Generator Commissioning Procedure

Generator No.	

REVISION HISTORY

Revision	Date	Description
2	01/02/2011	Inserted section 4.2 for circuit breaker settings. Added reverse power test (4.9.7). Section 4.10 added to verify PLC instrumentation. Added section 4.11 facility to record serial numbers.

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1 INTRODUCTION

1.1 Purpose

This document is designed to verify the generator control systems functions to support normal drilling operations, and to minimize redundant controls testing.

This document defines the commissioning requirements for fully installed, operational equipment, and demonstrates the capability of the systems to perform their functions as designed.

All functions defined in this document must be verified prior to commissioning.

1.2 How To Use This Procedure

This document describes the procedure for one generator section. A copy of the procedure should be printed out for each generator section, and completed accordingly.

The front sheet of this document can be used as a cover sheet for each generator procedure. Enter the generator number in the box provided.

Parts of the procedure require that other generator sections are available for testing, therefore it is not possible to complete the entire procedure for one generator without partially commissioning at least one other section. It is not a requirement of this procedure that the testing be completed in a linear and uninterrupted fashion.

A blank punch list is provided at the end of this document which may be used to record items requiring rectification. It may be copied as many times as required and added to the procedure for each generator.

It is a matter of judgement for the commissioning engineer whether or not testing may continue with issues outstanding.

Finally, section 4.12 contains a declaration that all test have been satisfactorily completed and must be signed by the senior commissioning engineer, customer representative and certifying authority representative (where applicable).

1.3 Equipment Description

The switchboard includes 4 generator sections, each equipped with the following essential equipment:

- Main Circuit Breaker
- Circuit Breaker Trip Unit
- Voltage Regulator (Basler DECS200-1-L)
- Engine Governor (Woodward 2301D)
- Panel mounted instrumentation
- Panel mounted control switches
- Panel mounted indications
- Remote indications (PLC)

The generators sections are interconnected by a 600V, 6000A 3-phase busbar system. Each generator section is capable of full operation without the PLC controller being present or energised.

Synchronisation of the generators to the main bus is achieved through a common, remote synchronising panel.

2 TESTING PREREQUISITES

2.1 General

Prior to commencing commissioning operations, all parties involved must ensure that the required testing conditions have been met and that all required equipment and materials are on hand and made available to commissioning personnel.

2.2 Safety Pre-Checks

The commissioning personnel must conduct a pre-commissioning safety meeting to address all safety issues, and to ensure all participants have a complete understanding of the scope of the procedure.

All non-essential personnel must stay clear of the test location for the duration of the commissioning procedures.

All commissioning personnel must wear standard protective equipment.

All participants shall be aware of potential environmental hazards during all phases of the procedure. Ensure that proper precautions are taken to minimise the impact of any environmental hazard encountered.

Any member of the test team may stop the testing at any point should danger to personnel, the environment, or equipment exist.

Verify all bus work is clear of any debris and tools before powering up.

Ensure that the engine overspeed, emergency stops and any other mechanical protection systems have been verified and are fully operational.

Verify all outgoing feeder breakers and isolators are open status before applying power to the main bus.

Remove all fuses connected to the 600V busbar in all switchboard sections.

All personnel must follow the appropriate lock out/tag out procedures.

2.3 Test Equipment

The following test equipment will be required:

- Digital Multimeter with 1000V probes
- AC Clamp Meter
- 1000V Megger (or similar insulation test equipment)
- 2-channel oscilloscope with 1000V rated probes (differential type preferred)
- Torque wrench (calibrated in Nm)

3 COMMISSIONING OUTLINE

The commissioning procedure for each generator section is outlined as follows

- Turn the engine over using the starter and verify the presence of the excitation voltage from the Permanent Magnet Generator (PMG).
- If sufficient residual magnetism is present, the phase rotation of the main generator connections to the incoming circuit breaker is verified.
- Confirm the presence of engine speed feedback signals.
- Start the engine and verify that voltage excitation build-up.
- Confirm that voltage regulation is operational and stable.
- Confirm that speed regulation is operational and stable.
- Synchronise the generator on to a dead bus.
- Check synchronisation of generator section to a live bus.
- Check emergency stops.
- Check any relevant alarm functions.
- During load tests, confirm that load sharing and regulation is within the requirements of the certifying authority.

4 COMMISSIONING PROCEDURE

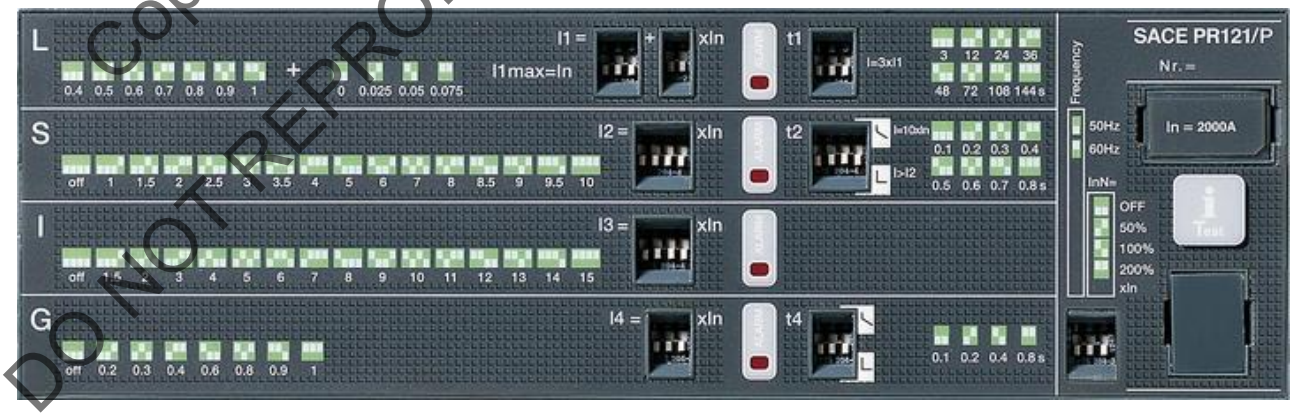
Perform the following for each generator:

4.1 Visual Checks

Item	Procedure	Result	OK	Comments
4.1.1	Visually inspect the section for signs of damage, loose connections and remove all debris and tools			
4.1.2	Check that all earth bonding is in place			
4.1.3	Inspect the busbar and generator incoming connections for mislaid tools and clear all debris.			
4.1.4	Check for loose or missing busbar bolts, especially at splice plates. Where loose or missing bolts are found the following should be used: M16 265Nm (274Nm max) M12 100Nm (110Nm max) M10 50Nm (60Nm max) M8 30Nm (35Nm max) M6 10Nm (13Nm max)			

4.2 Circuit Breaker Settings

Verify the circuit breakers settings with the co-ordination study recommendations and indicate below:



4.3 Insulation Tests

Item	Procedure	Result	OK	Comments
4.3.1	Ensure all control fuses have been removed and that all isolators, feeders and fuses connected to the 600V busbars have been opened or removed. Check for safety fuses in the rear of each compartment.			
4.3.2	With a 1000V Megger, measure the resistance at the generator incoming terminals as follows:			
	A phase to ground	_____MΩ		
	B phase to ground	_____MΩ		
	C phase to ground	_____MΩ		
	A phase to B phase	_____MΩ		
	B phase to C phase	_____MΩ		
	C phase to A phase	_____MΩ		
4.3.3	With a 1000V Megger, measure the resistance at the main busbar terminals as follows (this test must be performed during commissioning of the first generator, but may be omitted during the commissioning of subsequent generator sections at the discretion of the engineer):			
	A phase to ground	_____MΩ		
	B phase to ground	_____MΩ		
	C phase to ground	_____MΩ		
	A phase to B phase	_____MΩ		
	B phase to C phase	_____MΩ		
	C phase to A phase	_____MΩ		

4.4 Generator Start Up

Item	Procedure	Result	OK	Comments
4.4.1	Verify that all engine and generator safety checks have been performed and that the engine and generator are fit to run.			
4.4.2	Using the engine starter crank the engine and check the following at the generator cubicle using an oscilloscope: Presence of PMG voltage (F15) Correct rotation of generator phases with respect to main bus (F98). Presence of magnetic pick-up voltage (speed feedback)			
4.4.3	Check incoming terminals of 24VDC battery supply for Woodward Governor. Verify correct polarity and record voltage.	_____ VDC		
4.4.4	Temporarily remove wire 345 from terminal B7 of the Basler unit and insulate. Fit fuse F18 to connect 24VDC to the Woodward unit. Select IDLE on the front panel governor control switch and allow the Woodward unit to take the engine to idle speed.			
4.4.5	Verify operation of engine speed raise/lower controls.			
4.4.6	Stop the engine and re-connect wire 345 to the Basler unit. Insert PMG fuses (F15). Insert generator safety fuses (F98) and PT primary and secondary fuses (F1 & F12).			
4.4.7	Start the engine, run up to idle speed and verify that the Basler unit regulates the voltage.			
4.4.8	Check operation of voltage raise and lower controls.			
4.4.9	Insert remaining PT fuses (F12) to apply power to the Woodward unit and Integra transducer.			
4.4.10	Select run speed and ensure that the engine speed ramps up smoothly to stabilise at full speed, and that voltage regulation is present and stable. Adjust speed and voltage as necessary.			

4.5 Instrumentation & Control

Item	Procedure	Result	OK	Comments
4.5.1	Insert control transformer fuses (F4 & F14). Run the engine up to full speed.			
4.5.2	Verify Engine Run lamp.			
4.5.3	Verify CB Open lamp			
4.5.4	Verify the front panel voltage indication against digital multimeter set to measure 600VAC. Record the following: AB Voltage Indicated/Actual BC Voltage Indicated/Actual CA Voltage Indicated/Actual	 _____/_____VAC _____/_____VAC _____/_____VAC		
4.5.5	Carefully insert a digital multimeter set to measure DC milliamps in series with the actuator control signal. At full speed, no load the actuator current should be 25-35mA. Record actual value.	_____mA		
4.5.6	Measure the output from the PMG using a digital multimeter set to measure AC voltage and record: AB Voltage BC Voltage CA Voltage	 _____VAC _____VAC _____VAC		
4.5.7	Check the output voltage of the magnetic pick-up (speed feedback) from the engine with an oscilloscope. The voltage should be at least 20V peak-to-peak. Record the actual voltage.	_____VPK		
4.5.8	Check that the main circuit breaker charges automatically.			
4.5.9	Observe the temperature monitor and ensure readings are reasonable.			
4.5.10	Ensure the main bus is dead and that all feeder circuits are disconnected. Select generator on the synchronising switch and verify the main circuit breaker UV is energised. Press the circuit breaker close button and verify that the circuit breaker closes.			
4.5.11	Verify the CB Closed lamp			
4.5.12	Turn the sync switch to the off position. Circuit breaker should remain closed.			

4.6 Trips and Protective Functions

Item	Procedure	Result	OK	Comments
4.6.1	Check engine emergency stop/shutdown circuit			
4.6.2	Restart the engine and run up to full speed and voltage.			
4.6.3	Monitor the voltage on the main circuit breaker UV coil with a digital multimeter set to measure AC voltage. With no trips present the coil should be energised with 120VAC. Record the measured voltage. The coil will de-energise in a trip condition	_____VAC		
4.6.4	Force the engine speed down and record the frequency at which the underfrequency trip operates.	_____Hz		
4.6.5	Force the engine speed up and record the frequency at which the overfrequency trip operates. WARNING: take care not to overspeed the engine. Ensure the mechanical overspeed protection has been tested.	_____Hz		
4.6.6	Force the generator voltage down and record the level at which the undervoltage trip operates	_____VAC		
4.6.7	Force the generator voltage up and record the level at which the overvoltage trip operates	_____VAC		
4.6.8	Repeat one of the tests above with the circuit breaker closed and verify that the circuit breaker trips under the fault condition.			

4.7 Synchronising (requires second generator)

Item	Procedure	Result	OK	Comments
4.7.1	Complete the above sections for a second generator and place on line. Start up the generator under test and run up to full speed. Select the generator on the synchronising switch.			
4.7.2	Connect a digital multimeter set to monitor 1000VAC across the A phase incoming and load connections of the main circuit breaker.			
4.7.3	Adjust the engine speed so that the variations on the digital multimeter are as slow as possible. Confirm that as the voltage on the digital multimeter approached zero the synchronising lamps are dim.			
4.7.4	Verify that as the synchronising lamps dim the synchroscope moves to point vertically upwards.			
4.7.5	Verify that as the synchroscope points vertical that the CB Close pushbutton receives a control voltage for a short window either side of vertical.			
4.7.6	Press the CB Close pushbutton when the synchroscope points vertical and verify that the main circuit breaker closes.			
4.7.7	Check the Amps, KW and KVAR meters between the two generators are close to zero and balanced. Adjust the generator voltage to balance the KVAR if necessary.			
4.7.8	Check that raising or lowering the generator voltage causes current to circulate between the generators, and can be set in balance.			

4.8 Load Testing

Note that load testing may be limited by the available load capacity (load bank).

Item	Procedure	Result	OK	Comments
4.8.1	Shut down all engines. Connect a 600V 3-phase load bank to the main busbars. Adjust the load bank for minimum (or no) load.			
4.8.2	Start up the engine and run up to full speed. Place the generator on line.			
4.8.3	Monitor the load on the load bank with an AC clamp meter on the A phase. Increase the load to about 200A.			
4.8.4	Check the ammeter readings for each phase and verify with the clamp meter. Record the values. A Phase Current Indicated/Actual B Phase Current Indicated/Actual C Phase Current Indicated/Actual	 _____/_____AAC _____/_____AAC _____/_____AAC		
4.8.5	Verify the kW reading. At 600V/200A the KW meter should show about 208KW (assuming a resistive load). Record the value here.	_____KW		
4.8.6	Gradually increase the load to 100% of the generator, engine or load bank full load rating (whichever is lowest). Check that the load bank and cables are not overheating. Record the following: A Phase Current Indicated/Actual B Phase Current Indicated/Actual C Phase Current Indicated/Actual AB Voltage BC Voltage CA Voltage KW KVAR Frequency	 _____/_____AAC _____/_____AAC _____/_____AAC _____VAC _____VAC _____VAC _____KW _____KVAR _____Hz		

Item	Procedure	Result	OK	Comments
4.8.7	Allow a period of time for stabilisation of the generator temperature readings and record: Stabilisation Time A Phase Temperature B Phase Temperature C Phase Temperature Bearing NDE Bearing DE	 _____m:s _____°C _____°C _____°C _____°C _____°C		
4.8.8	Carefully insert a digital multimeter set to measure DC milliamps in series with the actuator control signal. At full speed, no load the actuator current should be 130-200mA. Record actual value.	_____mA		
4.8.9	Confirm that the no-load to full-load speed regulation is within the requirements of the certifying authority			
4.8.10	Confirm that the no-load to full-load voltage regulation is within the requirements of the certifying authority			
4.8.11	Adjust the load bank to the required step-load percentage of generator full load (e.g. 60%). Open the main circuit breaker and check that the regulation of voltage and speed meets the requirements of the certifying authority.			
4.8.12	Close the circuit breaker on to the load and check that the regulation of voltage and speed meets the requirements of the certifying authority.			

4.9 Load Sharing

Item	Procedure	Result	OK	Comments
4.9.1	Reduce the load bank to zero and run the generator on line in parallel with another generator			
4.9.2	Monitor the load on the load bank with an AC clamp meter on the A phase. Increase the load to about 400A.			
4.9.3	Adjust the engine voltage(s) so that the KVAR (if any) are shared equally between the two generators			
4.9.4	Verify that the current and KW are shared equally between the two generators			
4.9.5	Gradually increase the load as far as possible and verify that load sharing is within acceptable limits across the range.			
4.9.6	Adjust the load so that each generator is at 50% load. Trip the circuit breaker of the other generator and verify that the generator under test picks up the remaining load and that speed and voltage regulation meets the requirements of the certifying authority.			
4.9.7	With both generators synchronised and sharing load (min 20%) disconnect the governor signal and verify that the generator trips on reverse power.			

4.10 PLC Instrumentation

Item	Procedure	Result	OK	Comments
4.10.1	Ensure the PLC system has been commissioned and powered up			
4.10.2	Verify that the PLC generator status screen accurately reflects the status of the generator circuit breaker			
4.10.3	Verify that the PLC generator status screen accurately reflects the load and running conditions of the generator and record (where applicable)			
	AB Voltage Panel/PLC	_____/_____VAC		
	BC Voltage Panel/PLC	_____/_____VAC		
	CA Voltage Panel/PLC	_____/_____VAC		
	KW Panel/PLC	_____/_____KW		
	KVAR Panel/PLC	_____/_____KVAR		
	Frequency Panel/PLC	_____/_____Hz		
	Power Factor Panel/PLC	_____/_____		
	A Phase Current Panel/PLC	_____/_____AAC		
	A Phase Current Panel/PLC	_____/_____AAC		
	B Phase Current Panel/PLC	_____/_____AAC		
	Temperature 1 Panel/PLC	_____/_____°C		
	Temperature 2 Panel/PLC	_____/_____°C		
	Temperature 3 Panel/PLC	_____/_____°C		
	Temperature 4 Panel/PLC	_____/_____°C		
	Temperature 5 Panel/PLC	_____/_____°C		
	Temperature 6 Panel/PLC	_____/_____°C		

4.11 Serial Numbers

Record the serial numbers of the principle equipment:

Item	Model	Serial Number
Main Circuit Breaker		
Trip Unit		
Governor Control		
Exciter Control		

4.12 Completion

Generator Number: _____ (enter generator section number)

The undersigned representatives hereby acknowledge that all checkout and testing work, as listed herein, has been successfully completed for the abovementioned generator section.

Name	**Company**	**Position**	**Signature**

Date of Completion: _____

5 COMMISSIONING PUNCH LIST

Equipment: _____ Page: _____

Rig: _____

Item	Description and Required Corrective Action	Responsible Party	Date Completed