APPLICATION AND INSTALLATION GUIDE

DIESEL ENGINE COMMISSIONING – 3600/C280

CATERPILLAR®

Contents

Foreword

This section of the Application and Installation Guide generally describes the commissioning of the Caterpillar® 3600/C280 engine. Additional engine systems, components and dynamics are addressed in other sections of this Application and Installation Guide.

Engine-specific information and data is available from a variety of sources. Refer to the Introduction section of this guide for additional references.

Systems and components described in this guide may not be available or applicable for every engine.

Diesel Engine Commissioning – 3600/C280

A well-planned engine installation will aid reliability, performance, and serviceability. To be successful, the installation designer must be aware of the application and installation requirements for Caterpillar 3600/C280 engines. As a first step, the designer should be aware of all pertinent Caterpillar reference publications, including the additional sections of this Application and Installation Guide, as well as other information available from the Caterpillar 3600/C280 family of engines.

SECTION CONTENTS

- Engine Performance Data
- Engine Instrument Panel & Generator

Control Panel Instrument Readings

Design Review

The engine and generator installation should be designed to give efficient and reliable operation. A poorly designed installation can hinder serviceability, and make routine maintenance and repairs difficult. The neglect of specific design requirements for mounting, alignment and support systems can lead to poor performance and increased cost of operation.

When the installation designer has completed a review of the Caterpillar application and installation requirements, a discussion should take place with Caterpillar dealer personnel to cover concerns he may have about specific areas of the design. This will establish ground rules for further working relationships in the design phase. After the initial installation drawings have been completed, follow-up discussions should take place with the designer to make sure the drawings meet application and installation guide requirements. As an aid in the review of the design, use the 3600/C280 Generator Set Design Review Report on page 4 of this guide or the 3500 Industrial Engine Design Review Report.

Explanation of Design

Review Report

The design review reports in this guide provide a checklist for dealer or Caterpillar representative use only, and is available from Caterpillar.

It is a checklist to determine if sufficient information has been provided to the installation designer for completion of initial layouts in compliance with requirements in the 3600 EPG Application and Installation Guide.

The form should be completed with general information about the owner, power station, and builder/installer using design criteria of the power station, record specific data concerning physical features of the site as well as the engine and generator support systems.

There is provision to record Caterpillar reference materials provided to the designer as well as a checklist for results of the design and serviceability review. Compliance with Caterpillar requirements is noted by placing an “X” in the box next to the system reviewed, indicating satisfactory or unsatisfactory compliance. If the design of a system does not comply, space is provided to record action required to follow-up and correct the problem areas.

After completion of the design review and design review form, and after reaching agreement on required corrective action, it is recommended that all concerned parties sign the form at the designated location.

Caterpillar 3600/C280 Generator Set Design Review Report

General:

Selling Dealer: _____ District or Subsidiary: _____

Servicing Dealer _____

Equipment Suppliers and Contractors: _____

Customer: _____

Address: _____

Application: Prime Power: _____ Continuous: _____ @ _____% load

Peak Shaving: _____ Standby: _____

Expected Annual Operating Hours: _____

Consist:

Engine Model: _____ Engine Arrangement No.: _____

OT Specification No.: _____ Serial No.: _____

Rating: _____ bhp: _____ bkW:_____ @ _____

Engine Cooling System: Separate Circuit: _____ Combined Circuit: _____

Governor/Actuator: _____ Forward Acting: _____ Reverse Acting: _____

Heinzmann: ____ 3161: ____ Other: _____

Describe: _____

High Idle: Specified: _____ OT Specification: _____

Low Idle: Specified: _____ % Droop Specified: _____

Fuel Used: Distillate: _____ Blended: _____ Residual: _____

Fuel (API): _____ Corrected Density: _____ (kg/L): _____ (lb/gal): _____

Fuel Treatment: Coalescing Filter:___ Centrifuge:___ Viscosity Control:___

Engine Coolant: Antifreeze: _____ Corrosion Inhibitor: _____

Oil to be used in engine: _____

Engine Site Conditions: Elevation: _____

Typical Ambient Temperature range for the year: _____ to _____

Types of Cooling: Radiator: _____ Cooling Tower: _____

Typical Powerhouse Temperature Range: _____ to _____

Atmospheric conditions: Typical Relative Humidity Level: _____%

Air Quality: Salty: _____ Dusty: _____ Clean: _____

Application Summary:_____

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The following parties have discussed and agreed to the results and required action during the design review process.

Field Engineer Signature: _____ Date: _____

Builder/Installer Signature: _____ Date: _____

Owner Signature: _____ Date: _____

Design Review Results

System	Design Compliance with 3600/C280 Engine Requirements
Air Intake Satisfactory ☐ Unsatisfactory ☐	
Cooling Satisfactory ☐ Unsatisfactory ☐	
Starting Satisfactory ☐ Unsatisfactory ☐	
Exhaust Satisfactory ☐ Unsatisfactory ☐	
Fuel Satisfactory ☐ Unsatisfactory ☐	
Lubrication Satisfactory ☐ Unsatisfactory ☐	

System	Design Compliance with 3600/C280 Engine Requirements
Engine Mounting Satisfactory ☐ Unsatisfactory ☐	
Driven Equipment Satisfactory ☐ Unsatisfactory ☐	
Safety and Alarms Satisfactory ☐ Unsatisfactory ☐	
Engine Monitoring Satisfactory ☐ Unsatisfactory ☐	
Ventilation Satisfactory ☐ Unsatisfactory ☐	

System	Design Compliance with 3600/C280 Engine Requirements
Serviceability Satisfactory ☐ Unsatisfactory ☐	
Equipment Safety Satisfactory ☐ Unsatisfactory ☐	
Generator Controls Satisfactory ☐ Unsatisfactory ☐	
Switchgear Satisfactory ☐ Unsatisfactory ☐	
Operation and Maintenance Satisfactory ☐ Unsatisfactory ☐	

System	Design Compliance with 3600/C280 Engine Requirements
Crankcase Ventilation Satisfactory ☐ Unsatisfactory ☐	
Noise/Emissions Satisfactory ☐ Unsatisfactory ☐	
Auxiliary Cooling Satisfactory ☐ Unsatisfactory ☐	
Satisfactory ☐ Unsatisfactory ☐	
Satisfactory ☐ Unsatisfactory ☐	
Satisfactory ☐ Unsatisfactory ☐	
Satisfactory ☐ Unsatisfactory ☐	

Construction Review

After the design review is satisfactorily completed, the next step is the construction of the installation site. During this phase, visit the construction site at least twice to perform a review of systems installation progress.

The first visit should follow installation of the Caterpillar 3600/C280 generator set units. Additional visits may be necessary, depending on the difficulty of the installation, and the stage of completion. Make the final visit before the commissioning process begins.

The objective of these visits is to determine if the previously approved design is being followed. These visits not only continue to produce a better understanding of Caterpillar requirements, but also provide a more reliable installation. Experienced construction builders will make necessary changes as soon as possible, to avoid costly delays and eventual customer downtime.

Explanation of Construction Review Report

The Caterpillar 3600/C280 generator set construction review is intended to provide a checklist for dealer use only, and is available from Caterpillar. The report is a simple checklist used to determine if the previously agreed on design is being successfully implemented during the construction process.

Fill out the report with general information about the owner, installation site and builder/installer, including the power station physical features. Provisions are made for recording the generator set systems' descriptions, including serial numbers, and manufacturer, where applicable.

When the construction and installation are in compliance with Caterpillar requirements, indicate this by placing an "X" in the box next to the system reviewed for satisfactory or unsatisfactory compliance to requirements. If a system does not comply, there is space to record the necessary corrective action.

After the construction review and the construction review form are completed, and any corrective action is agreed to, it is recommended that all concerned parties sign the construction review form at the designated locations on the report.

Caterpillar 3600/C280 Generator Set Construction Audit Report

General:

Selling Dealer: _____ District or Subsidiary: _____

Servicing Dealer _____

Equipment Suppliers and Contractors: _____

Customer: _____

Address: _____

Application: Prime Power: _____ Continuous: _____ @ _____% load

Peak Shaving: _____ Standby: _____

Expected Annual Operating Hours: _____

Consist:

Engine Model: _____ Engine Arrangement No.: _____

OT Specification No.: _____ Serial No.: _____

Rating: _____ bhp: _____ bkW:_____ @ _____

Engine Cooling System: Separate Circuit: _____ Combined Circuit: _____

Governor/Actuator: _____ Forward Acting: _____ Reverse Acting: _____

Heinzmann: ____ 3161: ____ Other: _____

Describe: _____

High Idle: Specified: _____ OT Specification: _____

Low Idle: Specified: _____ % Droop Specified: _____

Fuel Used: Distillate: _____ Blended: _____ Residual: _____

Fuel (API): _____ Corrected Density: _____ (kg/L): _____ (lb/gal): _____

Fuel Treatment: Coalescing Filter:___ Centrifuge:___ Viscosity Control:___

Engine Coolant: Antifreeze: _____ Corrosion Inhibitor: _____

Oil to be used in engine: _____

Engine Site Conditions: Elevation: _____

Typical Ambient Temperature range for the year: _____ to _____

Types of Cooling: Radiator: _____ Cooling Tower: _____

Typical Powerhouse Temperature Range: _____ to _____

Atmospheric conditions: Typical Relative Humidity Level: _____%

Air Quality: Salty: _____ Dusty: _____ Clean: _____

Application Summary:_____

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The following parties have discussed and agreed to the results and required action during the design review process.

Field Engineer Signature: _____ Date: _____

Builder/Installer Signature: _____ Date: _____

Owner Signature: _____ Date: _____

Construction Audit Results

System	Design Compliance with 3600/C280 Engine Requirements
Air Intake Satisfactory ☐ Unsatisfactory ☐	
Cooling Satisfactory ☐ Unsatisfactory ☐	
Starting Satisfactory ☐ Unsatisfactory ☐	
Exhaust Satisfactory ☐ Unsatisfactory ☐	
Fuel Satisfactory ☐ Unsatisfactory ☐	
Lubrication Satisfactory ☐ Unsatisfactory ☐	

System	Design Compliance with 3600/C280 Engine Requirements
Engine Mounting Satisfactory ☐ Unsatisfactory ☐	
Driven Equipment Satisfactory ☐ Unsatisfactory ☐	
Safety and Alarms Satisfactory ☐ Unsatisfactory ☐	
Engine Monitoring Satisfactory ☐ Unsatisfactory ☐	
Ventilation Satisfactory ☐ Unsatisfactory ☐	

System	Design Compliance with 3600/C280 Engine Requirements
Serviceability Satisfactory ☐ Unsatisfactory ☐	
Equipment Safety Satisfactory ☐ Unsatisfactory ☐	
Generator Controls Satisfactory ☐ Unsatisfactory ☐	
Switchgear Satisfactory ☐ Unsatisfactory ☐	
Operation and Maintenance Satisfactory ☐ Unsatisfactory ☐	

System	Design Compliance with 3600/C280 Engine Requirements
Crankcase Ventilation Satisfactory ☐ Unsatisfactory ☐	
Noise/Emissions Satisfactory ☐ Unsatisfactory ☐	
Auxiliary Cooling Satisfactory ☐ Unsatisfactory ☐	
Satisfactory ☐ Unsatisfactory ☐	
Satisfactory ☐ Unsatisfactory ☐	
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Satisfactory ☐ Unsatisfactory ☐	

Evaluation Guidelines

Note: The project manager should insure proper systems integration between all disciplines before the start of commissioning.

This document gives guidance to personnel commissioning Caterpillar 3600/C280 Generator Sets. The included information should be used to prepare the final commissioning report and documentation of performance of each engine as it goes into full service. Any deletion of information can cause confusion during future maintenance or warranty activity. Each of the items included in each discussion should be documented in the final report that establishes the initial condition of engine operation.

Commissioning has many activities associated with its definition. The field engineer responsible for commissioning must be prepared to give guidance to all areas of the project as well as being the final evaluator of operating systems and engine performance. This guide is intended to assist in this activity and to complement the existing 3600 EPG Application and Installation Guide.

It is important to understand the standards established for each system and the specifications accompanying those standards to give the Caterpillar 3600/C280 generator set the highest reliability and customer satisfaction possible. Any deviation from the standards or specifications can be detrimental to the life of the product. Normal operation of systems can cause deterioration in their performance over their expected life. Starting with deviated standards and specifications will only shorten the expected life.

The items included in the system guides are intended to assist in the documentation of facts to be included in the final commissioning report. Pictures and other schematics or visual aids as attachments to the commissioning report are valuable to help others understand the descriptions given in the report.

It is to be understood that Caterpillar personnel are available to commission 3600/C280 generator sets for a nominal fee described in the "3600 Quoter." If this is not done, the responsibility of system evaluations and full commissioning is that of the described party designated by the project manager for any project.

Air Intake System Evaluation

To evaluate the engine air intake system for the 3600/C280 engines, the total system must be evaluated from the air source for the engine to the inlet to the turbocharger. This may include engine room air or the air cleaner may be mounted outside the engine room. Whichever the case, consider the following items when evaluating the air intake system.

Combustion Air

Air inlet temperature to engine should not exceed 49°C (120°F).

Is the quantity of air available for combustion sufficient? This requires approximately 0.1 m^3/min/bkW (2.5 ft^3 of air/min/bhp) for engines using distillate fuel. Heavy fuel engines may require 30 to 40% more for proper component temperatures.

The engine room or enclosure should not experience negative pressure if combustion air and ventilation air are from the same source.

For extremely cold climates, an alternate warm filtered air source should be available for starting the engine.

Remote Mounted Air Cleaners

Air cleaner elements must be accessible for periodic maintenance.

The air cleaner elements must be mounted in the housing to assure the engine does not ingest foreign material due to incorrect positioning.

The air cleaner housing air outlet must have flexible transition attaching the air inlet ducting. Double band clamping at each end of the flex is required to assure non-filtered air does not enter the ducting.

The air cleaner housing must have surface protection when subjected to a harsh environment such as salty atmosphere.

Air inlet restriction is recommended not to exceed 381 mm H_2O (15 in H_2O). New, clean systems should be near 127 mm H_2O (5 in H_2O) restriction to allow appropriate service intervals for the filter elements.

The air cleaner housing must be mounted in a position that will not allow recirculating exhaust gases, crankcase fumes, rain or sea spray to mix with the combustion air.

The air cleaners should draw outside air through the elements and use air ducting to the turbocharger inlet.

In cold climates, the air cleaner can be subjected to filter icing when mounted outside of the engine room. Consider the year-round conditions at the site and insure provisions are available for the engine to receive filtered inlet air during all periods of engine operation.

Air Inlet Ducting

No rivets or mechanical fasteners can be used in the construction of the ducts. The intake air ducting must be clean and free of any weld slag, debris, rust or corrosion prior to operating the engine. This must be inspected prior to initial startup.

The interior surface of the intake ducting must be protected from future rust and corrosion due to intake air quality.

The intake air piping must have long gentle radius bends (2 x Dia = Radius) and generous straight lengths if a single straight length from the air cleaner housing is not possible.

The diameter of the intake ducting must be the same or larger than the air cleaner housing outlet and the air inlet adapter for the turbocharger. Any abrupt changes must be

avoided, see "Air Intake System" of the 3600 EPG Application & Installation Guide for more information on air inlet ducting.

The air inlet restriction created by the ducting must be minimal to allow normal service intervals for the air cleaner elements.

Air inlet ducting must not be rigidly mounted to the air cleaner housing or to the turbocharger inlet. Flexible non-metallic connections must be used between the ducting of both the air cleaner housing and the turbocharger. The turbocharger must not support the weight of the ducting. Also, there must be double band clamping to insure non-filtered air does not enter the engine.

Observe the proximity of the exhaust piping and the air intake ducting. Ensure there is no heat transfer between the two sets of piping. If evident, insist either or both are insulated to protect both air inlet temperature and the non-metallic connections.

Air inlet ducting must be inspected for leaks during engine operation.

Filtered Engine Room Air

An air intake silencer can be used at the turbocharger inlet if combustion air supplied to the engine room is properly filtered.

If an intake silencer is remote mounted, the same requirements apply for ducting to the turbocharger inlet as in the case of a remote mounted air cleaner housing.

Air Cleaner Provided by Others

Air cleaners not provided by Caterpillar for the engine must meet airflow and contamination containment requirements to protect the engine from shortened component life. This requires prior factory approval.

Cooling System Evaluation

A cooling system evaluation for the 3600/C280 engines must include engine operating parameters, external system piping, water quality and external cooling components. A properly controlled cooling system is essential for satisfactory engine life and performance. Defective cooling systems and careless maintenance are a direct cause of many engine failures. Consider the following when evaluating the engine cooling system.

Engine Cooling Circuits

Water flow from the left side pump (viewed from the rear) is split between the aftercooler and oil cooler. Flow balance orifices are used on the outlet of both components. Ensure these orifices are in place.

The right-hand pump (viewed from the rear) supplies water to the jacket water system. Ensure the orifice(s) are in place.

The two-pump design can be used as either a combined or separate circuit cooling system. The temperature of the water is always inlet controlled. During performance testing of the engine, ensure the appropriate inlet water temperature is being supplied to both circuits and the temperature rise of the water is within specified limits.

System Coolers

3600/C280 generator sets have the coolant water cooled by various means. The most common are radiators. Others include heat exchangers and cooling towers.

It is the user/installer's responsibility to provide proper venting and isolation of the cooler for required maintenance or repair.

If an open cooling tower system is used, insure the water from the cooling tower does not enter the engine. Debris collected by the water from the atmosphere can be detrimental to water pumps and be deposited in the engine. Consider the cooling tower water as raw water and configure the engine cooling circuits as a closed-loop system using a heat exchanger. It is the user/installer's responsibility to ensure sufficient make up water to the cooling tower.

Note: Raw water should be good quality and treated with chemicals to prevent heat exchanger fouling.

When not practical to route vent lines long distances to a common venting point, an APCO air release valve, Model 200AB.3, or equivalent is recommended. It has a cast iron body and stainless steel trim. The cover includes a 1/2 inch NPT plug that should be removed for installation of a nipple and ball allowing rapid venting during initial fill of the system. The air release valve's internal diaphragm collects entrained air and automatically releases it to atmosphere during operation.

Cooling System External Pressure Drop

Regardless of the type of cooler used, the external system resistance in the piping and through the cooler must be adjusted to a specification based on the rated speed of the engine and full flow to the external system. Circuits with thermostats must be replaced with blocked open thermostats (for adjustment only) to allow full flow.

The inlet and outlet pressure of the coolant must be measured as close to the engine as possible to obtain a correct external system resistance. Customer piping must have monitoring ports added for this measurement.

Ensure the flow control orifice is positioned in the outlet line(s) from the engine to the cooler. A lockable plug valve is preferred, but a plate-type orifice or other adjustable valves are permitted. It is important to maintain the external system resistance at the specified value. Refer to the Cooling System section of the 3600 Application & Installation Guide.

Expansion Tank

The water level in the expansion tank should be at the highest point in the cooling system to allow proper venting during initial filling of the system. This will also provide a single fill point for the cooling system.

If the expansion tank is not the highest point in the system, it is the user/installer's responsibility to provide an auxiliary expansion tank at the highest point in the system.

The auxiliary tank must be interconnected with the expansion tank to provide complete venting of the system.

Any other cooling system component should have vent lines run to the auxiliary tank or must be vented independently.

Initial filling of the system must be done at a rate so that complete venting of the cooling system can occur. Always be ready to add a supplemental volume of water to system at initial start-up in case air has been trapped in the system. The Caterpillar expansion tank is provided with a 48.3 kPa (7 psi) pressure cap. During testing and adjusting the external system resistance, the pressure cap must be removed. Install the pressure cap prior to the engine performance testing under load.

When altitude becomes a consideration for the boiling point of water, ensure that the standard pressure cap is adequate to prevent coolant boiling below the alarm and/or shutdown protection settings. For example, a jacket water temperature shutdown would require a 51.7 kPa (7.5 psi) cap at sea level to maintain 104 °C (219°F) setting. At 3048 m (10,000 ft), the pressure cap would only provide the equivalent of 27.6 kPa (4 psi) and the boiling point of water is reduced to approximately 93 °C (200°F). The shutdown setting would not protect the engine. A 96.5 kPa (14 psi) cap would be required.

If an expansion tank pressure cap is not used, adjust water temperature alarm and shutdown contactors according to atmospheric conditions to ensure adequate engine protection.

If a non-Caterpillar expansion tank or a shunt style cooling system is provided for the engine, a complete test must be done complying with requirements listed in LEKQ7235, Cooling System Field Test, EDS 50.5.

Cooling System Protection

Protecting the engine from cooling system problems is imperative. Ensure the engine is equipped with the following, and the projection system functions according to specification.

- High jacket water temperature alarm and shutdown
- High oil temperature alarm and shutdown
- Jacket water pressure alarm and shutdown
- High air inlet manifold temperature alarm
- Low water level alarm

It is the user/installer's responsibility to provide additional pressure and temperature gauges and alarms in the external system for the operators to monitor daily. Detection of a developing cooling system problem can prevent an unscheduled shutdown of the engine or an operation alarm condition.

Central Cooling Systems

Cooling multiple engines from a common system is not recommended. A devoted cooler for each engine is preferred.

If a central cooling system is required for the installation, ensure that the system performance is evaluated with the maximum heat rejection possible from all engines being cooled from the system. Since every system, application and installation is unique, Caterpillar approval is required.

External System Piping

The external system piping must be clean and free of weld slag and other debris that can be detrimental to engine components.

Inspect cooling system piping prior to the initial filling of the system. If debris is found, insure the piping is cleaned before filling the system.

Install temporary strainers at the engine in the coolant inlet line(s) prior to initial engine operation. Operate the engine at no-load and rated speed for at least 15 minutes. Remove the strainers and check for debris. If debris is found, install the strainers and repeat the operation. Continue this procedure until no debris is found in the screen. Do not adjust external system resistance with the strainer installed. The temporary strainers are available from Caterpillar for 4 in. (4C9045), 5 in. (4C9046) and 6 in. (4P9047) pipe.

If a permanent strainer in the coolant inlet lines is provided by the user/installer, ensure pressure drop across the strainer can be monitored. Excessive pressure drop can cause improper coolant flow to the engine. The same procedure should be followed for permanent strainers as described for temporary strainers during initial engine operation. At maximum flow condition, any clean strainer should have maximum capacity to create no more than 10 - 14 kPa (1.5 - 2.0 psi) pressure drop when clean.

External piping must be isolated from the generator set. The recommended flexible couplings are; (4P5906) for 4 in. pipe, (4P5905) for 5 in. pipe and (4P5907) for 6 in. pipe. The couplings should be installed between the point of piping support on the generator set and the closest external piping support to the engine.

Corrosion Protection

Ensure Caterpillar guidelines established for water quality are followed precisely. These guidelines are published by Caterpillar and available in the standard publication system. Two sources for information are:

- LEBV0915, Engine Installation and Service Handbook
- SEBD0970, Coolant and Your Engine

Ensure the proper quality of fresh water is installed in the system. Also ensure that the water is properly treated with corrosion inhibitor.

If ambient conditions require anti-freeze to be used, ensure only low silicate anti-freeze is installed.

Ensure that the Cooling System Test Kit (8T5296) is used to evaluate the concentration of corrosion inhibitor in the system. Excessive concentrations are as detrimental to the engine as insufficient concentrations.

Heat Recovery

Recovering heat from the engine coolant can improve the efficiency of the operation, but can also be detrimental to the engine if not designed and installed properly.

Ensure any external temperature regulators for the cooling system do not, in any way, inhibit operation and temperature control of the engine temperature regulators.

Ensure external heat recovery components do not contribute excessive resistance to the coolant flow.

Inlet temperature control at the engine is many times misunderstood during the design of the system. Ensure that the water temperature returning to the engine has been cooled sufficiently to achieve the required coolant temperature at the engine pump inlet(s). Very simply, for the jacket water system, 1/3 of the flow at 95°C (203°F) cannot be mixed with 2/3 of the flow at 90°C (194°F) and achieve 90°C (194°F) coolant temperature into the engine jacket water system.

Cooling System Performance

The complexity of the external cooling system, which may include heat recovery and/or some other cooler, is best understood by reviewing the installed system and producing a schematic of that system. The schematic should indicate all the system flow paths, test and monitoring points, and external system components.

Include the system schematic as an attachment to the commissioning report.

Assign 900 series description numbers to each of the test and monitoring points and record on the commissioning report test sheet.

Starting System Evaluation

Air starting, either manual or automatic, is the typical starting system for 3600/C280 generator sets, but indeed not the only system. The components of this system or any other system can have a significant affect on the life of the starters. Consider the following when evaluating a starting system.

Air Compressor

The air compressor must be sized to match the air receiver tank(s) make-up rate due to starting. Also consider generator set site for altitude and air density.

An air dryer on the compressor outlet is suggested to prevent water vapor in the air from freezing if expanded below 0°C (32°F).

Air Receiver Tanks

Ensure the air receiver tanks are sized to provide the required consecutive engine starts without depletion of air pressure below the minimum starting pressure.

Receiver tanks must have manual or automatic drains to allow oil and

water condensate to be drained daily to prevent damage to the starters. Operators must be informed of this requirement.

Receiver tanks should have manual or automatic drains to allow oil and water deposits to be drained daily to prevent damage to the starters. Operators must be informed of this requirement.

Receiver tanks must meet specific characteristics, such as the specifications of the American Society of Mechanical Engineers (ASME). Ensure each receiver tank has been tested at 1.5 times the normal working pressure unless local codes require some greater value. Set the tank relief valve pressure at a level below the test pressure.

Receiver tanks must be equipped with a maximum pressure relief valve and a pressure gauge. These should be monitored periodically to assure proper operation.

Air Supply Piping

Piping should be sized to provide a minimal pressure drop of supply air from the receiver tank to the engine starters. Piping should not be smaller than the connection at the engine.

Piping should be routed so that water vapor and oil deposits collect at a trap in the lowest point in the piping. The trap should be drained daily. Operators must be informed of this requirement.

Prior to initial start-up of the engine, disconnect the air piping from the engine and allow controlled air to blow any water vapor, oil deposits or debris out of the pipe to prevent ingestion into starters.

Engine Starters and Accessories

The starter lubricator should be adjusted during the initial starting of the engine to limit slobber of starter lubricant at the starter air outlet.

Care should be taken when starting the engine so the starter silencer discharge does not endanger personnel safety. If the discharge is directed toward any potential occupied area, provide shielding between the starter and the area in question.

Alternate Forms of Starting

There may be situations when electric starting or turbine air starters are provided on the engine. Each should be treated in a similar manner as the standard air starting system.

Electric starters must have enough battery potential to complete the consecutive starts required without overheating the cables or starters.

Turbine air starters also require multiple start demonstration. Ensure air capacity is available for this activity.

Exhaust System Evaluation

The exhaust system for 3600/C280 engines must be evaluated from the exit of exhaust gases from the turbocharger to the atmospheric conditions existing at the muffler outlet. Fuel consumption and engine component life are affected by a non-designated or incorrectly installed exhaust system.

Consider the following items when evaluating the exhaust system.

Exhaust System Warnings

The engine installer must protect engine room equipment and personnel from the heat of exhaust system piping.

The engine installer must provide appropriate drains and/or rain caps to protect the engine from rainwater entering the engine through the exhaust piping. The last few feet of the exhaust outlet should be installed to prohibit rainwater entry without inducing excessive exhaust backpressure.

The use of a common exhaust system between engines is to be strictly avoided.

The turbocharger must be protected from debris entering the exhaust outlet during construction of the exhaust piping. A properly tagged blanking plate is recommended. The tagged plate must be removed prior to initial engine operation. The debris collected on the plate must not go into the turbocharger.

Exhaust System Piping

The exhaust system piping must be made of a material to withstand the effects of exhaust gas temperature, pressure, velocity and thermal expansion. Ensure that any insulation added to exhaust piping does not deteriorate the piping since the pipe temperature will be higher than if uninsulated.

The backpressure of the total piping system must be minimal to allow for muffler restriction, outlet piping from the muffler and piping degradation during the life of the engine. Fuel consumption and component life will be affected if the backpressure is beyond the recommend value of 254 mm H_2O (10 in H_2O).

The exhaust backpressure on each bank of the twin turbocharged 3612/C280-12 and 3616/C280-16 (vee) engines must be balanced; even when the dual pipes exiting the turbochargers are transitioned into one larger pipe going to the muffler. Do not allow gas flow to turn at a right angle during a transition. Do not allow the exhaust system piping for a vee engine to be routed vertically from each turbocharger and then be blended horizontally. This will cause excessive backpressure on one bank. Blend the exhaust gases into a common pipe before the direction change is made or during a long radius bend in the directional change.

Exhaust piping should not be supported from the engine package.

There must be expansion joints and vertical supports in the appropriate positions to assure free movement of the exhaust piping during thermal expansion.

The exhaust piping should be rigidly supported, (with off-engine supports) near the engine to minimize compression and offset of the engine exhaust bellows. Exhaust pipe expansion must be in the direction away from the engine. Rollers are strongly recommended when vertical supports are required

between expansion joints and rigid supports.

The exhaust piping routing must not interfere with the service of the engine. Pay particular attention to the use of an overhead bridge crane.

A point for measuring exhaust system backpressure should be in a straight length of the exhaust pipe at least 3 to 5 pipe diameters away from the last size transition change from the turbocharger outlet. System backpressure measurement is part of the engine performance testing.

Distillate Fuel System Evaluation

Clean fuel meeting Caterpillar fuel recommendations provides outstanding engine service life and performance; the use of lesser fuels is the user's responsibility. To assure the engine is receiving good, clean fuel, the entire system must be evaluated from the fuel storage tank to the engine. In addition to the fuel being consumed, the system is considered to include the controls for fuel to the engine. The governor control system should be described along with pertinent information concerning the governor interaction with the engine operation. Consider the following when evaluating the fuel system.

Fuel Tanks

The fuel level in the tanks should be maintained as full as possible at all times. The rise and fall of fuel level can pull moist air into the tank through the vent, leading to water condensation with temperature changes.

Fuel tanks vented to atmosphere must have some form of flame arrester in the vent opening to prevent possible flames from entering or exiting the tank. The outlet opening in the tank vents should have a fine mesh screen to act as a flame arrester as a minimum precaution. Other forms of flame arresters may be used. Also ensure that the vent opening is never left totally open to the atmosphere.

The fuel supply piping should draw fuel from at least 50 mm (2 in.) above the bottom of the tank.

The fuel return to the day tank should enter at the top and opposite the supply end of the tank.

The tank drain must be able to drain the complete contents of the tank as well as being used as a sediment drain.

Fuel Lines

Galvanized fittings or piping must not be used in any portion of the lines.

Fuel line size and length must conform to the fuel transfer pump inlet restriction limit and the maximum fuel return restriction. The inlet restriction must not exceed 39 kPa (5.7 psi) and the fuel return line restriction must not exceed 350 kPa (51 psi). These values should be measured and recorded. Note that these requirements are independent of each other and should not be combined in any evaluation.

Fuel lines must be treated (pickled) and coated inside with lube oil prior to final assembly. “Refer to Caterpillar Flushing and Pickling Guidlines.”

Fuel lines must never be smaller than the engine connections of 31.7 mm (1.25 in.) pipe for supply and 25.4 mm (1 in.) pipe on return. Customer fuel piping to the engine should not be smaller that the inside diameter of the engine mounted inlet and return fuel piping. Flexible connections must be used at both the fuel inlet and return, connecting the customer piping to the engine mounted piping.

Fuel Filters

Initial fuel filter differential should be monitored to eliminate premature plugging of engine filters.

The user and/or installer are responsible for providing primary filtering of fuel supplied to the engine. Water separation is of prime concern. Water separators or coalescing filters should be installed. If fuel does not meet the required recommendations, a fuel centrifuge/purifier should be used.

An initial stock of engine fuel filters should be on-site prior to initial starting of the engine.

Fuel Coolers

A fuel cooler may be required when the return fuel is not returned to the main tank and the day tank is not large enough to handle the heat transfer from the injection pumps. The fuel cooler should be sized to cool fuel returning to the day tank below 40°C (100°F), with distillate fuel.

Note: Refer to the Fuel System section of the 3600 EPG Application & Installation Guide for additional information on fuel temperature requirements.

An air-to-fuel cooler is preferred. A water-to-fuel cooler is allowable, but there must be an awareness that a cooler failure can result in water entering the fuel supply, leading to subsequent, possible, fuel injector failures.

Governors and/or Actuators

The type of governor being used, and its operating characteristics, must be described on the commissioning report.

If a hydra-mechanical governor is used, ensure that compensation is adjusted to provide engine stability for synchronizing and load changes.

If an electronic governor and hydra-mechanical ball head backup actuator is being used, ensure proper engine operation with both governing systems. Refer to the Starting System Evaluation section of this guide for the appropriate starting and stopping procedure for the engine.

The high idle of the engine, (for each governor system used) must agree with the droop setting if the engine is to operate in droop mode.

Caution: With an electronic governor and a backup ball head actuator, the ball head governor speed must be set above the electronic governor speed by a minimum of 15 rpm, (plus any droop). Excessive speed on the ball head can cause engine overload if a paralleled unit goes

off-line during parallel and ball head operation.

Ensure stability for synchronizing and load changes when using total electric governor systems.

Control System - ADEM III (C280 only)

Verify the loaded flash file in the ECM is correct for the application. Ensure the governing control system is on the correct setting for the application, using Caterpillar Electronic Technician. If the ADEM III is being used to control the engine speed, refer to Caterpillar media number RENR5083 for instructions on governor adjusting. If Direct Rack setting is used, setup governor using manufacturers recommendations.

Lubrication System Evaluation

The lubrication system supplies a constant oil flow to engine components. Oil is filtered, cooled and pressure regulated throughout the engine operating range. Bearing failure, piston ring sticking and excessive oil consumption are classic symptoms of oil related engine failures. Maintaining the lubrication system, scheduled oil sampling and quality oil can mean the difference between repeated oil related failures and satisfactory engine life. Consider the following when evaluating the Caterpillar 3600/C280 engine lubrication system.

Engine Oil

The oil to be used in the engine must meet Caterpillar 3600/C280 engine oil requirements prior to filling the oil sump. Record the oil brand and type.

Note: Refer to the Lubrication section of the 3600 EPG Application & Installation Guide for additional information.

A system must be in place to properly handle the waste oil from engine oil changes.

Oil samples should be scheduled every 250 engine hours with appropriate transportation to provide adequate turn around time for results. Submit a sample of new oil for testing prior to the first interval sample. If transportation is a serious problem, ensure the minimum oil change period is communicated. Only after several sampling periods during this mode of operation, can the engine be allowed to go beyond the minimum change period. Ensure the appropriate oil information is provided to the operating personnel and other appropriate personnel to enforce this. Instruct the personnel on trending the results of the oil analysis. Refer to the appropriate manuals for further description:

- SEBU6121, Operation and Maintenance Manual for 3606 and 3608 engines
- SEBU6122, Operation and Maintenance Manual for 3612 and 3616 engines

Engine Sump

The oil sump must be filled through the coil filler tube. Do not remove the engine crankcase cover to fill the sump.

The user must connect oil sump drain valves to external piping for draining oil during an oil change. Additionally, a flexible connector should be provided between the external piping and the drain valve.

A dedicated pump should be used if oil is to be pumped into and out of the oil sump. This helps eliminate the chance of foreign material or debris entering the oil sump.

Ensure cold engine oil level is correct and check the oil level several times during initial engine operation. Allow engine oil temperature to reach normal operating temperature 82 - 85°C (180 - 185°F). The dipstick must be marked for proper operating level at rated speed and load.

Engine Prelube

If equipped, ensure the air prelube motor is properly lubricated prior to operation.

Check the air receiver tank's sizing for the required starting requirements. Consider air prelubing requirements if so equipped.

Is the time for prelubing within the required time for starting the engine?

Electric prelube systems must have motor starters sized for current draw to maintain pump operation until prelubing is complete.

Continuous prelube systems must have the Caterpillar spill-tube system to prevent oil collecting in cylinders resulting in hydraulic lock and damage to cylinder components upon start-up.

Oil Pressure and Temperature

Safety shutdowns and alarms should be provided for these engine operating parameters.

Mounting and Alignment Evaluation

The 3600/C280 generator set packages using the Caterpillar rigid base are self-supporting structures. The package will maintain alignment if the floor is true (flat). The Caterpillar spring vibration isolators can be adjusted to minimize forces transmitted to the floor. Consider the following when evaluating the proper mounting of the package and checking alignment of the engine and generator or engine and drive equipment on-site.

Vibration Isolators

It is the user/installer's responsibility to provide adequate number of anchor bolts between the floor and the bottom of the isolator if the generator set is to be paralleled with one or more other generator sets.

The snubber bolts on the isolators should be tightened hand-tight and locked in that position prior to starting the engine. Refer to the Vibration section of the 3600 EPG Application & Installation Guide for further instruction of isolator adjustment.

The leveling nuts should be adjusted if the isolators are not level.

Ensure the dampening blocks between the snubber push plate and the inner spring cage plate are installed properly.

Adjust snubber bolt tightness during normal generator set operation to ensure proper vibration dampening to match the installation site requirements.

Note: Tightening snubber bolts greater than finger tight reduces isolator efficiency. It is normal for engine motion to increase during startup and shutdown. Should this motion be intolerable, tighten snubber bolts slightly; remember, for maximum durability of the isolators, some clearance is required.

Note: System piping or any support stands should not be located in front of base-mounted vibration isolators; this will prevent access to isolators for serviceability.

Engine Base

If generator and/or engine have been removed during shipment, ensure engine, coupling and generator mounting bolts are properly torqued prior to alignment checks.

Ensure flexible connectors are used between the generator set and external system components rigidly mounted off the package.

Engine to Generator Alignment

Ensure that the engine and generator are properly aligned by taking bore and face dial indicator readings. The engine must be prelubed before the appropriate alignment procedure can begin for either single or two-bearing generators.

Make necessary adjustments to the alignment prior to starting the engine.

Record the final alignment measurements and include the measurements as an attachment to the commissioning report.

Check the crankshaft endplay and crankshaft deflection. Include the measurements as an attachment to the commissioning report.

A vibration signature must be taken on each generator set. Record the readings and include as an attachment to the commissioning report.

Driven Equipment Evaluation

Driven equipment for the 3600/C280 engines have been selected based on the particular load profile of the site necessary to be compatible with the total system. Driven equipment can be in many configurations, but each must be evaluated according to the external distribution system requirements. When more than one generator is involved in the driven equipment, each must be described in the commissioning findings report.

Consider the following items while evaluating the driven equipment.

Generator

Record the serial number of the generator and other appropriate data relating to the voltage and generator capacity.

Ensure that the generator space heaters have been operational several days prior to the anticipated start-up date. To be effective in many situations, covering the air inlet and outlet screens on the generator may be necessary.

Ensure that the generator space heaters are controlled to be off during generator set operation and on during shutdown periods. There are contacts available in the engine electrical system to control this or an alternate arrangement may be considered.

Ensure that the generator windings have been meggered prior to initial excitation. In addition, the cables between the generator and first circuit breaker should be meggered.

Ensure the generator mounting, alignment and connections are correct based on the contents of the 3600 EPG Application & Installation Guide.

Safety System Evaluation

The safety system on the engine gives early alert to operators of a pending problem or shutdown to the engine to protect the engine and/or generator from imminent danger or limit contingent damage due to failure. Proper maintenance of the system is imperative for constant protection. Consider the following when evaluating the generator set safety system.

Engine Contactors

Ensure minimum shutdown and alarms are supplied for the engine. For the requirements of generator set engines refer to the Equipment Selection section of the 3600 EPG Application & Installation Guide.

The contactors at the engine must demonstrate trip settings according to specifications for alarm and shutdown requirements.

The alarm or shutdown fault signal must be wired to remote annunciation points to alert operators.

Ensure contactor capillary tubes have not been damaged.

An emergency stop button must be available at the engine.

Generator Safety Relays

Ensure Resistive Temperature Devices (RTD)s for generator winding and bearing(s) temperatures are connected to instrumentation to monitor and alarm temperature faults found in the bearings or the windings of the generator.

Confirm a relay coordination study has been completed for proper setting of protective relays in the switchgear.

External Engine Support Systems

The user must provide alarms and/or shutdowns on external system components that can adversely affect engine operation in a fault condition. These components may include fuel day tanks, primary fuel filters and/or centrifuges, radiator fans and similar devices.

The user must provide both audible and visual annunciation of faults in both the engine room and the control room. This should include horns, rotating beacons or any other form of audible or visual alert.

Emergency Stops

The user must provide remote, emergency stop buttons allowing an operator to safely shutdown the system without endangering personnel.

The stop buttons must be guarded from accidental personnel contact, but accessible by trained personnel in case of an emergency in the engine room and the control room.

Monitoring System

Monitoring the generator set requires periodic readings of gauges and readouts during a 24-hour period to ensure all the systems are operating normally. Consider the following when evaluating a system for monitoring generator set operation.

Generator Monitoring System (GMS)

3600/C280 EPG packages equipped with GMS should have sensors checked and calibrated before the engine is put into service. These sensors include transmitters, resistive temperature devices, thermocouples, jacket water detectors, oil mist detectors, contactors and thermocouples. Refer to RENR2491 for testing and calibrating.

Engine Operating Parameters

Gauges and instrumentation, whether on the engine gauge panel or mounted by user/installer on the external systems, should give accurate readings of operational parameters for the oil, water, fuel, air and exhaust systems for the engine.

Periodic maintenance of oil, fuel and air filters is based on differential pressure as well as hours. Ensure differential pressure gauges or restriction indicators are provided to monitor filter condition. An hour meter is required to monitor operating time.

Generator Operating Parameters

The user is responsible to ensure that the generator output can be properly monitored to allow correlation with other data and to monitor electrical production.

The user is responsible for monitoring generator winding and bearing conditions.

External Engine Support Systems

The user is responsible for providing gauges and/or instrumentation to monitor operation of the external engine support systems. These should include but are not exclusive to the following:

- Fuel day tank site glass
- Oil storage tank site glass.
- Water temperature to and from external cooler. This may include radiators, heat exchangers or cooling towers.
- When strainers are permanently installed before the pump inlets, monitor pump inlet pressure for condition of strainers.

Daily Log Sheet

The user is responsible to provide a log sheet to record all gauge and instrumentation readings periodically by operators and/or automatic monitoring system.

The user is responsible for maintaining trained personnel capable of recognizing operational

changes in a monitored parameter, and be aware of the effect the change may have on engine operation.

Ventilation System Evaluation

The heat radiated from generator sets and switchgear can cause the site temperature to rise. This can adversely affect personnel as well as generator set and switchgear performance. Ideally, clean, cool air should be supplied to switchgear rooms and engine rooms and flow across and around the equipment to carry the radiant heat out of the engine room.

Consider the following when evaluating the ventilation system.

Engine Room Ventilation

Ventilating air should enter near the floor of the engine room and then flow upward around the engine before exiting above the engine.

Building ventilation should be designed to bring the coolest air to the generators or driven equipment.

If the building has a pitched roof, ventilating air should flow out at the peak or near the top of the gable ends. The source of the air must be low in the room and rise across the engine or generator set and other equipment.

For personnel comfort, maintain air velocity at 1.5 m/sec (5 ft/sec) in areas of heat sources or areas exceed 38°C (100°F).

Potential dead air spaces should be checked for temperature rise during engine operation. Check all electrical and mechanical equipment in the dead air space for any detrimental effect from the temperature rise. Require corrections if necessary.

Engine room pressure should not become excessively negative. This would indicate a shortage of ventilating air or excessive ventilating fans if equipped.

Switchgear Room Ventilation

Cool, dry ventilating air should flow across the switchgear cabinets to remove the radiated heat created during generator set operation.

Switchgear room pressure should not be negative. This would indicate a shortage of ventilating air.

Serviceability Evaluation

Well-designed engine rooms include features contributing to the serviceability of the engine(s) and support equipment. These features can include an overhead lifting, push carts, component storage and cleaning, and building equipment arrangement along with the required tools.

Consider the following for the evaluation of serviceability.

Engine Component Removal

Overhead and side clearance must be provided around the engine for major component removal and use of necessary tools. Unfortunately, at the time of commissioning, it may be too late to change the configuration in some cases.

Overhead lifting equipment must be provided. Most all major engine components are heavier than one person can safely lift. Review the overhead features for multi-direction

motion. Most engine component removal involves at least two-direction motion for removal.

Multiple engine installations should be arranged to use the same overhead lifting equipment without major disassembly of piping or ducting.

Equipment should be available for engine component movement to and from the engine room.

Engine Maintenance

The generator set installer is responsible for providing an engine service platform to perform all periodic maintenance functions. This should consider all daily inspections and activities including an engine overhaul.

Overhead and/or side clearance and a platform must be provided for servicing all periodic maintenance components. For example, changing air, fuel or oil filters and setting valve lash.

Reserved Work Area

A work area should be provided in the engine room for disassembly and cleaning of engine components and other engine support equipment. The area must have overhead lifting capacity sized for the largest component to be placed in this area.

Spare Parts Storage

Reserve an area for storage of spare parts and tools for all equipment in the engine room. The parts and tools should be inventoried to insure ready access during a repair. Ensure the area can be locked to prevent the loss of parts or tools that would impair scheduled maintenance or repair.

Equipment Safety Evaluation

The commissioning engineer must be able to recognize a safe operating environment. The entire system operation must be reviewed to provide operator safety during any normal or abnormal situation.

Consider the following when evaluating the safety of operating systems.

Engine Room

Hot engine water pipes should be shielded or guarded to prevent operator contact.

All generator drive components and damper guards must be in place prior to operating the engine.

All floor openings in the engine room must be covered with plating or grating.

Chains and hooks on overhead lifting equipment must not endanger personnel.

Floors must be cleaned of any debris or liquid spills.

Engine heat shields must be in place prior to operating the engine.

Remote emergency system stops must be guarded, but must operate during a safety simulation.

Test fire suppression systems prior to allowing normal operation. If this has already been completed, verify a certificate of system operation exists.

Independently test all emergency stops for the engine while operating at no load.

Check engine room noise levels in normal operating areas and compare to general rules or local specifications. Include this data in the commissioning report.

Control Room

Ensure that the control system meets local fire protection codes.

Ensure that control room emergency stops are guarded to prevent accidental contact.

Ensure that all high voltage equipment and cabinets are inaccessible via locks and/or cages with locks.

Ensure Kirk-Key interlocks are available for the appropriate switchgear cabinets.

Check control room noise levels and compare to general rules or local specifications. Include this data in the commissioning report.

Generator Control Evaluation

Control of generator output is imperative to maintain the residential and/or commercial customers during prime power operations. The generator sets in severe climates are extremely important to provide life support power. Standby generator sets can also be applied in both of the above situations. It is not typically the responsibility of the commissioning engineer to make these systems operate according to required specifications, but to ensure the systems are compatible with the design requirements.

Consider each of the following items during the evaluation and the specific application requirements during the evaluation.

Generator Voltage Control

The voltage regulator must have the voltage droop adjusted to be compatible with the system and/or with other generator sets being paralleled to provide electrical power onto a distribution buss.

For paralleled generator sets, cross-current compensation is necessary.

Ensure automatic voltage control systems have manual control that can be operated if problems develop with the automatic control.

Although not required, monitoring exciter DC voltage is a common gauge to detect any diode or surge suppressor problem in the exciter. Ensure the gauge is operating properly, if provided.

Several different voltage regulators are supplied for specific applications. Volts-per-Hertz, constant voltage and the combination of both functions are available. Ensure that the regulator output to the generator provides the correct system voltage and voltage response to load changes.

If a constant voltage regulator is used, ensure that the excitation circuit can be turned off before the engine is started and ramped up to speed, or is stopped and ramped down in speed. Operating at other than synchronous speed can be very detrimental to the voltage regulator.

Generator Monitoring

Generators are supplied with either 10 Ohm or 100n Ohm RTDs

mounted in the windings and the bearing housing(s). Ensure the temperatures can be monitored daily. Several types of alarms and or shutdowns are optional. If included, ensure they function properly.

Ensure generator voltage, amperage, power factor and kW load are gauges in the control panel and are monitored on a daily basis. Initial readings should be compared to engine operating parameters to ensure proper wiring.

Switchgear Evaluation

Switchgear is a necessary part of distributing generated electrical power, as well as providing input to monitoring and control systems. This equipment's interaction and possible detrimental effect on engine and generator operation makes it necessary to ensure that the system functions according to specifications.

Consider the following when evaluating switchgear systems.

Switchgear Cabinets

Ensure that switchgear cabinets are properly vented and ventilation air is available.

Switches and controls not involved in daily operations should be mounted inside the cabinets.

Ensure that any high voltage cabinet has Kirk-Key interlocks (or equivalent) to lock the cabinet and prevent accidental personnel contact.

Current and Potential Transformers

Inspect the mounting and wiring of all current and potential transformers to ensure they are installed properly before energizing the voltage control circuit. This is imperative for proper monitoring of engine operation.

Circuit Breakers

Ensure the circuit breaker has been manually tested before installing in the test position.

Ensure the circuit breaker is in the test position during any testing of the generator controls and/or engine safety system.

Initial energizing of the electrical system with the circuit breaker should be coordinated with all on-site personnel.

Electrical Cables

Electrical cables between the generator and the switchgear cabinets must be high-pot tested prior to terminating. Review data from tests and include in the commissioning report.

Ensure terminations have shielding removed from ends prior to connecting.

Generator Protective Relays

Ensure the generator protective relay setting for both the instantaneous and time-delay agree with the results of the relay coordination study of the system.

Control Voltage

A mixture of control voltages may require multiple banks of batteries. Ensure the appropriate charging method for the batteries is maintained.

Ensure the batteries are placed between the charger and the controls to prevent the controls from

receiving voltage spikes or stray currents from the battery charger.

Paralleling Operations

Protect manual paralleling operation against out-of-phase engagement of the circuit breaker. A synch check relay and SPM synchronizer are typical components to provide this protection.

Auto paralleling is typically controlled by an SPM synchronizer; both engine speed and generator voltage, or just engine speed, can be controlled. If voltage control is not included, the system voltage must not vary more than the voltage regulator compensation capability with a closed circuit breaker.

Parallel generators must have the same pitch to prevent harmonics creating current flow on the neutral side of the system. Use a neutral ground resistor if neutral currents exist.

Operation and Maintenance Evaluation

Operation and maintenance training for operators designated to be involved in the operation and/or maintenance of 3600/C280 generator sets, and the associated support equipment, is an important factor in achieving dependable generator set operation. The commissioning engineer should be prepared to give this training on the generator set.

Consider the following when evaluating how well operation and maintenance will be completed.

Engine Operation and Maintenance

Ensure each operator is introduced to the maintenance guide for the engine and each of the topics explained. This may require the presentation to be given several times to match the shift work of the operators. Coordinate the effort with the appropriate operating supervisor.

Ensure instruction is given for starting and stopping the engine. Include a demonstration at the engine and allow each operator to observe and follow the directions given. Follow the procedure outlined in the starting system evaluation section.

The servicing dealer is responsible for providing appropriate forms and records keeping information.

Engine Support Equipment

Review the list of equipment suppliers that will be on-site during commissioning. If the representative is going to be on-site, ensure they are prepared to train operators.

Mechanical Training

Operators and maintenance personnel should be trained to make minor repairs if needed; or provide assistance to the dealer mechanic while making a repair.

Maintenance Contracts

Review any maintenance contract to ensure all maintenance and repair responsibilities are defined for each activity. Also, understand and record the duration of the contract. Ensure responsible personnel are properly trained to perform their respective functions. If a training deficiency is found, take corrective action.

Crankcase Ventilation System Evaluation

Normal combustion pressures of an internal combustion engine cause a certain amount of blow-by past the piston rings into the crankcase. These crankcase fumes must be piped away from the engine to atmosphere.

Consider the following when evaluating crankcase ventilation systems.

Crankcase Breathers

Crankcase breathers can be arranged in several positions to match the best piping routing away from the engine. Ensure that breather connections can be easily disconnected for scheduled maintenance.

Crankcase Ventilation Piping

Generally, piping of the same size as the breather outlet is suitable unless the length and or bends cause excessive restriction and a false crankcase pressure measurement.

Note: See the Ventilation section of the 3600 EPG Application & Installation Guide for additional information on pipe sizing requirements. Consideration must be given to the blow-by requirements of a worn engine when initially sizing the pipe.

A separate ventilation piping system must be installed for each engine.

Piping should slope away from the engine at a minimum of 13 mm per 300 mm, (1/2 in. per ft).

The outlet should be configured to collect oil droplets prior to fumes exiting the piping.

If piping rises from the engine, a trap must be installed to collect any condensation or oil droplets before they re-enter the breathers.

Crankcase fumes must never be discharged in the engine room.

Startup & Shutdown Procedure

The following procedure is intended to serve as a guide for:

- 3600/C280 engine startup procedures
- Design consideration of the engine control systems

Before Starting the Engine

1. Check coolant level in expansion tank site glass.
2. Check crankcase oil level using the engine dipstick. Be sure to use the side marked Engine Stopped Cold Oil.
3. Assure all protective guards are in place and the barring device disengaged.
4. Open and close drain valve on the bottom of the starting air tank and fuel day tank to drain condensation and sediment from bottom of tanks.
5. Open starting air shutoff valve at side of engine.
6. Check starting air pressure. Ensure maximum 1551 kPa (225 psi) or minimum 862 kPa (125 psi) air pressure for starting.
7. Check air starter lubricator oil level. Check prelube motor

lubricator oil level (if air prelube equipped).

8. Ensure that the engine control system allows engine starting from the engine starting panel (local/remote) and the engine starting speed is at idle.
9. Other engine support systems or control systems must be prepared for the start of the engine. This includes items such as reduction gear prelube, injector tip cooling, cooling systems, voltage regulator ON/OFF switch, idle/rated switch and external piping system valve position check.
10. Customer fuel piping to the engine should not be smaller that the inside diameter of the engine mounted inlet and return fuel piping. Flexible connections must be used at both the fuel inlet and return, connecting the customer piping to the engine mounted piping.

Starting the Engine

1. Put the engine fuel ON/OFF switch to the ON position.
2. Put the engine START/PRELUBE switch in the PRELUBE position. The green indicator will be observed when prelube oil pressure reaches 7 kPa (1 psi). The engine can not be started. It is a good idea to verify oil pressure on the gauge if time is not a critical factor.
3. Move engine START/PRELUBE switch to the START position while viewing the engine tachometer. When 130 to 150 rpm is achieved, the START/PRELUBE switch can be released from the start position. If not, the starters will automatically disengage when the engine reaches 170 rpm.
4. The engine should stabilize speed at low idle; typically 350 rpm. Ensure gauge panel oil and fuel pressure reach normal levels.
5. Inspect engine for any leaks and/or abnormal noises.
6. After assured of proper engine operation, adjust engine and other control systems to increase engine speed/load to achieve normal operation.

After Starting the Engine

1. Close the starting air shutoff valve.
2. After engine is started and at rated speed and load, fuel pressure should be between 800 to 840 kPa (116 to 121.8 psi). Fuel pressure should be adjusted if not within tolerance using the engine mounted fuel regulator.
3. Monitor engine operating parameters every hour and record on an appropriate log sheet.
4. Compare operating parameters recorded to specifications for normal engine operation on a daily basis. Monitor operating parameter trends and take action when discrepancies are found.

Stopping the Engine

1. Reduce load on engine to zero.
2. Allow engine to operate for the period of time necessary to

reduce jacket water temperature to 85°C (185°F) and the average cylinder exhaust temperature (of all cylinders; when exhaust pyrometer equipped) is reduced to below 150°C (300°F). Fifteen minutes will normally achieve the cooler temperatures. Cool down is best performed at or near rated speed whenever possible.

3. Adjust other control systems prior to engine shutoff; voltage regulator, idle/rated switch, raise/lower switch.
4. Turn the engine fuel ON/OFF switch to the OFF position. The engine will coast to a stop by energizing the fuel shutoff solenoid.
5. Check and put into shutdown mode, all other non-engine system components that have been operating to support engine operation.

Caterpillar 3600/C280 Generator Set Commissioning Report

General:

Selling Dealer: _____ District or Subsidiary: _____

Servicing Dealer _____

Equipment Suppliers and Contractors: _____

Customer: _____

Address: _____

Application: Prime Power: _____ Continuous: _____ @ _____% load

Peak Shaving: _____ Standby: _____

Expected Annual Operating Hours: _____

Consist:

Engine Model: _____ Engine Arrangement No.: _____

OT Specification No.: _____ Serial No.: _____

Rating: _____ bhp: _____ bkW:_____ @ _____

Engine Cooling System: Separate Circuit: _____ Combined Circuit: _____

Governor/Actuator: _____ Forward Acting: _____ Reverse Acting: _____

Heinzmann: ____ 3161: ____ Other: _____

Describe: _____

High Idle: Specified: _____ OT Specification: _____

Low Idle: Specified: _____ % Droop Specified: _____

Fuel Used: Distillate: _____ Blended: _____ Residual: _____

Fuel (API): _____ Corrected Density: _____ (kg/L): _____ (lb/gal): _____

Fuel Treatment: Coalescing Filter:___ Centrifuge:___ Viscosity Control:___

Engine Coolant: Antifreeze: _____ Corrosion Inhibitor: _____

Oil to be used in engine: _____

Engine Site Conditions: Elevation: _____

Typical Ambient Temperature range for the year: _____ to _____

Types of Cooling: Radiator: _____ Cooling Tower: _____

Typical Powerhouse Temperature Range: _____ to _____

Atmospheric conditions: Typical Relative Humidity Level: _____%

Air Quality: Salty: _____ Dusty: _____ Clean: _____

Application Summary:_____

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The following parties have discussed and agreed to the results and required action during the design review process.

Field Engineer Signature: _____ Date: _____

Builder/Installer Signature: _____ Date: _____

Owner Signature: _____ Date: _____

Analysis of Test Data & Physical Systems

System	Summary of Results
Air Intake Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Cooling Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Exhaust Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Fuel Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Lubrication Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Monitoring System Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Driven Equipment Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	

System	Summary of Results
Safety and Alarms Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Engine Monitoring Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Crankcase Ventilation Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Starting Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Ventilation Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Equipment Safety Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	

System	Summary of Results
Serviceability Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Operation and Maintenance Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Generator Controls Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Switchgear Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Noise / Emissions Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
Auxiliary Cooling Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	

System	Summary of Results
_____ Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
_____ Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
_____ Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
_____ Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	
_____ Satisfactory ☐ Unsatisfactory ☐ Not Complete ☐	

Engine Performance Data

Record the following data using field test equipment while the engine is being load tested under site conditions.

_____% Load

900 Series Points	Description	Actual Measured

Comments: _____

_____

_____

Engine Instrument Panel & Generator Control Panel Instrument Readings

Engine S/N: _____ Generator Set

Description		0%	25%	50%	75%	100%	110%
Actual Load	EMW						
Voltage	kV						
Amperes	A						
Power Factor	LAG	0.	0.	0.	0.	0.	0.
Gen Bearing Temp	°C						
Gen Stator Temp	°C						
Engine Coolant	°C						
Air Inlet Man. Temp	°C						
Air Inlet Restr. LH	kPa						
Air Inlet Restr. RH	kPa						
Oil Pressure	kPa						
Oil Temperature	°C						
Oil Filter Press Diff	kPa						
Fuel Filter Press Diff	kPa						
Crankcase Pressure	kPa						
Air Inlet Man. Press	kPa						
Fuel Pressure	kPa						
Engine Hours							
Stack Exh Temp RH	°C						
Stack Exh Temp LH	°C						
Cyl Exh Temp 1	°C						
Cyl Exh Temp 2	°C						
Cyl Exh Temp 3	°C						
Cyl Exh Temp 4	°C						
Cyl Exh Temp 5	°C						
Cyl Exh Temp 6	°C						
Cyl Exh Temp 7	°C						
Cyl Exh Temp 8	°C						
Cyl Exh Temp 9	°C						
Cyl Exh Temp 10	°C						
Cyl Exh Temp 11	°C						
Cyl Exh Temp 12	°C						
Cyl Exh Temp 13	°C						
Cyl Exh Temp 14	°C						
Cyl Exh Temp 15	°C						
Cyl Exh Temp 16	°C						

Comments: _____

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