frozen. Make sure that the batteries have enough electrolyte.

8. The positive ends of the jump start cable are red. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Some machines have battery sets.

Note: Batteries that are in series may be in separate compartments. Use the terminal that is connected to the starter solenoid. This battery or battery set is normally on the same side of the machine as the starter. The positive ends of the jump start cable are red. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Do not allow the positive cable clamps to contact any metal except for the battery terminals.

9. Connect the other positive end of the jump start cable to the positive cable terminal of the electrical source.

10. Connect one negative end of the jump start cable to the negative cable terminal of the electrical source.

Note: In 24 volt battery systems, the negative cable terminal of the electrical source is connected to the battery disconnect switch in the same battery set that is used in Step 9.

11. Finally, connect the other negative end of the jump start cable to the frame of the stalled machine. Do not connect the jump start cable to the battery post. Do not allow the jump start cables to contact the battery cables, the fuel lines, the hydraulic lines, or any moving parts.

12. Start the engine of the machine that is being used as an electrical source or energize the charging system on the auxiliary power source.

13. Wait at least two minutes before you attempt to start the stalled machine. This will allow the batteries in the stalled machine to partially charge.

14. Attempt to start the stalled engine. See your machine's Operation and Maintenance Manual, "Starting Above 0°C (+32°F)" for the correct starting procedure.

15. Immediately after you start the stalled engine, disconnect the jump start cables in reverse order.

16. Conclude the failure analysis on the starting system of the stalled machine and/or on the charging system of the stalled machine.

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Engine Starting with Auxiliary Start Receptacle

SMCS Code: 1000; 7000

Some Caterpillar products may be equipped with auxiliary starting receptacles as standard equipment. All other machines can be equipped with a receptacle from parts service. The installation of an auxiliary starting receptacle will provide a permanent receptacle for jump starting.

Two cable assemblies are also available in order to jump start the stalled machine from another machine that is also equipped with this receptacle or with an auxiliary power pack. Your Caterpillar dealer can provide the correct cables for your application.

1. Make the initial determination of the machine's failure to crank. Refer to Special Instruction, SEHS7768, "Use of 6V-2150 Starting Charging Analyzer Group". The procedure is applicable, even if the machine does not have a diagnostic connector.

2. Move the transmission control of the stalled machine into the NEUTRAL position. Engage the parking brake. Lower the attachment to the ground. Move all controls to the HOLD position.

3. Turn the engine start switch of the stalled machine to the OFF position. Turn off all accessories.

4. Turn the battery disconnect switch of the stalled machine to the ON position.

5. Move the machine that is being used as a power source so that the jump start cables can reach the stalled machine. **Do not allow the machines to contact each other.**

6. Stop the engine on the machine that is being used as a power source. If you are using an auxiliary power source, turn off the charging system.

7. On the stalled machine, connect the appropriate jump start cable to the auxiliary starting receptacle.

8. Connect the other end of the jump start cable to the auxiliary starting receptacle that is on the power source.

9. Start the engine on the machine that is being used as a power source. If you are using an auxiliary power source, energize the charging system on the auxiliary power source.

10. Wait for a minimum of two minutes while the batteries in the stalled machine partially charge.

11. Attempt to start the stalled engine. Refer to Operation and Maintenance Manual, "Starting Above 0°C".

12. Immediately after you start the stalled engine, disconnect the jump start cable from the machine that is being used as a power source.

13. Disconnect the other end of the jump start cable from the stalled machine.

14. When the engine is running and the charging system is in operation, conclude the failure analysis on the starting charging system of the stalled machine, as required.

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Engine and Machine Warm-Up

SMCS Code: 1000; 7000

Whenever a machine has been parked for a long period of time, some of the systems will cool to below normal operating temperatures. Always warm the machine systems before operating the machine at full operation.

Damage to engine valve control components can result from engine operation for short intervals during operation in very cold weather conditions. If the engine is not allowed to warm completely, the engine can be damaged by repeated starting and stopping.

During engine operation below normal operating temperature, fuel and oil are not completely burned in the combustion chambers. This fuel and oil causes soft carbon deposits on the valve stems. Generally, these deposits do not cause problems because these deposits are burned off during operation at normal engine temperatures.

Carbon deposits will interfere with valve operation. When the engine is started and stopped at short intervals, carbon deposits will form. The short operating times do not allow the engine to reach normal operating temperature. The carbon deposits will continue to build up. Valve operation is affected by carbon deposits. Carbon deposits can cause the following problems: burned valves, bent pushrods, and other damage to valve mechanism components.

To avoid valve damage, always run the engine until the coolant temperature is at least 82°C (180°F). This will keep carbon deposits on the valve stems at a minimum.

Thoroughly warming the engine will keep the other engine parts in better condition. This could also extend the service life of the engine. With less acid and less sludge in the oil, lubrication will be improved. This will give longer service life for engine bearings, piston rings, and other parts.

White smoke is generated when you start the engine in cold weather. In order to minimize white smoke, owners of 3208 Diesel Engines can install a 9N-3771 Cetane Injection Group. See your Caterpillar dealer for more information.

After the engine is warm, warm up the other systems. Start with the hydraulics. Run the engine at less than one-third throttle, and slowly move the control lever in order to lift the attachment. Initially, lift the control lever for a few centimeters (inches). Lower the attachment slowly. Continue the sequence: raising, lowering, extending, and retracting. Extend the travel during each cycle. Perform this operation for all hydraulic circuits. Alternate between all of the attachments.

Exercise the transmission and the power train. If you cannot move the control for the transmission, perform the following steps:

- Engage the parking brake or apply the brake pedal.
- Run the engine slightly above LOW IDLE.
- Shift the transmission several times from FIRST GEAR FORWARD to FIRST REVERSE.

Release the brake. Move the equipment forward and backward for several meters (feet). Exercise the machine for several minutes.

In order to reduce the total warm up time, start exercising the entire machine before you complete the hydraulic warm up time.

Operate under light load until the systems reach normal operating temperatures.

If the engine temperature is not high enough, enclose the engine and block the radiator. A thermostat that opens at a higher temperature will not increase the engine temperature if the engine is not under load.

In order to prevent seal damage and gasket damage, keep the engine crankcase breather pipe clear of blockage.

In extreme conditions, use a canvas over the engine compartment. Heat the engine area with a space heater. This will aid in starting the engine. Extending the canvas over the hydraulic components will provide initial warming of the components.

Multigrade lubricants (10W30) may be used successfully at ambient temperatures below the pour point of the oil. However, in order to use this oil, you must leave the engine running at low idle. This helps keep lubricants and compartments warm for the engine and for the transmission. Running the engine at low idle will not keep the hydraulic systems warm.

Cold weather operations require more time for completion than other operations. The extra time that is spent in properly caring for the equipment can prolong the life of the equipment. Longer equipment life will decrease overall cost. This is especially true in extreme conditions.

Parking Recommendations

i01837459

Parking

SMCS Code: 7000

Always park the machine in the proper area. Park the machine on wooden planks. The planks will keep the machine from freezing to the ground.

Before parking a track-type machine, operate the machine in forward and in reverse, on hard, dry material. Travel in second speed and in third speed. Move the machine 15 to 20 meters (40 to 60 feet) in each direction. This procedure ensures that the track parts are free.

Clean all debris from the roller frames and from the track. Support the attachments on wood blocks . The wood blocks will keep the attachments from freezing to the ground.

Follow the recommendations for stopping and for parking that are in the Operation and Maintenance Manual for your machine.

Maintenance Section

Fluid Recommendations

i02663274

Fluid Recommendations

SMCS Code: 1000; 1250; 1280; 1350; 1395; 7000; 7581

Reference: Refer to Special Publication, SEBU6250, “Caterpillar Machine Fluids Recommendations” for more information on fluids in your machine.

Antifreeze

NOTICE
Adding coolant to an overheated engine could result in damage to the engine. Allow the engine to cool before adding coolant.

If the machine is to be stored in, or shipped to, an area with freezing temperatures, the cooling system must be protected to the lowest outside (ambient) temperature.

The engine cooling system is normally protected to a minimum of−29°C (−20°F) with Caterpillar Antifreeze, when shipped from the factory unless special requirements are defined.

Frequently check the specific gravity of the antifreeze in order to ensure proper protection.

Glycol in the antifreeze provides freeze protection. Glycol in the antifreeze prevents water pump cavitation. Glycol in the antifreeze also reduces cylinder liner pitting. For optimum performance, Caterpillar recommends a solution that contains a 50/50 mixture of water and of glycol.

NOTICE
All Caterpillar diesel engines equipped with air-to-air aftercooling (ATAAC) require a minimum of 30 percent glycol to prevent water pump cavitation.

Most heavy-duty antifreezes use ethylene glycol. Propylene glycol may also be used. In a mixture that is 50 percent water, ethylene glycol and propylene glycol have similar properties that are relative to the following elements: freeze protection, control of corrosion, and compatibility with the seal. Check the glycol level of the antifreeze with the 1U-7298 Coolant/Battery Tester (Degrees Celsius) or with the 1U-7297 Coolant/Battery Tester (Degrees Fahrenheit). Tables 7 and 8 define the freeze protection for ethylene glycol and for propylene glycol.

Table 7

Ethylene Glycol	
Concentration	Freeze Protection
50 Percent	−37°C (−34°F)
60 Percent	−51°C (−60°F)

Table 8

Propylene Glycol	
Concentration	Freeze Protection
50 Percent	−29°C (−20°F)

NOTICE
Do not use propylene glycol in concentrations that exceed 50 percent glycol because of propylene glycol’s reduced heat transfer capability. Use ethylene glycol in conditions that require additional freeze or anti-boil protection.

Note: Propylene glycol antifreeze that is used in Caterpillar Diesel Engine cooling systems must meet “ASTM D6211-98 "Fully-Formulated Propylene Glycol-Based Engine Coolant for Heavy-Duty Engines”. When Propylene glycol antifreeze is used in heavy-duty diesel engines, regular treatments of Supplemental Coolant Additive (SCA) is required for protection of the liner. Consult your Caterpillar dealer for more information.

Fuel Recommendations

- Purchase fuel from a reputable supplier.
- Use fuel that at least meets the specifications for distillate fuel. These fuels have a minimum lubricity level of 3100 g. This result is obtained by conducting the Scuffing Load Wear Test (SBOCLE). If a High Frequency Reciprocating Rig (HFRR) is used for testing, you may expect a wear scar of .45 mm (0.018 inch) maximum at 60°C (140°F) or a wear scar of .38 mm (0.015 inch) at 25°C (77°F).

- Keep the fuel storage tank clean of water, debris and sediment.
- Drain water and sediment from the fuel storage tank weekly. Drain water and sediment before the tank is refilled.
- Keep the area around the fuel tank filler neck clean of debris in order to prevent contamination of the fuel tank.
- As required, clean the inside of the vehicle's fuel tank.
- Drain water and sediment from the vehicle's fuel tank daily. Drain the tank at the start of a shift. After the fuel tank has been filled, allow the fuel to settle for ten minutes. This will allow the water and sediment to separate from the fuel. Then, drain the water and sediment from the tank.
- Install water separators.
- Drain the water from the water separator daily.
- For some applications, Caterpillar high efficiency fuel filters are required in order to provide maximum life to the fuel system.
- Change fuel filters at the scheduled interval. Never fill the new fuel filter with fuel before installation. Use the fuel priming pump to remove air from the system.
- Install breather filters on the fuel tanks.

Fuel Information for Gasoline Engines

Use a regular grade of fuel or use an unleaded grade of fuel. These fuels must have a minimum octane rating of 87.

Fuel Information for Engines That Use LP Gas

Use grade HD5 LPB. LP Gas is a highly volatile fuel. LP Gas has an octane rating of 100 to 140. Follow local ordinances regarding the storage of tanks of LP Gas. Follow local ordinances regarding the filling of tanks for LP Gas.

Fuel Information for Diesel Engines Only

When diesel fuel is stored outdoors, the water will freeze after the water separates from the diesel fuel. Any effect that is caused by storing the fuel outdoors should immediately appear in the fuel. Fuel that is stored in underground tanks or fuel that is stored in a heated area will be easier to pump. However, moisture in the fuel will not freeze until the fuel is in the machine. Any effect that is caused by cold weather will not appear until the fuel has cooled to the outside temperature. It is preferable to determine any detrimental effects of temperature before the fuel is in the machine.

The two basic types of diesel fuel are No. 2 diesel fuel and No. 1 diesel fuel. No. 2 diesel fuel is a heavier diesel fuel than No. 1 diesel fuel. Heavier fuels can cause problems with fuel filters, fuel lines, fuel tanks, and fuel storage in cold weather. Heavier diesel fuels such as No. 2 diesel fuel can be used in diesel engines that operate in cold temperatures with a minimum amount of pour point depressant additive. For more information on fuels which include blends of No. 1 and No. 2 diesel fuel, consult your fuel supplier.

When you use No. 2 diesel fuel or other heavier fuels, some of the fuel's qualities may interfere with successful cold weather operation.

Reference: Refer to Special Publication, SEBU6250, "Caterpillar Machine Fluids Recommendations", "Characteristics of Diesel Fuel and Modification to Characteristics of Diesel Fuel" for more information.

There are several possible methods that can be used to compensate for the fuel qualities that may interfere with cold weather operation. These methods include the use of starting aids, engine coolant heaters, fuel heaters, and de-icers.

Starting Aids

The use of a starting aid is a conventional method of assistance for cold starts in low temperature conditions. A variety of starting aids are available for Caterpillar engines. Follow the recommendations that are provided by the manufacturer of the starting aid. Information about the use of starting aids is included in the Operation and Maintenance Manual for your machine.

Engine Coolant Heaters

These heaters heat the engine coolant. The heated coolant flows through the cylinder block. The flow of heated coolant keeps the engine warm. A warm engine is easier to start in cold weather. Most coolant heaters use electrical power. A source of electricity is necessary for this type of heater. Other heaters that burn fuel are available as a source of heat. These heaters may be used in place of the electrical heaters.

With either type of heater, starting aids and/or fuels with higher cetane numbers are less important because the engine is warm. Problems with fuel cloud point can cause the plugging of fuel filters. Problems with fuel cloud point cannot be corrected by engine coolant heaters. This is especially true for machines that allow the fuel filter to be cooled by air flow during operation.

Fuel Heaters

The fuel cloud point is related to problems with fuel filters. The heater heats the fuel above the cloud point before the fuel enters the fuel filter. This prevents wax from blocking the filter. Fuel can flow through pumps and lines at temperatures below the cloud point. The cloud point is often above the pour point of a fuel. While the fuel can flow through these lines, the wax in the fuel can still plug the fuel filter.

In some engine installations, small modifications can prevent problems that are caused by the cloud point. One of the following changes can prevent problems in many conditions: a change in the location of fuel filters and/or supply lines and the addition of insulation. In extreme temperatures, heating of the fuel may be required to prevent the filters from plugging. There are several types of fuel heaters that are available. The heaters use either engine coolant or exhaust gas as a heat source. Most of these systems will prevent problems with the filters without the use of de-icers. These systems may be ineffective when the fuel contains a large amount of dirt or of water. Use of a fuel heater can help eliminate some cold weather problems. A fuel heater should be installed so that the fuel is heated before flowing into the fuel filter.

Note: Only use fuel heaters that are controlled by thermostats or use fuel heaters that are self-regulated. Do not use fuel heaters in warm temperatures.

Select a fuel heater that is mechanically simple, yet adequate for the application. The fuel heater should also prevent overheating of the fuel. Disconnect the fuel heater or deactivate the fuel heater in warm weather. An unacceptable loss of fuel viscosity and engine power will occur if the fuel supply temperature is allowed to become too hot.

For additional information on fuel heaters, see your Caterpillar dealer.

De-Icers

De-icers lower the freezing point of the moisture in the fuel. De-icers are not generally needed when fuel heaters are used. If you experience trouble, consult your fuel supplier for recommendations of a compatible commercial de-icer.

Lubricants for Cold Weather

Before attempting to start the engine, make sure that the oil in the engine, the oil in the transmission, and the oil in the hydraulic system are fluid enough to flow. Check the oil by removing the dipsticks. If the oil will drip from the dipstick, then the oil is fluid enough to start the engine. Do not use oil that has been diluted with kerosene. Kerosene will evaporate in the engine. This will cause the oil to thicken. Kerosene will cause swelling and softening of the silicone seals. If your machine is equipped with a gasoline starting engine (earlier machine), make sure that the oil is fluid enough to flow.

If the viscosity of the oil is changed for colder weather, also change the filter element. If the filter is not changed, the filter element and the filter housing can become a solid mass. Drain all hydraulic cylinders and lines. After you change the oil, operate the equipment in order to circulate the thinner oil.

When you start an engine or when you operate an engine in ambient temperatures that are below−20°C (−4°F) use base oils that can flow in low temperatures. These oils have lubricant viscosity grade of SAE 0W or of SAE 5W.

When you start a machine or when you operate a machine in ambient temperatures that are below −30°C (−22°F), use a synthetic base stock multigrade oil. The oil should have a lubricant viscosity grade of SAE 0W or SAE 5W. Use an oil with a pour point that is lower than −50°C (−58°F).

Because the number of acceptable lubricants is limited in arctic conditions, Caterpillar has special recommendations for arctic conditions. Refer to Special Publication, SEBU6250, “Caterpillar Machine Fluids Recomendations”, “Lubricant Viscosities” for more information.

- **Engine Oils**

NOTICE
Using oils that are not recommended as first choice oils could result in shortened life of the engine.

First Choice – use a Cat DEO multigrade or a commercial diesel engine oil that meets the Cat ECF-1 specification with one of the following lubricant viscosity grades: SAE 0W-20, SAE 0W-30, SAE 0W-40, SAE 5W-30, and SAE 5W-40.

Second Choice – use a commercial oil that is API CI-4 (API CI-4 PLUS), API CH-4, or API CG-4 licensed. The oil must have one of the following lubricant viscosity grades: SAE 0W-20, SAE 0W-30, SAE 0W-40, SAE 5W-30, and SAE 5W-40.

Note: Do not use API CF-4 oils in Caterpillar machine diesel engines.

- **Transmission/Drive Train Oils**

NOTICE
Use of oils that are not recommended as first choice oils could result in reduced performance and shortened life to the transmission, differential, and final drive.

First Choice – use Cat Arctic TDTO or commercial oil that meets the following requirements: formulated from a full synthetic base stock without the viscosity index improvers, meets the performance requirements of the TO-4 specification, and requirements for the SAE 30 lubricant viscosity grade. Typical lubricant viscosity grades are listed below: SAE 0W-30, SAE 5W-30, and SAE 0W-20.

Second Choice – use a commercial oil with a TO-4 type additive package and use one of the following lubricant viscosity grades: SAE 0W-30, SAE 5W-30, and SAE 0W-20. These oils have not been tested against the TO-4 specifications.

Note: For maximum service life, use an oil with the highest lubricant viscosity grade that is allowed for the ambient temperature. **Refer to the "Lubricant Viscosities for Ambient Temperatures" tables and the associated footnotes in order to determine the recommended oil viscosity.**

- **Hydraulic Oils**

Any of the oils that have a minimum zinc additive of 0.09 percent (900 ppm) are acceptable. These oils are listed under the heading of "Engine Oils" or "Transmission/Drive Train Oils".

- **Final Drive and Axle Oil**

First Choice – Cat FDAO (Final Drive and Axle Oil) of the recommended viscosity grade.

Second Choice – commercial oil of the recommended viscosity grade that meets the Caterpillar FD-1 specification.

NOTICE
Cat FDAO or commercial oil meeting the Caterpillar FD-1 specification should not be used in compartments that contain friction material unless otherwise specified, because they do not develop sufficient friction coefficient to satisfy the requirements of most clutches and brakes.

- **Multipurpose Tractor Oil (MTO)**

Cat MTO (Multipurpose Tractor Oil) is available for use in the following systems for the Caterpillar Challenger tractor: implement steering, hydraulic systems, and steering control mechanisms. Cat MTO is also recommended for use in the rear drive axles of the Caterpillar Backhoe Loader and certain 500 Series Vibratory Soil Compactors. This oil has an ambient temperature range of −25°C (−13°F) to 40°C (104°F) for these applications.

For ambient conditions that are below −25°C (−13°F), check with your supplier. The multipurpose tractor transmission fluids that are commercially available must meet the required ambient temperature capability for your area. These fluids must also meet the Ford/New Holland specification of "M2C134-D".

Note: For recommendations that are specific to your machine, refer to the Operation and Maintenance Manual for your machine.

NOTICE
Cat MTO is not the same as Cat TDTO, and does not meet the Caterpillar TO-4 or TO-4M transmission/drive train oil specification. Cat MTO should not be used in compartments that specify TO-4 or TO-4M oil.

NOTICE
Cat MTO is not the same as Cat FDAO, and does not meet the Caterpillar FD-1 final drive and axle oil specification. Cat MTO should not be used in compartments that specify FD-1 oil.

Warm-Up Procedures for Machines that are used in Cold Weather (Generic)

Note: For recommendations that are specific to your machine, refer to the Operation and Maintenance Manual for your machine.

After the engine is warm, warm up the other systems. Start with the hydraulic system. Run the engine at less than one-third throttle and slowly move the control lever in order to lift the attachment. Initially, lift the control lever for a few centimeters (inches). Lower the attachment slowly. Continue the following sequence: raising, lowering, extending, and retracting. Extend the travel during each cycle. Perform this operation for all hydraulic circuits. Alternate between all of the attachments.

Exercise the transmission and the power train. If you cannot move the control for the transmission, perform the following steps:

- Engage the parking brake or apply the parking brake.
- Run the engine slightly above LOW IDLE.
- Shift the transmission several times from FIRST GEAR FORWARD to FIRST REVERSE.

Release the brake. Move the equipment forward and backward for several meters (yards). Exercise the machine for several minutes.

In order to reduce the total warm up time, start exercising the entire machine before you complete the hydraulic warm up time.

Operate under a light load until the systems reach normal operating temperatures.

If the engine temperature is not high enough, enclose the engine and block the radiator. A thermostat that opens at a higher temperature will not increase the engine temperature if the engine is not under load.

In order to prevent seal damage and gasket damage, keep the pipe for the engine crankcase breather clear of blockage.

In extreme conditions, use a canvas over the engine compartment. Heat the engine area with a space heater. This will aid in starting the engine. Extending the canvas over the hydraulic components will provide initial warming of the components. Follow all applicable safety guidelines.

Running the engine at low idle will not keep the hydraulic systems warm.

Cold weather operations require more time for completion than other operations. The extra time that is spent in properly caring for the equipment can prolong the life of the equipment. This is especially true in extreme conditions. Longer equipment life will decrease overall cost.

Battery Recommendations

i00793167

Battery Information

SMCS Code: 1401

⚠ WARNING

Personal injury can result from battery fumes or explosion.

Batteries give off flammable fumes that can explode. Electrolyte is an acid and can cause personal injury if it contacts the skin or eyes.

Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jumper cable ends to contact each other or the engine. Improper jumper cable connections can cause an explosion.

Always wear protective glasses when working with batteries.

The 1U-7297 Coolant/Battery Tester (Fahrenheit) or the 1U-7298 Coolant/Battery Tester (Celsius) are available for testing the condition of the battery fluid and for checking the freezing point of the coolant. These testers are optical refractometers. The optical refractometer will automatically compensate for temperature. The readings are correct without adjustment for temperature.

The temperature of the battery affects the battery's cranking power. When the battery is too cold, the battery will not crank the engine, even though the engine is warm. Keeping the battery warm will maintain at least 70 percent of the battery's cranking power. When possible, keep the batteries warm. Batteries may be stored in a warm environment or the battery compartment can be heated.

Whenever the engine operates below the normal rpm, the batteries may not be recharged. Whenever an engine is not being operated in cold weather, use a battery charger to keep the battery charged. A full charge prevents the battery from freezing.

All batteries should be kept charged to a corrected specific gravity of 1.250 or above.

If a hydrometer is used in place of the recommended refractometer, use the following table or follow the procedure to correct the reading.

In order to achieve the corrected reading, use the following procedure.

At the temperature of 27°C (81°F), the specific gravity should be 1.220. Subtract .004 from the reading for each increment of 6°C (10°F) below 27°C (81°F). The result should be 1.220.

Table 9

Corrected Specific Gravity for the Battery at the Specified Temperatures						
Temperature	**Actual Readings of the Hydrometer That Were Taken at Specific Temperatures**[1]					
27°C (80°F)	1.300	1.280	1.250	1.220	1.190	1.160
−18°C (0°F)	1.332	1.312	1.282	1.252	1.222	1.192
−23°C (−10°F)	1.336	1.316	1.286	1.256	1.226	1.196
−29°C (−20°F)	1.340	1.320	1.290	1.260	1.230	1.200
−34°C (−30°F)	1.344	1.324	1.294	1.264	1.234	1.204
−43°C (−45°F)	1.350	1.330	1.300	1.270	1.240	1.210
−54°C (−65°F)	1.358	1.338	1.308	1.278	1.248	1.218
Approximate State of Charge Shown as a percent of Full charge	100	90	75	50	25	0

(1) Scales of the hydrometer do not usually show decimal readings. A reading of 1280 is equivalent to a specific gravity of 1.280.

Tire Inflation Recommendations

i00793367

Tire Inflation Information

SMCS Code: 4203

Tires that are inflated below the recommended pressure will have shortened life. A tire that is inflated to the correct pressure in a 18 to 21°C (64 to 70°F) warm shop area will have an incorrect tire pressure in freezing temperatures.

Use dry nitrogen gas to inflate the tires. Nitrogen gas is N_2. Dry nitrogen is recommended in order to eliminate ice crystals. Ice crystals could hold the valve stem open in the tire.

The table shows the correct pressures for tires that are inflated in an area with a temperature of 18 to 21°C (64 to 70°F). These pressures are adjusted for the environmental working temperature of the machine.

Tire inflation should be done in a heated area. The tire bead will seat better when the tire bead is warm. The initial tire pressure should be fifteen to twenty percent higher than the operating pressure in order to seat the tire bead against the rim. Deflate the tires to operating pressure before operating the machine. The contact surface of tires will become flat in cold weather when a machine is parked. To return the tire to a normal shape, move the machine gradually.

Some tractors and some wheel tractor-scrapers are equipped with wheel coolant in order to prevent overheating of the rims and overheating of the tires during the braking operation. This coolant consists of a mixture of twenty percent ethylene glycol and eighty percent water. Even though freezing may begin at −12°C (10°F), these coolant solutions can be used in temperatures of approximately −51°C (−60°F).

Table 10

Recommended Inflation Pressure	Recommended Inflation Pressure that is Adjusted for a Specific Ambient Temperature			
	−1°C (30°F)	−18°C (0°F)	−29°C (−20°F)	−40°C (−40°F)
205 kPa (30 psi)	230 kPa (33 psi)	250 kPa (36 psi)	270 kPa (39 psi)	285 kPa (41 psi)
240 kPa (35 psi)	260 kPa (38 psi)	290 kPa (42 psi)	310 kPa (45 psi)	325 kPa (47 psi)
280 kPa (41 psi)	305 kPa (44 psi)	330 kPa (48 psi)	350 kPa (51 psi)	370 kPa (54 psi)
310 kPa (45 psi)	340 kPa (49 psi)	365 kPa (53 psi)	395 kPa (57 psi)	415 kPa (60 psi)
345 kPa (50 psi)	380 kPa (55 psi)	405 kPa (59 psi)	430 kPa (62 psi)	460 kPa (67 psi)
380 kPa (55 psi)	415 kPa (60 psi)	450 kPa (65 psi)	470 kPa (68 psi)	500 kPa (73 psi)
415 kPa (60 psi)	450 kPa (65 psi)	490 kPa (71 psi)	510 kPa (74 psi)	550 kPa (80 psi)
450 kPa (65 psi)	490 kPa (71 psi)	520 kPa (75 psi)	550 kPa (80 psi)	590 kPa (86 psi)
480 kPa (70 psi)	520 kPa (75 psi)	570 kPa (83 psi)	590 kPa (86 psi)	630 kPa (91 psi)
520 kPa (75 psi)	560 kPa (81 psi)	610 kPa (88 psi)	630 kPa (91 psi)	670 kPa (97 psi)
550 kPa (80 psi)	600 kPa (87 psi)	640 kPa (93 psi)	680 kPa (99 psi)	720 kPa (104 psi)
590 kPa (86 psi)	630 kPa (91 psi)	680 kPa (99 psi)	720 kPa (104 psi)	760 kPa (110 psi)
620 kPa (90 psi)	670 kPa (97 psi)	725 kPa (105 psi)	760 kPa (110 psi)	800 kPa (116 psi)
660 kPa (96 psi)	710 kPa (103 psi)	760 kPa (110 psi)	800 kPa (116 psi)	840 kPa (122 psi)
690 kPa (100 psi)	745 kPa (108 psi)	800 kPa (116 psi)	840 kPa (122 psi)	890 kPa (129 psi)
725 kPa (105 psi)	780 kPa (113 psi)	840 kPa (122 psi)	885 kPa (128 psi)	930 kPa (135 psi)
760 kPa (110 psi)	820 kPa (119 psi)	885 kPa (128 psi)	925 kPa (134 psi)	980 kPa (142 psi)
795 kPa (115 psi)	855 kPa (124 psi)	925 kPa (134 psi)	965 kPa (140 psi)	1030 kPa (149 psi)
830 kPa (120 psi)	890 kPa (129 psi)	965 kPa (140 psi)	1005 kPa (146 psi)	1060 kPa (154 psi)