newfoundland labrador hydro
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July 20, 2015

The Board of Commissioners of Public Utilities
Prince Charles Building
120 Torbay Road, P.O. Box 21040
St. John's, NL
A1A 5B2

ATTENTION: Ms. Cheryl Blundon
Director of Corporate Services & Board Secretary

Dear Ms. Blundon:

Re: Holyrood Field Investigation for Unit 1 and Unit 3 – March 4, 2015

Enclosed please find the original and 12 copies of Hydro's report entitled "Holyrood Thermal Generating Station Field Investigation for Unit 1 and Unit 3, March 4, 2015". This report is the result of Hydro's field investigation on Unit 1's delay return to service and the Unit 3 trip, identifying causes and enhancements to address these causes.

Should you have any questions or comments, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Geoffrey P. Young
Senior Legal Counsel

GPY/bds

A REPORT TO

THE BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

Holyrood Thermal Generating Station
Field Investigation for Unit 1 and Unit 3, March 4, 2015

July 20, 2015

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Table of Contents

1.0 Executive Summary

On Friday February 27, Holyrood Unit 1 was taken offline for an emergency outage to repair a leak in the lube oil system with an estimated return to service time of Tuesday March 3 at 20:00. The repair was completed within the planned time period, however the return to service of Unit 1 was delayed until March 4 because:

1. The start of the Unit 1 re-gassing procedure was delayed for 2.5 hours due to the need to carry out an emergency repair to the Unit 2 air drive heater motor.
2. The re-gassing process took longer than had been planned due to instrumentation problems and carbon dioxide piping leaks.

Unit 1 was consequently not available to meet the peak demand on the morning of March 4. That unavailability coincided with a delay in the start up of the Holyrood combustion turbine, for unrelated causes addressed in a separate report, which caused a sustained under voltage condition at the Holyrood Thermal Generating Station's incoming Station Service feed. Unit 3 then shut down when the low voltage condition caused its Forced Draft Fan Motor to trip. Unit 2 does not utilize Variable Frequency Drives for its Forced Draft Fan Motor and continued to operate.

All three units were online at the end of Wednesday March 4, with Unit 3 coming back online at 10:14 and Unit 1 coming back online at 16:00.

2.0 Detailed Description of Events

Unit 1 Bearing Oil Leak Repair and Unit Return to Service

On Thursday, February 19, oil ingress was noted in the Unit 1 brushgear housing during a weekly generator preventative maintenance (PM) routine. The unit's rotating shaft runs through the turbine and generator extending into the housing (see Figure 1 – Unit 1 Brushgear Housing). The housing contains the brushgear – the equipment where the rectifying current is transferred to the field of the generator rotor. Oil contamination in this location may cause a fire or flashover due to sparks from the current. While the unit was operating, the area was inspected by several HTGS personal to determine the source of oil contamination. It was determined that the contamination was lube oil from the generator bearing and that it was not an immediate cause of concern as the amount of oil had not increased over the hours it was observed. Plans were made to thoroughly clean the brushgear housing and investigate the leak during the next maintenance outage.

On Thursday, February 26, the same weekly generator PM was completed and it was observed that the oil contamination had increased. The oil had been lightly sprayed throughout the brushgear housing and had caused oil-carbon residue to build up in the brush gear, increasing the risk of fire or flashover. A teleconference was convened that day with Alstom, the Turbine and Generator service provider for HTGS, to discuss the situation. It was decided that the unit should be taken offline to clean the brushgear and investigate the cause of the leak to ensure safe and reliable operation of the unit. A schedule was developed to enable a quick return to service. This included HTGS personnel working around the clock and an Alstom technical field advisor (TFA) present on site Saturday, February 28. The outage was scheduled with the ECC to run from Friday, February 27 at 12:00 to Tuesday,March 3 at 20:00.

Figure 1- Unit 1 Brushgear Housing

On Friday, February 27, load on the system required Unit 1 stay in service until mid-afternoon. After approval from the ECC, Unit 1 was taken offline at 15:23 and placed on turning gear. Putting the unit on turning gear is an intermediary step whenever a unit is taken offline. The turning gear keeps the hot turbine rotor turning at slow speed (2 rpm) until it cools enough that it can be stopped without causing distortion of the rotor. As a precautionary measure to ensure personnel safety, and following Alstom's recommendation, HTGS Operations began purging the generator of hydrogen gas on Friday evening. Historically, purging the unit requires 16 hours but can take as long as

24 hours. In this instance, an issue with a generator casing pressure indicator[1] impacted the process and the purge took 20 hours. While the purge and rotor cooling was ongoing, HTGS personnel worked to prepare work protection permits, to erect scaffolding on the second floor, to set up the gantry, and to prepare the area for the investigative work.

As the purge continued and the rotor continued to cool, the Alstom TFA arrived on Saturday morning and began non-intrusive observations and testing with the support of HTGS personnel. Visual inspections were performed on the lube oil system, the seal oil system, the vapour extraction system, the brush gear, and brush gear housing. A work list was developed based on the results of the investigations to guide the corrective and investigative work throughout the maintenance outage.

By 08:00 on Sunday, March 1, the rotor had cooled sufficiently to stop the turning gear and shutdown the lube oil system. The required work permits to safely isolate the work area were then established to allow the full investigation and corrective work to be completed. Work continued on a two-shift, around the clock basis throughout Sunday night.

On Monday, March 2, the Alstom TFA and HTGS personnel met to discuss the findings of the work and investigation. From the findings and from observing the amount of oil present, it was concluded that the ingress of oil into the brushgear was the result of an intermittent lube oil system upset rather than a continuous leak. One of the observations that supported this was that the oil deflector was in good condition and in

[1] The issue was initially identified as an incorrect (high) remote indication of generator casing pressure. A work order was entered to correct this and the unit purge and subsequent re-gassing continued using the local gauges. It was later determined that leaks in the carbon dioxide system also contributed to the rate of the purge.

place. If this was not the case, much more oil would have spilled in the brushgear housing and other areas. No repairs to the lube oil, seal oil, or bearing systems were required. Problems with the lube oil tank vapour extractor[2] and the hydrogen vent fan on the detraining tank[3] were identified and corrected, as they may have contributed to the initial oil ingress. A sealing device was installed in the generator brushgear housing to prevent any future ingress of lube oil onto the generator brushgear assembly. The brushgear was removed, cleaned, and tested and returned to operational condition. It was decided that the emergency outage had accomplished its goal and the unit could return to service for safe operation.

The work permit was terminated from the unit on Monday, March 2 at 15:36. At this point, all maintenance work had been completed and the process of returning the unit to service was started. Once the isolations had been removed at 18:36, the startup plan was for the unit to be re-gassed, pre-warmed, and synchronized with the system for 20:00 Tuesday, March 3. Re-gassing of the unit followed HTGS Procedure 0576 - POP-011. Returning Unit 1 to service followed Procedure 0324 - POI-04, a cold start with available auxiliary steam (i.e. another unit already online). Refer to Appendix E for both procedures.

During re-gassing, carbon dioxide is introduced to the generator to push air out. Hydrogen is then pushed into the inert environment. While re-gassing normally takes 16-24 hours, delays were encountered. The start of the re-gassing procedure itself was delayed by 2.5 hours because of problems on the Unit 2 air heater drive motor[4]. This

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[2] The lube oil vapour extractor creates a vacuum in the lube oil tank to remove gaseous impurities in the lube oil.

[3] The detraining tank collects lube oil after it has gone through the generator bearings. The hydrogen vent fan removes hydrogen as it degasses from the lube oil.

[4] The issue on the Unit 2 air heater drive motor was unrelated to the Unit 1 repair, and occurred and was resolved hours before the low voltage condition on the morning of March 4.

was an urgent situation and action had to be taken immediately to keep Unit 2 on-line. All available resources had to be assigned immediately for work protection permits as well as to complete the emergency repairs. Re-gassing of Unit 1 commenced at 21:00 on Monday, March 2, but progressed slower than anticipated. The progress of a re-gassing is monitored by a portable gas meter which displays a percentage of gas purity[5]. The gas meter indicated that the flow of carbon dioxide was not inducing the expected change in the generator casing[6]. Operations attempted to speed up the process by increasing carbon dioxide flow but this flow is limited by the size of the gas regulator in the carbon dioxide delivery system. Too much flow will cause the regulator to freeze, stopping any further flow of gas. The flow of carbon dioxide was increased to near the freezing point to deliver maximum flow to the unit.

As re-gassing continued into Tuesday, March 3, it was estimated that Unit 1 could be available for service at approximately 05:30 on Wednesday, March 4, provided no additional delays were encountered. This estimated timeline included re-gassing being completed by 00:00 Wednesday, March 4 and reducing the pre-warm period to 3-4 hours from the normal 10-12 hours[7]. The final duration of the pre-warming would be dictated by the temperature and metallurgy of the cold unit. Re-gassing continued to be slower than expected and did not complete until 04:30 Wednesday, March 4.

Once re-gassing was completed the unit began pre-warming. Unit 1 pre-warming was extended by approximately 3 hours because of additional tests on the lube vapour

[5] The portable monitors at Holyrood give "% Carbon Dioxide in Air" and "% Hydrogen in Carbon Dioxide" and are used to monitor all stages of purging and re-gassing.
[6] Carbon dioxide to purge the unit of air was being lost to leaks, resulting in a slow change in the generator casing throughout the re-gassing.
[7] The reduction in time to pre-warm is implemented infrequently, but can be done safely while paying close attention to the operational parameters of this process (ex. Metallurgy bounds, etc.).

extractor/lube oil pumps that were suggested by Alstom, and therefore, no time was gained on the pre-warming process.

Later, after pre-warm, the unit was brought up from turning gear speed to synchronous speed, from 2 rpm to 3600 rpm, and then synched with the system. This process took the expected amount of time with Unit 1 going online at 16:00 Wednesday, March 4. It should be noted that Unit 1 could have come on line earlier in the day, however, after Unit 3 tripped, operations focused on getting Unit 3 back on line first as this unit was easier to get on line faster than Unit 1 following the Unit 3 trip.

Unit 3 Trip, March 4, 2015

Unit 3 tripped at 07:14 on Wednesday March 4, 2015 while operating at a load of 145MW. Abnormal system conditions in the Island Interconnected System resulted in an under voltage condition at the Holyrood Thermal Generating Station (HTGS). Unit Service (UB) voltages for both Unit 2 (UB-2) and Unit 3 (UB-3) sagged from a nominal 16kV to about 14.5kV shortly before the trip (see Appendix A – Unit Board Voltage Sag on Unit 2 and Unit 3 and Appendix B – HTGS Single Line Diagram). The voltage sag also presented itself on the Station Service Boards (SB) on both Unit 3 (SB34) and Unit 2 (SB-12) – the incoming feeds from the system dropping from 4160V to approximately 3300V (20% below nominal voltage). This is beyond the ±4% operating voltage that is considered acceptable for a 4160V system as per HTGS Engineering Directive ED-059 (see Appendix C – ED-059 Acceptable 4kV Bus Voltages).

All electrical loads are designed with a nominal operating voltage and with a tolerance to voltage fluctuations. A resistive load, such as an incandescent lightbulb, has a high tolerance to voltage fluctuations. It may dim in an under voltage condition but return to normal operation as nominal voltage returns with no negative effect. An inductive load, such as an electric motor, is less tolerant of under voltage conditions – it may continue to operate or it may shut down, depending on the severity of the event and the characteristics of the motor. An electronic load, such as a computer, is very intolerant of under voltage conditions and will shut down unless it is provided with the expected voltage.

The Variable Frequency Drives (VFDs) that power the Forced Draft (FD) Fan motor on Unit 3 have two sensitive electric loads powered by a 600V auxiliary feed – the electronic control processor (CP) and the cooling fans. The VFDs were designed by the manufacturer to tolerate ±10% of nominal voltage for the auxiliary feed, per IEC 61800-4 (see Appendix D – Excerpt from Siemens Manual A5E32043214). The 600V supply comes from the Essential Service MCC (ESB34), which is in turn fed from the Station Auxiliary board (SAB34). As SB34 sagged 20%, the effect was passed down through SAB34, ESB34, and finally to the VFD cabinet itself (again, refer to Appendix B – HTGS Single Line Diagram). Voltage to the CP and cooling fans decreased until the critical point was reached, tripping the VFDs. Once the VFDs ceased to operate, the equipment protection removed both FD fans from service, immediately tripping Unit 3 because of the lack of airflow to the boiler. Unit 2, while experiencing the same under voltage event, was able to safely remain online as its FD fans were not powered by VFDs at that time.

3.0 Analysis

The trip on Unit 3 occurred when abnormal system conditions (sustained under voltage) caused a trip of the variable frequency drives on the forced draft fans. This caused a trip of the boiler and loss of the unit.

The Unit 1 emergency outage work was planned and executed by HTGS personnel under the technical direction of an experienced Alstom TFA. Because of the efforts made in scheduling, planning, and executing work, the investigative and corrective work was completed ahead of the original schedule. However the start-up of Unit 1 took longer than expected, delaying the return to service beyond the anticipated schedule.

The delay in the return to service was due to:

1. The start of the de-gassing was delayed due to the emergency repairs that had to be conducted immediately on Unit 2;
2. The re-gassing was slow due to instrumentation problems and leaks in the carbon dioxide system that were unknown at the time of work.

4.0 Remedial Actions

1. Identify and correct instrumentation problems experienced during purging and re-gassing of all units. Review the other units for similar problems.

   Status: Completed. Instrumentation problems have been identified and corrected. Purging and Re-gassing procedures have been reviewed with Operations.

2. Provide the VFD equipment with more stable electrical feed.

   Status: Ongoing. Engineering has been completed to identify new 600V feed from Unit Board buses. Materials have been ordered and plant resources for the work have been identified. Required corrections will be made before Unit 3 is returned to generation – completion date of August 31, 2015.

3. Investigate providing more reliable carbon dioxide supply - replace leaking carbon dioxide piping.

Status: Preliminary design has been completed. Design will utilize existing piping to bypass all underground sections of the existing carbon dioxide system. Tie-ins to existing systems, materials, and required plant resources to be identified – completion date of October 31, 2015.

Appendix A – Unit Board Voltage Sag on Unit 2 and Unit 3

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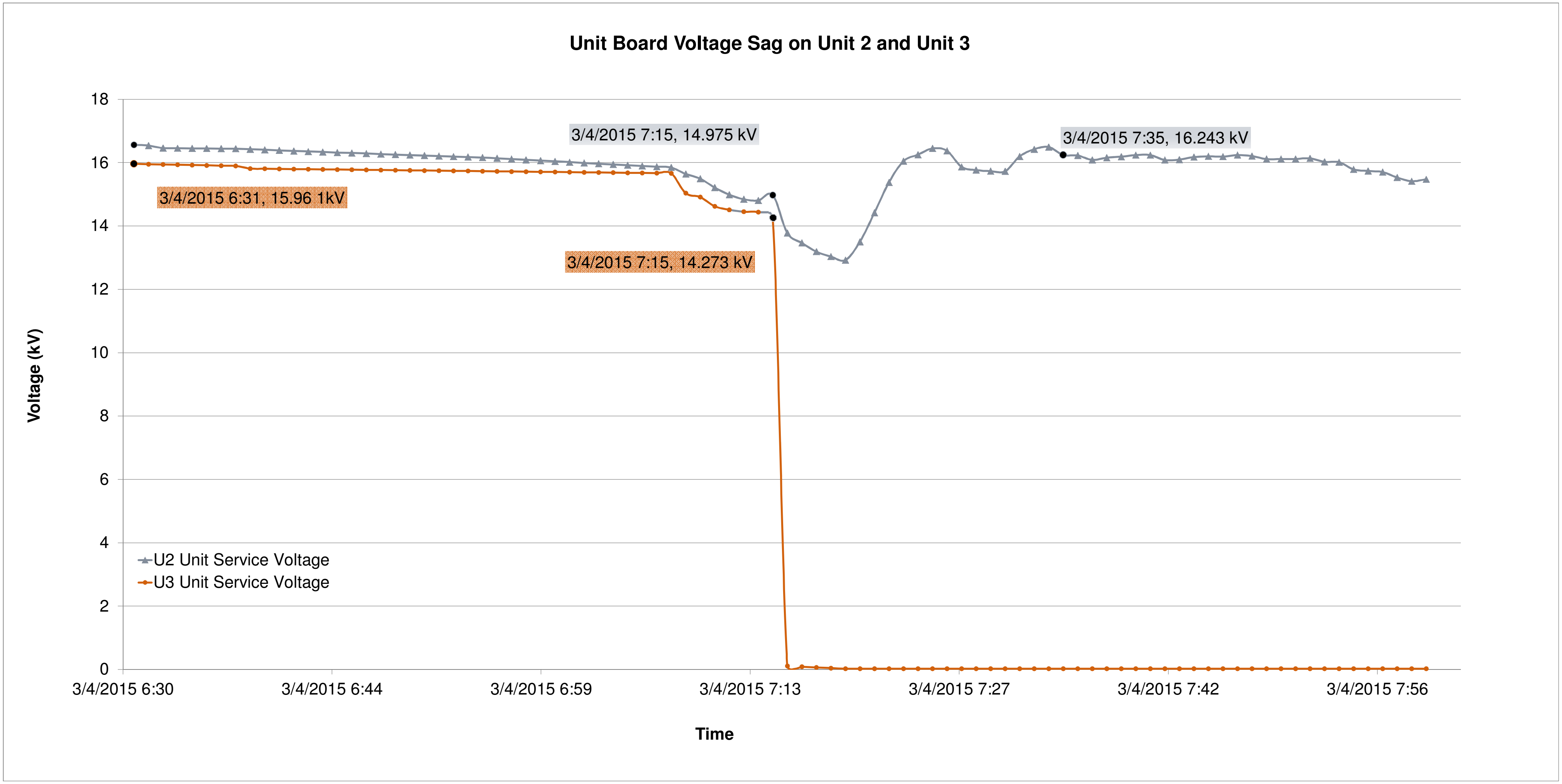
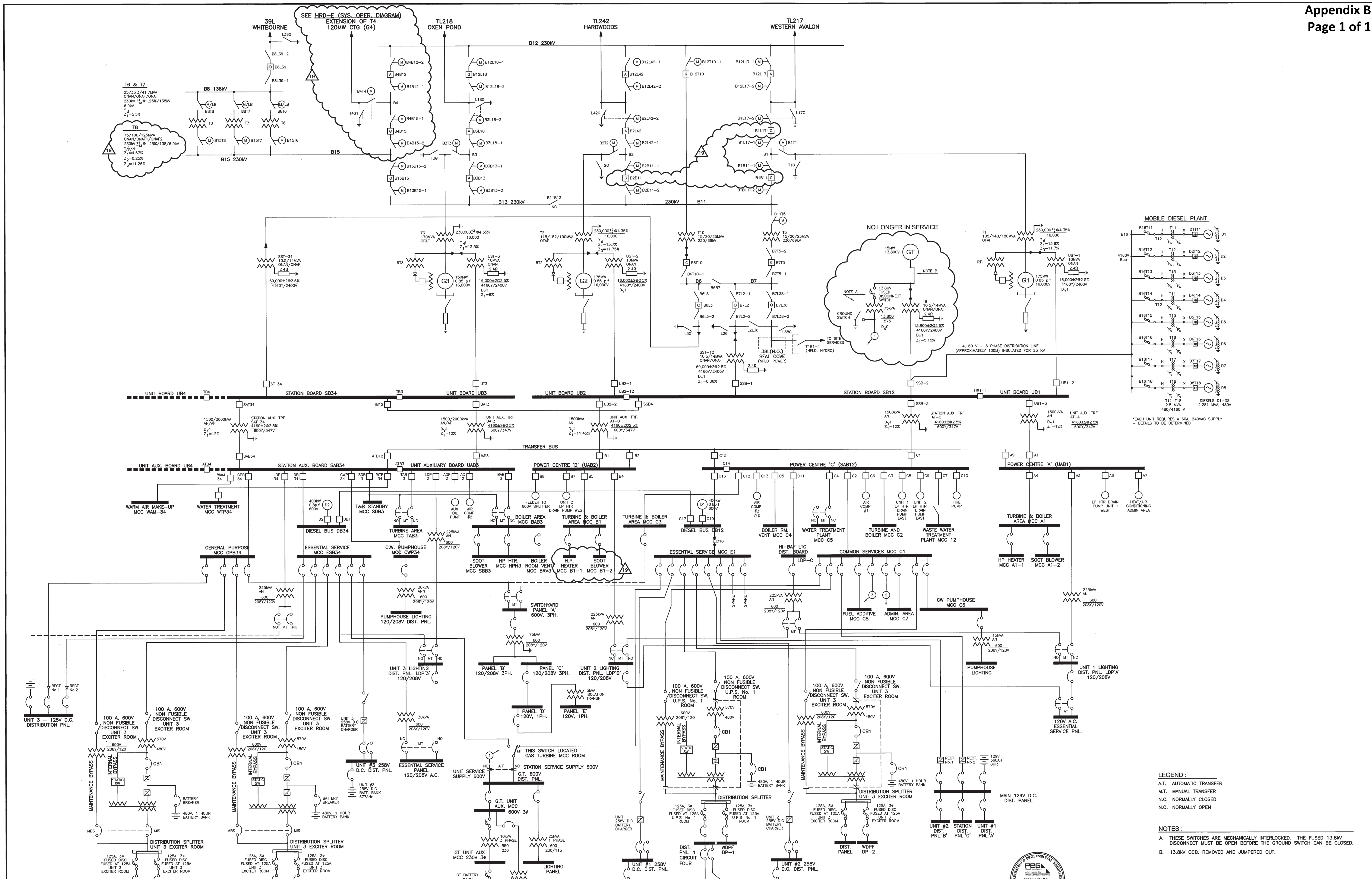

Unit Board Voltage Sag on Unit 2 and Unit 3
18
16
14
12
10
8
6
4
2
0
Voltage (kV)
3/4/2015 7:15, 14.975 kV
3/4/2015 7:35, 16.243 kV
3/4/2015 6:31, 15.96 1kV
3/4/2015 7:15, 14.273 kV
U2 Unit Service Voltage
U3 Unit Service Voltage
3/4/2015 6:30
3/4/2015 6:44
3/4/2015 6:59
3/4/2015 7:13
3/4/2015 7:27
3/4/2015 7:42
3/4/2015 7:56
Time

Appendix B – HTGS Single Line Diagram



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Newfoundland and Labrador Hydro

HOLYROOD GENERATING STATION
POWERHOUSE AND SWITCHYARD
SINGLE LINE DIAGRAM

NO.	DATE	DESCRIPTION	DWN
19	15-03-16	REVISED "AS BUILT" WITH NEW T4 EXTENSION	C.R.H
18	14-10-01	BLACK START 8-1825 kW DIESELS ADDED	D.O
17	10-09-14	CHANGED NUMBERING OF AIR COMPRESSORS	D.O
16	05-06-15	UPDATED	K.B.R
15	03-01-16	AS BUILT	G.W
14	02-05-02	TL218 & TL242 NAMES CHANGED	W.B
13	01-11-03	UPS # 3 AND # 4 REPLACEMENT	G.W

SCALE: NONE
DRAWN: D. MONTAGUE
DATE: 1993-01-27

DWG NO. A0 - 1403-500-E-001 REV 19.

PLOT SCALE 1:1 CAD

Appendix C – ED-059 Acceptable 4kV Bus Voltages

HTGS Procedures
Procedure: 0083 (ED-059 Acceptable 4kv Bus Voltages)

ISO 14001
QMI-SAI Global

Procedure Number: **0083**
Entered By: Cheryl Oliver
Date Entered: Feb 17th, 1999 10:52 AM

Title: **ED-059 Acceptable 4kv Bus Voltages**

Archive Information	
Issue Date:	**01/17/95** **Jan 17th, 1995**
Distribution:	**Manager - LT Asset Planning, Manager - Safety Health and Environment, Manager - Work Execution, Manager - Operations, Manager - Thermal Generation, Short Term Work Planning & Scheduling Supervisor**
Manual/Group:	**Engineering Directives, Plant Operating Procedures**
Revision No:	**2**
Revision Date:	**06/11/2007** **June 11th, 2007**
Prepared By:	**Peter Robbins**
Controller:	**Jeff Vincent**
Reviewers:	**Sean Mullowney**
Approved By:	**Terry LeDrew/HO/NLHydro**

Procedure Scope

SCOPE: To specify the acceptable operating voltage level for all 4 kv electrical equipment which will ensure proper personal and equipment protection.

Reference Information

EQUIPMENT: All Electrical Equipment with 4 kv Operating Voltage Requirements

Electrical equipment (especially a motor) is designed to run at a specified voltage. If the operating voltage is too low, the equipment will tend to run hot due to the high current required to maintain power output. If the operating voltage is too high, it may exceed the maximum voltage requirement of the insulation.

Procedure Details

DIRECTIVE: All electrical equipment 4 kv operating voltage requirements shall have an operating voltage range of ± 4% of normal operating voltage (4160 V). That is, the minimum operating voltage shall be 4000 V and the maximum operating voltage shall be 4320 V.

Document is valid for 14 days from 05/28/2015

Appendix D – Excerpt from Siemens Manual A5E32043214

Technical Data

B

B.1 WCIII System Technical Specifications

The specifications shown in the following tables apply to the standard open loop or closed loop vector control system performance for induction or synchronous motors.

Table B-1 WCIII Parameters and Ratings

Parameter	Rating
Input Voltage	2400 to 13800 V / +10%, -5%
Input Frequency	50 or 60 Hz / +10%, -5% input voltage worst case
Input Power Factor	0.95 or better with motor speed 25% rated or higher (not valid for unloaded motor)
Input Current Harmonics	Meets most stringent TDD requirements from IEEE 519
Transformer Windings	Copper
Output Power	4000 Hp / 2984 kW to 19000 Hp / 14169 kW single inverter
Output Voltage	2.3 kV to 8.0 kV
Output HVF	< 0.03
Output dV/dt	< 1000 V/uS
Output Frequency and Drift	0.5 – 330 Hz, +/- 0.5%
Harmonic Voltage Factor	Less than 0.03 per NEMA MG-1
Motor Speed Range	f_0 = 0.5 to 166 Hz (motor dependent); 300 Hz ≤ f_c ≤ 600 Hz SWF
Motor Speed Range	f_0 = 167 to 330 Hz (motor dependent); 1200 Hz ≥ f_c ≥ (3.6 x f_0) Hz SWF
Output Torque[1]	2 or 4 Quadrant f_0 = 0.5 to 10 Hz derated torque f_0 = 10 to 167 Hz full rated torque f_0 = 167 to 330 Hz derated torque
Auxiliary Voltage (± 10% auxiliary voltage tolerance, per IEC 61800-4. For more information, refer to standard.)	• 208 V, 60 Hz, 3-phase • 230 V, 60 Hz, 3-phase • 380 V – 400 V – 415 V, 50 / 60 Hz, 3-phase • 460 V – 480 V, 60 Hz, 3-phase • 575 V, 60 Hz, 3-phase • 690 V, 50 Hz, 3-phase If exciter is needed, a separate auxiliary voltage supply is needed.
Acceleration/Deceleration Time	0.5 to 3200 seconds (load dependent)
Cell Frame Sizes	880 Amp and 1250 Amp
Overload Capacity	Refer to *WCIII Current Parameters* Section.
Efficiency Motor load PF = 1.0 Cells at 100% continuous rating	• Total System 96.5% / Transformer 97.5% + Cells 99.0% (cell redundancy = N+0) • Total System 96.4% / Transformer 97.5% + Cells 98.9% (cell redundancy = N+1) • Total System 96.2% / Transformer 97.5% + Cells 98.7% (cell redundancy = N+3)
Enclosure Type	• MV Power Sections: IP 53 (NEMA 12) • LV Control Sections: IP 21 (NEMA 1)

Altitude	• No de-rating up to 3300 feet / 1006 meters above Mean Sea Level. • Above 3300 feet / 1006 meters, refer to Cell Output Deration Formulas. • Above 6562 feet / 2000 meters, consult Siemens customer service.
Sound level[2]	Less than 76 dB at 3 feet (~ 1 meter) from cabinet.
Control Power[3]	One: single phase, 120 VAC RMS ± 10%, 50 / 60 Hz Three: three phase, 380 VAC RMS ± 10% / 50 Hz or 460 VAC RMS ± 10% / 60 Hz
Control	NXGII hardware + Eagle software
Cooling	De-ionized water and glycol mix
Design Life	20 years
Accessibility	Rear access is required for maintenance and installation. For details, contact Siemens customer service.

1 Refer to deration formulas in *Power Cell Specifications*Section.

2 The WCIII drive generates acoustic noise levels above 70 dB. Hearing protection is not required.

3 Control Power is sourced by the customer in the standard configuration. A fourth three-phase feed (± 10% continuous RMS voltage tolerance) is required if a forced air type drive main heat exchanger is used.

Note

Synchronous motor operates at fixed 1.0 (Unity) Power Factor.

Appendix E – HTGS Procedures

HTGS Procedures
Procedure: 0324 (POI-04 Turb./Gen. Operation - Cold Start-up of Unit #1 & #2 from a Major or minor Overhaul, with Another Unit On-Line)

Procedure Number: **0324**
Entered By: Cheryl Oliver
Date Entered: Feb 18th, 2000 03:02 PM

Title: **POI-04 Turb./Gen. Operation - Cold Start-up of Unit #1 & #2 from a Major or minor Overhaul, with Another Unit On-Line**

Archive Information	
Issue Date:	**11/10/95** **Nov 10th, 1995**
Distribution:	**Operations Performance Specialist, Shift Supervisor, Thermal Plant Operator**
Manual/Group:	**Plant Operating Instructions, Plant Operating Procedures**
Revision No:	**1**
Revision Date:	**10/03/2005** **Oct 3rd, 2005**
Prepared By:	**Ray Rossiter**
Controller:	**Gerard Cochrane**
Reviewers:	**Ross Norris**
Approved By:	**Terry LeDrew/HO/NLHydro**

Procedure Scope

Reference Information

To ensure that the unit is returned to service by a reliable and co-ordinated procedure after shutdown.

STARTUP CHECKS All UNITS.dc

Procedure Details

Start-Up Procedure

1. Release Permit, Major Overhaul Permit Release will take 24 hours. Minor Overhaul Permit Release will take 24 hours.

2. When work permit is released and valves and breakers returned to operating

position, the C.W. system should be placed in service.

(a) Travelling screens and screen wash pump selector switch placed in AUTO.
(b) Turn OFF C.W. pump motor heater.
(c) Open fully the condenser outfall valves and the partition valves.
(d) Select the C.W. pump discharge valve to 'AUTO'.
(e) When the pump is started and the discharge valve moves to the "cracked" position, select "manual" and slowly open valve keeping watch on condenser for leaks. Place valve selector switch in "AUTO" when valve is fully open.
(f) After two (2) hours the partition valves may be closed.

NOTE: The partition valves are opened and the C.W. discharge lines are flushed after lengthy shut down to avoid plugging condenser tubes with mussels that may have grown in the discharge pipe.

(g) Vent condenser by throttling outfall valve and opening condenser vents until water issues from vents.

3. Turbine Generator cooling system to be placed in service.

(a) Open cooling water (sea water from C. W. System) inlet valve to cooler and vent coolers.

NOTE: The inlet valve to cooler should be left closed until the C. W. system has been flushed and placed in service, to prevent plugging.

(b) T. G. head tank should be at normal level and the level control valve placed in "AUTO" on W.D.P.F. console.
(c) Start T.G. pump with discharge valve closed and slowly pressurize system.
(d) Vent T. G. coolers, Hydrogen coolers, Turbine lube oil tank coolers and Boiler feed pump coolers.

4. Generator

(a) Verify that turbine lube oil reservoir is full and the Bowser has been cleaned.
(b) Pressurize generator casing with air to 15 to 30 kPa.
(c) AC oil pump can now be started and depending on the position of the three-way supply valve (located in the lube oil tank) oil will be supplied to the bearings and generator seals or to generator seals only.
(d) With oil flowing to bearings and seals; perform tests of the oil pumps as follows:
(1) Leave the D.C. oil pump breaker open.
(2) North A.C. oil pump in operation and south in "AUTO".
(3) Stop NORTH pump. Check that south A.A. pump starts automatically.
(4) Place North A.C. oil pump in "AUTO" and stop South A.C. pump. Check that North starts automatically.

(5) Close breaker on D.C. oil pump and place in "AUTO". Stop A.C. oil pumps. Check that D.C. pump starts automatically.
(6) Start one A.C. oil pump and place the other A.C. pump in "AUTO". Shut down D.C. pump and place in "AUTO".

(e) The turbine may be placed on turning gear.

NOTE: It is recommended that the turbine be on turning gear eight (8) hours prior to pre-warming.

(f) Carbon dioxide is now admitted to the generator to purge the air. CO_2 is admitted to the bottom of the generator through the CO_2 distribution pipe and air in the generator is discharged to atmosphere through the Hydrogen feed pipe. The admission of CO_2 is controlled by valve C42 and C45 always maintaining between 15 and 30 kPa generator pressure during purging. CO_2 shall be admitted to the generator until the percentage of CO_2 in the discharge (vent) pipe is in excess of 70%.

(g) Hydrogen may now be admitted through the top of the generator through the hydrogen distribution pipe and the carbon dioxide-air mixture is discharged to atmosphere through the CO_2 feed pipe. The admission of hydrogen (H2) to the generator is controlled with valve H-26, maintaining a generator pressure 15 to 30 kPa. Hydrogen shall be admitted until the gas mixture discharged is in excess of 90%.

(h) The generator can be pressurized to operating pressure of 320 kPa and the seal oil booster system placed in service. As the pressure increases the purity should increase to exceed 95%.

(i) Hydraulic fluid pumping system start-up.
1. Verify turbine in tripped condition.
2. Check hydraulic fluid tank level.
3. Check coolers in service.
4. Open by-pass valve and start hydraulic fluid pump.
5. Close by-pass slowly - pressurizing system.
6. Place 2nd pump in stand-by.

5. Low Pressure Feedwater System

Note: Refer to Procedure #'s POP-003, POP-015, POP-016, POP-032, POP-053, POI-01/02/03 and POI-13

The Deaerator should be filled and steam open to coil allowing the water to heat up. After this is achieved, do not use RFW pump to put water in the boiler.

1. Ensure that there is an adequate water level in both the RFW tanks and in the Hotwell.

2. Ensure Hotwell water is checked by the Lab for chlorides, Condensate Polisher Regeneration chemicals, etc. (Lab) before and after the CW (salt water) system is placed in service as per Procedure POP-015.
3. Ensure Extraction pumps have proper oil levels.
4. Close all known vents and drains on the LP Feed system. Refer to dry lay-up instructions POI-001/002//003 as required.
5. Check the DA rundown and DA recirculation are closed when filling DA.
6. Ensure Extraction Pump Seal Water is in service.
7. Ensure Hotwell make-up and Surplus Stations are in service. Align set point and process of Hotwell Level Control at normal operating level and place in auto.
8. Check the 4kv starter Breakers for proper operating position.
9. Check the discharge valves are opened approximately 10% on both Extraction pumps before starting Extraction pumps.
10. Open suction Valves to both Extraction pumps.
11. Ensure that the Condensate Polisher has been rinsed down. Refer to POP-053 Putting a Condensate Polisher in line.
12. Ensure that the Condensate Polisher plant is at '0%' percent before starting Extraction pump.
13. Ensure that the Low Load Recirc Valve is in the open position.
14. Ensure Extraction Pump Motor Cooling Water is in service (Unit #3 only).
15. Start the Condensate Extraction Pump as per Procedure POP-032.
16. Start hydrazine/ammonia pump if required, and slowly open Deaerator (Fill) Control Valve to fill D.A. if required, **maintaining a slow rate of fill**, while monitoring the Hotwell level at the same time as per Procedure POP-003. Check for leaks and at normal level 70%, the steam coil may be opened partially.
17. Open the Pegging Steam supply to the Deaerator, if hot, prior to adding water.
18. Slowly open the pump discharge valve and allow the system to purge and fill with water.
19. Check system periodically after start up for anything that is not normal.
20. Refer to POP-053 Putting a Condensate Polisher in line.
21. Refer to POP-003 Filling the Deaerator using Condensate Extraction pump.

6. Boiler water side and gas side preparation for firing.

a) Open drum vents and superheater vents.
b) Verify gauge glass valves are open and Boiler drum doors are secured.
c) Verify isolating valves are open on the start-up vent and motorized start-up valve is open.
d) Check header isolating valves open on superheater drains.
e) Open SH-1, SH-5, SH-3 and SH-4 and the above seat drain on boiler Stop Valve.
f) All furnace doors and observation ports check closed and secured.
g) Check gas outlet dampers open and air heater doors closed.
h) Check economizer drains closed and bottom blowdown valves closed.
i) Open reserve feed water transfer pump isolating valves at economizer inlet 7th floor and fill boiler to operating level using R.F.W. pump.

j) Check that all burners and igniters are installed and secured.

k) Start Ljungstrom air preheaters and open the air supply cock. Test for air supply cock. Test for air drive operation by opening the air heater drive 600V breakers. The air solenoids should be open on loss of power. Close 600V breakers and start motors again, the air solenoids should close.

l) Open the atomizing steam supply from the auxiliary steam system and slowly open the atomizing steam control valve to warm up heater. When the pressure reaches 750 kPa the control valve on the W.D.P.F. station may be placed in "AUTO".

m) Check F.D. fans for operation - oil levels, damper positions, linkages, cooling water, doors or any obstructions. F.D. fans may now be started and air flow increased to 35% to 40%.

n) Start

(1) Seal air booster fan;
(2) Both scanner fans; and
(3) Igniter fan.

7. Fuel Oil Systems Light and Heavy

a) Check light oil pumping set and start one pump. Pressure should stabilize around 200 kPa.

b) Open steam to the heavy oil set heater and allow condensate to drain, using shell drain manual valve.

c) When steam issues from drain, close drain valve.

d) Start fuel oil pump with pressure control valve open. (W.D.P.F. station set at 0%)

e) Slowly increase fuel oil discharge pressure to set point 1550 kPa and place in "AUTO".

f) Boiler purge permissives, these conditions must be met:

* No active Boiler trips;
* All burner fuel valves closed;
* All igniter valves closed;
* Both F.D. fans running;
* Aux. air dampers modulating;
* Main oil trip valve closed;
* Igniter oil trip valve closed;
* Long recirc. valve closed;
* Air flow > 30%;
* No flame verified by scanners;
* All fuel air dampers open.

<u>Start Boiler Purge Five (5) Minutes</u>

When purge complete
* Open light oil trip valve; and
* Start required igniters (from 1 to 12).

During initial firing, do not let furnace exit gas exceed 530°C. Close drum vents at approximately 200 kPa. Close all superheat drains except start-up vent, SH-1 and SH-5 and Boiler stop valve above seat drain, these will be throttled. Fire with igniters until air heater back end temperature is >80°C. Control drum temperature limits as per attached - Figure 1.

8. Boiler feedwater pump preparation.

1) D.A. temp must be 80°C+.
2) Backfill B.F.P. discharge line.
a) Open B.F.P. suction valve.
b) Open gland sealing water control valve and place in "AUTO" (W.D.P.F. station).

NOTE: The gland seal water can be supplied from the emergency gland seal water pump or from the extraction pump. If the extraction pump supply is open the emergency pump will have to be shut down and placed in stand-by because it can't overcome the high pressure of the extraction pump and if left running, will cause damage to itself.

c) Open recirculating valves at recirc. control valve station and at D.A., check control valve open.
d) Manually open B.F. pump discharge valve partially, open feedwater control valve motorized isolator and its associated control valve.
e) Place H.P. heaters in service and open vent valve on feedwater line before economizer isolating valve.
f) When water issues from vent, close same, check economizer inlet valve open, close B.F. pump discharge valve and control valve.
g) Check water open to motor coolers and lube oil cooler. Check lube oil tank level and start aux. lube oil pump. When oil is sufficient on all bearings and the oil pressure permissive is satisfied the B.F. pump may be started.

9. All turbine drains, turbine stop valve drains and main steam line drains to be opened in preparation for turbine warming.

10. When boiler pressure is approximately 100 kPa the Boiler stop valve pilot valve can be opened to start warming main steam line before turbine stop valve. As the main steam line warms the main Boiler stop valve con be opened slowly. During Boiler pressure raising, do not exceed the maximum allowable rate of increasing pressure change as noted in Figure 1 attached.

11. a) At approximately 1200 kPa drum pressure the steam control valve to the air heaters can be opened.
b) At 1200 kPa all manhole doors and furnace doors should be snugged up.

12. <u>Firing Main Burner</u>

* Open main fuel oil trip valve. Atomizing steam pressure is a prerequisite! At least 200 kPa at the burner.
* Open fuel oil control valve 20% to allow fuel to circulate around heater and temperature probe.

* When fuel oil temperature reaches 100 °C the fuel oil temperature control valve may be placed in "AUTO". Temp control valve will not operate until pump is started!

These conditions must be met before burner will fire:
* Air flow >30% but <40%.
* Burner tilts at 0° or horizontal.
* Oil temperature permissive satisfied. Oil temperature >90° C.
* Burner local switch on burner control panels at each elevation in "AUTO".
* Manual valves for fuel and steam open.

Burner guns should be cleaned and installed.
Advance/retract should have been previously tested as well as limit switch and valve operation. Someone must be standing by the burner before starting, to verify no leaks. As each burner is established - set up scanners.

13. <u>Turbine Pre-Warming</u>

a) Prewarm unit until first stage inner metal temperature reaches 150°C.
b) Boiler steam pressure must be 1800 kPa or greater to five required steam seal pressure (14 kPa).
c) Check reheat valve drains open.
d) Throttle turbine casing drains.
e) Throttle main stop valve drains.
f) Check all turbine control dials at 0 position.
g) Reset turbine at control panel and if necessary the front standard.
h) Close vacuum breaker valve and start vacuum pump. 34 kPa by manually opening vacuum breaker valve, and hold.
i) Start Gland seal exhauster and put steam sealing system in service (14 kPa).
j) Open exhaust hood spray water valve.
k) Load Limit and speed load control dials open fully.
l) Push pre-warming button to close heating steam blocking valve.
m) Slowly open Turbine stop valve and admit steam to start warming. First stage temperature will start to increase.
n) Inner metal temperature to outer metal temperature differential is not to exceed 83° C.
o) Main stop valve to be closed when first stage temperature 150° C.

14. Preparation for Roll-Off

a) Open Intercept valves fully.
b) Open all turbine drains.
c) Close vacuum breaker and raise full vacuum.
d) Turbine bearing oil temperature must be 35° to 40°.

e) Slowly open the turbine stop valve and accelerate the turbine at the pre-determined rate. For cold start approximately 100 rpm. Follow the starting times and holds, noted in Figure 3, relative to the steam conditions and metal temperatures.
f) Closely monitor bearing vibration, eccentricity and differential expansion through run-up.
g) Hold turbine speed at approximately 1000 rpm until HP Turbine metal temperatures start to converge.
h) With the automatic voltage regulator (AVR) in the ON position, pulse the field breaker closed.
i) Increase turbine speed to next hold 3000 rpm and hold, check for satisfactory HP Turbine inner and outer metal temperatures. (See Figure 4)
j) At approximately 3450 rpm inform ECC that generator field has flashed.
k) Inform ECC that main generator breakers are to be opened and the generator disconnect is to be closed. Verify disconnect closed.
l) Increase turbine speed to 3600 rpm and match incoming voltage to running voltage, before synchronizing, then synchronize unit and raise load.

15. Increase load on turbine slowly, keeping the turbine metal temperature increase below 65° C per hour. Use Figure 5 to determine the maximum load to be carried for the actual first stage shell temperature.

16. At 15-20 MW all turbine drains and boiler drains should be closed, and exhaust hood sprays sheet down.

17. At 30 MW, change to unit service supply by matching unit service voltage to station service voltage and pulsing the unit tie breaker closed. The change will occur automatically. Manual Transfer - The synchronizer switch must be selected to desired transfer and then pulse tie breaker closed.

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HTGS Procedures
Procedure: 0576 (POP-011 Charging Units #1 & #2 Generators with Hydrogen)

Certified System ISO 14001 QMI-SAI Global

Procedure Number: **0576**
Entered By: Cheryl Oliver
Date Entered: Oct 10th, 2000 10:13 AM

Title: **POP-011 Charging Units #1 & #2 Generators with Hydrogen**

Archive Information	
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Prepared By:	**Gerard Cochrane**
Controller:	**Gerard Cochrane**
Reviewers:	**Eldon Emberley, Evan Cabot**
Approved By:	**Terry LeDrew/HO/NLHydro**

Procedure Scope

To charge Generator with H_2 Gas using accepted and approved procedure.

Reference Information

Procedure Details

Gassing #1 & #2 Generators:

1. Ensure portable gas analyzer has been calibrated and connected to the main generator vent via valve H-V525. (under generator, 2nd floor)
2. Ensure two CO_2 purge line valves to H_2 skids are closed. (H_2 shack)
3. Ensure one CO_2 skid is full and ready for service (H_2 shack)
4. Ensure that at least two H_2 skids are full and ready for service (H_2 shack)
5. Ensure that one H_2 skid is in service at a time. (H_2 shack)
6. Adjust CO_2 regulator to 100 KPA. (H_2 shack)
7. Ensure gas dryer inlet/outlet line valves are open (under generator, 2nd floor)

"Purging "Air with CO_2"

8. Ensure generator H_2 supply line valves H-V520, H-V521 and H-V522 are closed and attach caution tags indicating generator purge in progress. (under generator, 2nd floor)
9. Ensure CO_2 supply valves to generator and to gas dryer (valves CO-V46 and CO-V48, respectively) are closed. (under Generator, 2nd floor)
10. Open CO_2 line valve CO-V45 and verify pressure on gauge CO-PG1.
11. Open valve H-V524 from top of generator to main vent line.
12. Ensure shaft sealing asystem in in operation.
13. Position three-way H/CO-V544 to admit CO_2 to bottom of generator.
14. Throttle generator CO_2 supply line valve CO-V46 to increase pressure to 30 KPA.

Notes: 1) Float trap level should return to normal as generator pressure increases, and
2) Air/Gas flow rates must be kept low to avoid turbulence within the generator casing.

15. Throttle main generator vent valve H-V526 and CO_2 supply valve CO-V46 to maintain 30 KPA generator gas pressure.
16. Select "air in CO_2) on the gas analyzer and ensure gas is flowing through to main generator vent line via valve H-V525.
17. Maintain constant generator pressure and monitor same by trending on the WDPF System in the Control Room. Note: Maintain generator casing pressure below 35 KPA.
18. When Purity of "Air in CO_2" decreases to 30% or less, the air purge with CO_2 is complete.
19. Close generator CO_2 supply line isolating valve CO-V46 and attach caution tag indicating generator purge in program.
20. Close H_2 isolating valve H-V524 from top of generator. Note: Main generator vent valve H-V526 to remain in the throttled position.

Purging "CO_2 with H_2"

21. Position three-way valve H/CO-V544 from bottom of generator to main generator vent line. Decrease generator easing pressure to 10 KPA.

Notes: 1) Remain at location until desired generator pressure is achieved.
2) Float trap level will rise as generator casing pressure decreases, and
3) Air/Gas flow rates must be kept low to avoid turbulance within the generator casing.

22. Throttle generator H_2 supply valve H-V522 to increase generator casing pressure to 30 KPA.

Notes: 1) Float trap level should return to normal as generator casing pressure increases, and

2) Air/Gas flow rates must be kept low to avoid turbulance within the generator casing.

23. Select "H_2 in CO_2" on the gas analyzer and ensure gas is flowing through to the main generator vent line via H-V525.

24. Maintain constant generator casing pressure and monitor same by trending on the Foxboro DCS System in the Control Room. **Note:** Maintain generator casing pressure below 35 KPA.

25. When Purity of "H_2 in CO_2) exceeds 90%, the CO_2 purge with H2 is complete.

26. Position three-way valve H/CO-V544 to be closed from bottom of generator to the main generator vent line.

27. Close main generator vent line valve H-V526.

28. Increase generator casing H_2 pressure as required via H-V522 to a mazimum of 180 KPA.

Note: This allows for expansion and pressure increase due to increase in gas temperature after the unit is synchronized.

29. Remove caution tags from:

- Generator H_2 supply line values (H-V520, H-V521, and H-V522)
- Generator CO_2 supply line valve (CO-V46)