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September 2, 2011

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: Newfoundland and Labrador Hydro's 2012 Capital Budget Application

Please find enclosed the original and eight copies of a condition assessment of Units 1, 3 and 4 at the Bay d'Espoir Generating Station. This report is an Appendix to Hydro's report entitled "Replacement of Stator Windings at the Bay d'Espoir Hydroelectric Generating Station" located at Tab 1 of the Reports section of Volume I of the Application.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Geoffrey P. Young
Senior Legal Counsel

cc: Gerard Hayes – Newfoundland Power
Paul Coxworthy – Stewart McKelvey Stirling Scales
Thomas Johnson – Consumer Advocate
Dean Porter – Poole Althouse

amec

BAY D'ESPOIR GENERATING STATION

POWERHOUSE NO. 1

UNIT GENERATORS #1, #3 AND #4

CONDITION ASSESSMENT REPORT

Newfoundland and Labrador Hydro

Prepared for:

Newfoundland and Labrador Hydro

Prepared by:

AMEC Americas Limited
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REGISTERED PROFESSIONAL ENGINEER
PEG Newfoundland and Labrador
ANDREW DUPLESSIS
SIGNATURE
Sept. 1/2011
DATE
NEWFOUNDLAND & LABRADOR

Date: September 1st, 2011

AMEC Ref. No.: 168688 Rev. 1

BAY D'ESPOIR GENERATING STATION

POWERHOUSE NO. 1

UNIT GENERATORS #1, #3 AND #4

CONDITION ASSESSMENT REPORT

FOR

NEWFOUNDLAND AND LABRADOR HYDRO

REV.	DATE	REVISION(S)	PREPARED BY	CHECK	APP	CLIENT
1	September 1st, 2011	Issued Final (minor non-technical changes)	DVT	CD	AD	
0	August 22, 2011	Issued Final	DVT	CD	AD	
B	August 12, 2011	Issued for Client Review (Draft)	DVT	CD	AD	

amec	BAY D'ESPOIR GENERATING STATION POWERHOUSE NO. 1	AMEC JOB NO. 168688	
		REPORT NO. 168688	REV. 1
		PAGE 1 OF 1	

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EXECUTIVE SUMMARY

The purpose of this study is to assess the current condition of the generators at Newfoundland and Labrador Hydro's Bay d'Espoir Hydro-Electric Generating Station. Units #1 through 4 in Powerhouse No. 1, excluding No. 2, are in need of major upgrades, more specifically the stator windings are in poor condition. These three units have been ranked in order of precedence for a replacement plan.

Data was collected from all plant maintenance inspections, PM6 (annual) and PM9 (approximately every six years), along with the staff interview and the most recent data collected on a site visit (July 4 to 7, 2011). This data was analyzed and used to perform an assessment of the current condition of these units.

From our assessment of the three generators it is apparent that Unit #4 is in the worst condition. Based on the test results, the stator windings will need to be rewound as soon as possible or a failure during operation will be imminent. The most reasonable time to schedule this work is during the spring or summer of 2012.

Unit #1 has already had one coil failure during a Hypot test and the latest test results indicate weaknesses in the winding insulation. In order to maintain reliability, the stator rewinding is planned to follow Unit #4, while maintaining regular plant maintenance. It is recommended that this occur in 2013.

Unit #3 is expected to operate until the other two units are replaced. Annual maintenance and follow up testing should be performed to closely monitor any unexpected changes in the condition of the winding insulation until the stator is rewound. It is recommended that this occur in 2014.

Additional work on the rotors and auxiliary systems is recommended to occur at the same time as the stator rewinds.

An additional recommendation is to revise the DC voltage control step test to make this test a diagnostic test and not as destructive as the current testing method.

1.0 INTRODUCTION

The hydro generating station at Bay d'Espoir, NL consists of six generating units. The focus of this study is to assess the condition of Units #1, #3 and #4. A major overhaul to Unit #2 was carried out in 2010, which included a complete stator rewind. This unit is therefore not considered in this study. The three units have identical 85 MVA generators and therefore can be compared with one another in terms of condition assessment.

The ratings for Units #1, #3 and #4 are as follows:

Rated Output Power:	85 MVA
Rated Power Factor:	0.9
Rated Voltage:	13.8 kV
Rated Speed:	300 RPM
Rated Frequency:	60Hz
Field Amperage:	1500 A
Field Voltage:	125 V
Insulation Class of Armature:	Class B (Mica tape & Asphalt)
Insulation class of Field Windings:	Class B (Shellac and Asphalt)
Cooling Air Temperature:	30 °C
Temperature Rise of Armature:	60 °C
Temperature Rise of Field:	60 °C
Shaft Position:	Vertical
Number of Slots:	360
Commissioning Year:	Units #1,#3: 1967
	Units #4: 1968

2.0 METHODOLOGY OF ASSESSMENT

This assessment was conducted using the level one methodology from a three level detailed procedure of increasing detail developed by the Electric Power Research Institute (EPRI).

The level one condition assessment consists of the following:

- Failure history from plant records
- Operation condition (i.e. temperature)
- Maintenance records including tests and repairs.
- A site visit to conduct a walkthrough, a visual inspection and data collection from plant and plant staff interviews based on the equipment.

2.1 Site Visit

A site visit was conducted in July of 2011 to collect test data from Units #1 through #4, perform a visual inspection of the equipment and to meet with plant staff to discuss any problems. Unfortunately, due to system demand, only Unit #4 was arranged to be shut down for a visual inspection. A major overhaul to Unit #4 was just completed in May 2011 and had only been back on line for a little more than a month when the visual inspection took place (see report in Appendix A).

2.2 Background Review

Plant historical records were submitted by plant staff following the site visit in July for detailed review/analysis as follows:

- Major outage reports
- Failure reports
- Maintenance and inspection reports
- Testing reports

3.0 ANALYSIS

A review of all the available records for the generators on Units #1, #3 and #4 was performed. The following aspects were examined.

3.1 Thermal Aging of Winding Insulation

Units #1 and #3 are 44 years old and Unit #4 is 43 years old. According to industry experiences, the asphalt mica winding insulation on these three units has a life expectancy of 40 to 45 years. Therefore the generator winding insulation on these units is approaching the end of its life cycle.

Based on the 2010 operating data, the typical full load power on Units #1, #2 and #4 are as follows (see Appendix B).

- Unit #1 had almost 60 occurrences when the output power reached 80MW to 84MW.
- Unit #3 reached an output power of 83.3MW once and every other reading was below 80MW.
- Unit #4 peaked at 79MW once; every other reading was below 78MW.

As confirmed by plant staff the reactive power output of the three units is always maintained close to zero (unity power factor), therefore the 84MW real power output of unit one is still below the rated output 85kVA apparent power of the generator.

In order to determine if there are any effects of temperature that will affect the life expectancy of the winding insulation, the stator temperature trending for each unit was reviewed as follows (see Appendix B).

- Unit #1: The generator stator winding temperature (measured by RTD's) trending from January 1, 2000 to January 31, 2011 (11 years) has shown that the generator stator temperatures are around 60-65 degrees Celsius, except in 2006 when it spikes to 75 degrees Celsius and a short span operating at 80 degrees Celsius. These trends do not result in shortening the life expectancy of the winding insulation.

- Unit #3: The generator stator winding temperature trending from January 3, 2000 to March 14, 2011 has shown an average of 60-65 degrees Celsius, except for seven spikes of around 75 degrees Celsius and six spikes of around 78 degrees Celsius. These trends also do not result in shortening the life expectancy of the winding insulation.

- Unit #4: The generator stator winding temperature trending from January 3, 2000 to June 27, 2011, has shown an average of 65 degrees Celsius or below due to multiple start/stops. There are five spikes of 75 degrees Celsius and one spike at around 88 degrees Celsius. These cyclic changes of winding temperatures may cause more harm to the insulation than the steady temperatures of Units #1 and 3.

Based on the above stator temperatures trending, the winding temperatures of all three units are below the limit which can cause over temperature life reduction as in Montsinger's Law.

3.2 Generator Testing

As per normal practice at Bay d'Espoir, a number of tests are carried out annually during annual maintenance (PM6) outages and every six years during major maintenance (PM9) outages. The results of four of these tests, the Megger test, the Doble test, the PDA online measurements and the DC high potential tests have been analyzed. These four tests have been listed in order of increasing importance, with the DC high potential and PDA tests being the most useful test for determining the condition of the windings.

3.2.1 Megger Test

Megger testing is performed on the complete stator windings with or without the IPB (Isolated Phase Bus) and exciter rectifier transformer. This test only provides the global insulation resistance of all three phase windings to ground so it is not possible to compare the winding insulation resistances to see if they are comparable among phases.

3.2.2 Doble Test

Doble testing (power factor and tip up tests) of the generator windings was performed routinely on Bay d'Espoir generators since 1972. The generator winding under test has all split phases separated with test results on each split (6 in total) of the rotor windings. The test voltages are at 2, 4, 6, 8 and 10kVAC.

The trending of the Doble test is provided in (Appendix C.1) with the following observations:

Units #1 and #3 indicate good average power factor values at 2kV and 10kV without increasing in tip-up. Unit #4 also indicates good average power factor values at 2kV and 10kV up to 1989, when the power factor values start to increase until the latest tests in 2011 (the highest power factor of one split phase value is 4.6% at 10kV).

Based on the Doble test, the generator winding insulation to ground on Units #1 and #3 are acceptable. Conversely the generator winding insulation to ground is degraded on Unit #4.

3.2.3 PDA Online Measurements

The PDA activities on Units #1, #3 and #4 were reviewed in a detailed report from 1993 by Black and Veatch and again in 1998 by GE Armstrong Inc. These reports were based on the simple methods to interpret PD data on rotating machine stator windings.

With PDA-H tests in 1992 (Appendix C.2) the following were observed:

- Unit #1 stator windings have shown Qm values around the 90th percentile (508mV) of 13.8kV air cooled generators based on IEEE Objective Methods to Interpret Partial-Discharge Data on Rotating-Machine Stator Windings, G. Stone.
- Unit #3 stator windings have shown a number of Qm values exceeding the 90th percentile.
- Unit #4 stator windings have shown high Qm values exceeding the 90th percentile Phase A, BC2, and C of Unit #4 are well above the 90th percentile.

Qm values well above the 90^{th} percentile indicate a high risk of failure.

3.2.4 DC High Potential Tests

The Bay d'Espoir generating station has been using the DC high potential step voltage controlled tests in 3kVDC step/3 minutes up to 27kV (or 30kVDC) to test generator stator windings. At the last step of 27kVDC the duration stays for 10 minutes before ending the test. This step controlled voltage test is a very effective test to evaluate the weakness or deterioration of the stator winding insulation, particularly if it is performed on each phase with the other two phases grounded.

Based on test results (Appendix C.3):

- Unit #1 stator winding insulation to ground starts to show weakness from 15kVDC to 27kVDC.
- Unit #3 stator winding insulation to ground is good until the highest voltage of 27kVDC. With my experience in reviewing this type of test, there is no concern that this generator winding insulation will fail in service within the near future.
- Unit #4 stator winding insulation to ground has shown signs of deterioration since 2001 and later. This trend may indicate a potential winding insulation failure. Unit #1 may be similar or better then unit #4 because the test data for Unit #1 is limited to one measurement.

3.3 Generator Major Incidents/Electrical Maintenance

Using the timeline from commissioning year to present year (2011) the major incidents/maintenance of all three units are as listed below and summarized (in Appendix D).

3.3.1 Unit #1

1993

- Complete stator re-wedging using piggyback wedges, replacing old GE split wedges.

1994

- New maintenance forms started being used.
- PM6 is the annual maintenance or inspection sheet with the rotor in place.
- PM9 is major maintenance with the rotor removed. This maintenance is typically performed every 6 years.

1998

- A complete static exciter replacement with better performance.
- Asphalt leaking out of stator coils at the bottom end was detected by visual inspection.
- With the implementation of the new maintenance program, any deficiencies found during PM9 are to be corrected before re-assembly of the unit.

1999

- Replacement of loose wedges.

2000

- During PM9 one stator coil failed under Hypot test at 27kV and it was replaced.
- Repair loose V-block shim (micarta) between poles #18 & #19.
- Repair field leads.

2004

- During PM6, repair done to the flexible leads connecting the rotor bus leads to the slip rings.

2007

- PM9 Hypot test results at 27kV creeping up from 180 to 230 micro-amps during tests before and after cleaning.
- Replace slip rings by robbing unit #2 slip rings.

2008 – 2011

- Only annual PM6, all megger test results during PM6 since 1994 are normal and acceptable.

3.3.2 Unit #3

1991

- Complete stator and rotor re-wedging using piggyback wedges to replace old GE split wedges.

1994

- Start new preventative maintenance forms for annual PM6 and a 6 year cycle for PM9.

1995

- Slip rings dirty, meggered result only 45 Mega-ohms.

1997

- Exciter replacement.
- Stator core found damaged on phase B between 345-346 slots.

1998

- PM6: asphalt leaking out of stator bars in the coil.

1999

- Major work done during this PM.

2000

- Dry ice cleaning of stator and rotor.

2001 – 2007

- PM6, no abnormality found, PI tests are within normal range and acceptable.

2008

- Unit relayed out: IPB connection to the unit transformer damaged and broken then repair done.
- Slip ring needs cleaning, top of rotor cleaned with dry rags.

2009

- PM6: Generator cooler replaced.
- Wedge inspection.

3.3.3 Unit #4

1992

- Complete stator re-wedging using piggyback wedges replacing the old GE split wedges.
- Generator trip on stator ground fault: problem found at one of the main leads: bus was reinsulated.

1993

- Inspection: Loose core laminations, 12 to 16 shorted laminations.
- Need cleaning & epoxy coating.

1994

- PM6: PI test has a good result.
- Wedge inspection.

1995

- Inspection: No comment (OK).

1996

- Re-tape the rotor pole jumpers.

1997

- Start-up inspection (OK).

1998

- Exciter replacement.
- PM6: PI test barely acceptable (2.46).

1999

- PM9: Stator re-wedge with piggyback wedges.
- Re-tape generator rotor pole leads on stator line side connection and neutral leads..
- Repair four rotor rim keys.
- Re-torque stator core bolts.
- Install shims to tighten and fingers/repair 6 loose fingers.
- Correct shorted laminations in stator core.
- Clean rotor.

2000

- PM6: Wedge inspection, two slots loose.
- Section of stator insulation repaired.

2001

- PM6: PI = 3.6 before cleaning and 3.4 after cleaning which is within normal range.

2002

- PM6: PI = 3 (OK).

2003

- Major incident: Unit breaker malfunction (open and closed repeatedly). During investigation, stator windings were found damaged on the upper end turns of six stator coils (near the coil exit from the stator core). An in place repair was completed using RTV silicone and over taped with self amalgamating electrical insulation tape.

2004

- PM6: PI = 3.64 (OK).

2005 - 2006

- PM6: PI = 2.5 before cleaning and 3 after cleaning (OK).
- PM9: PI = 1.7 and 650M-Ohms at 10 minutes (this is below the minimum acceptance of 2).
- Dry ice cleaning of stator & rotor.
- Exciter has a lot of dust.
- Two brushes replaced.

2007

- PM6: Detailed inspection of slip ring and 9 brushes were replaced.

2008

- PM6: PI test result 2.91 (OK).
- Two rotor leads need to be re-taped.
- Stator needs cleaning.

2009

- PM6: PI = 3.27 (OK).
- Rotor bus corona found.
- Stator cleaned.

2010

- PM6: PI = 3.55 (OK).

2011

- PM6: PI = 3.27 (OK).
- PM9: loose pole keys on 6 rotor poles fixed.
- Damaged taping on poles.
- Shorted core laminations on stator repaired.
- Rotor pole leads re-taped.
- Wedge inspection.
- Stator and rotor cleaned.

3.3.4 Summary of Maintenance Reports

Unit #1 had one coil failure under a Hypot test. The failed coil was replaced but several other top coils in the span had to be pulled to replace the failed coil. This failure under test did not cause any detrimental effects to other windings. There was nothing abnormal reported on the stator, its frame or the IPB connections to the unit transformer. The generators rotor interpole V-block shims (spacers) between poles 18 and 19 were replaced along with the field leads and the rotor pole voltage drop test results are within acceptable limits. Water was leaking from the North upstream air cooler.

Unit #3 had a stator ground fault caused by a failure with the IPB (Isolated Phase Bus) flexible connections to the transformer, there was no effect on the stator windings. The stator core was damaged on phase B between slots 345 and 346 and was repaired the following year. Several items were addressed on the generator rotor including a pole adjustment, re-taping the pole leads and the slip rings were repaired. The rotor pole voltage drop test results are within acceptable limits. The IPB connections to the unit transformer were damaged on phase B and then repaired. No cooler water leaks were reported.

Unit #4 experienced loose wedges in 1999 (following a complete re-wedging in 1992) and was re-wedged. During an inspection in 2000, two slots wedges were found loose. Based on the finding of these loose wedges, it appears that the cyclic operation has affected the tightness of the stator coils. In 1993 the stator core had loose and shorted core laminations. In 1999 six loose press fingers of the core were repaired by shimming and tightening and the stator bolts were re-torqued.

In 2003 Unit #4 suffered a major incident due to multiple opening/closing actions on the unit breaker due to a malfunction. The end turns of six stator coils were damaged (just outside the coil exit from the core), apparently by a stray bolt. A compromised method of repair was done in place without pulling out the coils from the stator slots. This incident caused a significant impact on the generator both mechanically and electrically.

Other problems encountered on the Unit #4 stator include loose core laminations in the stator core were repaired by re-torquing the bolts, six loose press fingers were repaired by installing shims to tighten the end fingers and 12 to 16 shorted laminations were found and repaired. Several problems on the generator rotor were also addressed including re-taping of the rotor jumpers, repairs to four rim keys, detection of rotor bus corona by plant staff, loose pole keys on six rotor poles were fixed and damaged taping on the poles was corrected. The rotor pole voltage drop test also revealed deficiencies on five poles. There was nothing abnormal with the IPB connections to the unit transformer.

3.4 Unit #2 Used Coil Examination

One piece of used coil, approximately 12 inches long and from the slot of the core, was removed from Unit #2 in 2010 during the stator rewinding. This piece of coil was provided to AMEC for examination.

A visual examination was conducted, yielding the following comments:

- Oil mixed with black dirt is soaked into the outside overall tape of the coil. It is evident that the oil leaking problem that entered the stator slot from the top of the core is very serious.
- The insulation swell is observed at the core vent hole.
- Asphalt has migrated downward and the mica tape has a lack of asphalt on many layers.
- Mica tape delamination is evident.
- Turn insulation is not examined.

All of the observations above support the PDA monitoring in the past, indicating high activities of PD in the slots and delamination of the insulation. Over the long term, the common problem of oil leakage must be corrected for all units. The common long term oil leak problems for all units must be fixed.

3.5 Feedback from Voith during Unit #2 Complete Rewind of Stator

Feedback obtained from a Voith specialist is as follows:

- Stator coils were asphalt mica with heavy indications of slot discharges.
- Wedges were very loose.
- Coils were severely delaminated as the asphalt had migrated down.

- Stator core splits were OK.
- Rotor pole V-block were loose due to shrinkage in the micarta spacers.

At Bay d'Espoir, both Unit #2 and #4 have multiple start/stop cycles compared to the base load operation of Units #1 and #3. Therefore the condition of Unit #4 is likely similar to Unit #2.

4.0 CONCLUSION

Taking into account the analysis of the three units, the condition assessment is as follows.

4.1 Unit #4

Unit #4 is in the worst condition of the three units. Its reliable operation is uncertain and may lead to failure of the stator windings following an electrical system disturbance. With a major overhaul this year, Unit #4 is expected to operate until spring 2012 without a high risk of major problems, except for the fact that the winding insulation is weak. A complete stator rewind should be planned for spring or summer 2012, together with a stator repair to restore the integrity of the core for the life of the new stator windings. The rotor poles field windings are also to be re-insulated, V-blocks to be fixed and with other maintenance work performed.

4.2 Unit #1

Although weakness of the stator winding insulation to ground already shown in testing, it is likely able to operate without high probability of major failure on the stator windings until the spring of 2013. Follow up testing should be performed annually and a complete stator rewind should be scheduled for spring/summer 2013, together with reinsulation of the rotor poles field windings and other maintenance work.

4.3 Unit #3

The Unit #3 stator winding insulation is still in good condition, except the PDA measurements are around the 90th percentile, indicating future problems. With annual follow-up testing Unit #3 can be expected to be in service for a few years. It is recommended to follow the current schedule to replace the stator windings in the spring/summer of 2014, together with reinsulation of the rotor poles field windings and other maintenance work.

It is notable that Units #1 and #3 provide station services for the Bay d'Espoir generating plant. Therefore if Unit #1 and #3 are scheduled for stator rewind, it is worthwhile to consider to have redundant station service available by back feeding the unit transformer, with temporary ground fault protection set up for the ungrounded 13.8kV bus, or to move the station service to Unit #2 or #4.

4.4 Environmental Influences

The environmental influences on the insulation life as mentioned in IEEE Std. 434-2006 include moisture, oil vapor, carbon dust, brake dust and other contaminants. At the Bay d'Espoir plant, it appears that the oil leaks and carbon dust problems have been present for a long time on units one through four. No solution has surfaced to eliminate or reduce these effects. It is recommended that more effort be put into fixing these problems.

4.5 Work to be Carried Out During Generator Stator Re-wind

The stator re-wind will extend the life expectancy of the generator windings for another 40 years or more. It is recommended that other generator main components be repaired (or replaced) to match the life extension of the windings.

- Generator Core/Frame

  Major maintenance work should be carried out during the rewind outage to restore the core/frame integrity after the removal of the old windings and are as follows:

  - A thorough inspection after cleaning to identify core/frame deficiencies (backcore and inside the bore, core splits, etc.).
  - A thorough inspection of stator air vents to ensure that all air vents conditions are acceptable.
  - A core full flux test or an ELCID low flux test, to detect defects on the core laminations. (The ELCID is also a good tool to check/compare the core repair result with a good portion of the core).
  - A test for loose laminations at the step-down section of the core to detect loose pressure fingers. Corrective action would have to be done including shimming or re-torquing the stator finger bolts.

- Generator Rotor

  To extend the life of the rotor to match with the new stator rewind, the following work should be done:

  - In order to maintain the integrity of the field winding insulation, the pole field windings must be reinsulated with modern non-asbestos Class F insulating material (NOMEX).
  - All the inter-pole leads and main field leads (copper bars) connected to slip rings must be checked for cracks and re-taped properly.
  - The slip ring condition must be checked and re-machined if necessary.
  - The rotor rim and spiders must be examined by non-destructive testing (NDT) before re-assembling the poles.
  - Generator air coolers are to be cleaned and tested for leaks.

  - Generator isolated phase bus (IPB) is to be inspected, particularly the flexible connections at both ends (generator & transformer).

- Generator Protection

  The existing generator protection relays are electromechanical relays which have been in service for more than 40 years. It is recommended that the protection be upgraded to modern microprocessor based relays at the same time as the generator refurbishment. Modern relays offer faster response, better reliability and less routine maintenance.

- Generator Online Monitoring

  - The existing partial discharge analyzer (PDA) should remain in use.
  - The existing stator winding temperature monitoring should remain the same.
  - The generator air gap monitoring system should be installed during this re-wind (as already done for Unit #2).
  - It is worthwhile to add/to enable the rotor field temperature monitoring in the existing static excitation system.
  - The vibration monitoring should remain the same.

- Generator synchronizer

  The generator auto synchronizer performance is to be checked to conform to IEEE Std. C50.12.2005.

  Unit transformer and unit breakers have not been included in this scope.

4.6 Recommendations

Units #1, #3 and #4 are scheduled for refurbishment as per the following schedule.

- Unit #4 – As soon as possible. The earliest this refurbishment could reasonably occur is in the spring or summer of 2012.
- Unit #1 – Spring or summer of 2013.
- Unit #3 – Spring or summer of 2014.

For the annual follow-up DC controlled voltage tests, we suggest that the test procedure be revised as follows:

- The 3kVDC step/ 3 minutes appear to be too large. It is worthwhile to consider a 2kVDC/2 minutes step from 12kVDC and up (i.e. 14, 16, 18, 20, 22, 24, 26 and 27kV). As well, the charging current should be kept at 100-150 micro-amps maximum for each step.

- The current versus voltage curve should be plotted with the test results from each step, such that the test is aborted when the current is measured to be excessive. This will reduce the likelihood that the DC step control voltage test causes further damage.

These tests should be performed on Units #1, #3 and #4 every year until they have been refurbished. Poor test results may indicate a requirement for a more aggressive refurbishment schedule. However, because of other factors relating to the condition of these units, successful test results should not be used as a reason to delay refurbishment past the schedule outlined above.

5.0 BIBLIOGRAPHY

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[2] IEEE Trial-Use Guide to the Measurement of Partial Discharges in Rotating Machinery. *IEEE Std 1434-2000*. April 26. 2000.

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[5] C. Wendel. C-E. Stephen. T. Kunz. (2010, Nov.). Predicting the Remaining Life of Generator Components. Renewable Energy World. [Online]. Available: http://www.renewableenergyworld.com/rea/news/article/2010/11/predicting-the-remaining-life-of-generator-components

Appendix A: Project Site Report (July 4-7, 2011)

amec

PROJECT SITE REPORT

PROJECT: Generation Windings
Nalcor Energy Bay D'Espoir

REFERENCE NO.: 168688-9.4

CLIENT: Nalcor Energy

REPORT DATE: July 29, 2011

CONTRACTOR: ____________________

VISIT DATE: July 4 – 7, 2011

REPORT BY: David Jones and Jonathan Flynn

CATEGORY: **Civil:** ☐ **Arch:** ☐ **Mech:** ☐ **Elect:** X **Struct:** ☐

PURPOSE: **Quality/Progress Review:** **See Below** **Site Coordination:** ☐

Substantial Performance: ☐ **Final Performance:** ☐

PROGRESS: **Scheduled: ______%** **Actual: ______%**

Participants:

Bob Woodman, Nalcor, Bay D'Espoir
Louis Barnes, Nalcor, Bay D'Espoir
Ron Bartlett, Nalcor, Bay D'Espoir
Dave Jones, AMEC
Jonathan Flynn, AMEC

Purpose: **To collect information and data regarding generator windings.**

Monday, July 4, 2011

Dave Jones and Jonathan Flynn arrived at Nalcor, Bay D'Espoir, Powerhouse #1, at approx. 2:00pm, and were received by Bob Woodman, who carried out Site Orientation as per the Manual: BDE-Contractor Orientation Manual, Chapter 4, Appendices A & B. (Acceptance of Safety Requirements and dated signatures, are on file).

Following the orientation, Dave Jones, Jonathan Flynn and Bob Woodman, reviewed the Documents that were forwarded by Dat Tran on 07 June, 2011, with the following comments and understandings, in respect to units 1, 3 and 4.

1. Nalcor was asked to provide a 3-line diagram, as it would provide full details of unit protection typical of all units.
2. Nameplate ratings of generators and power transformers would be photographed.

3. Nalcor forwarded a stator wiring diagram, typical for all generators.
4. Generator excitation is static type for all units.
5. Operating histories for units 1, 2 and 3 will be provided, with the exception of core ELCID tests, which are not carried out.
6. Excitation system annual- maintenance histories will be provided. Bob Woodman will provide a brief write-up of the Bay D'Espoir operating history, which will include that units 1 and 3 are the station service units and their usage in the dispatch orders. Also the use of units based on island loads and system water management.
7. Information will be provided regarding any forced synchronization, and the resulting coil repairs, in the FO-03-002 Report.
8. Work Order Listings will be provided that arose due to electrical faults.
9. Any water cooler leaks, and repairs information will be provided by Nalcor, St. John's.
10. A section of used coil will be provided, if available. It may not be able to determine where the actual sample was taken from.
11. The FM Global Insurance Report will be provided.
12. Unit 2 Voith Rewind Report will be provided.
13. Information will be forwarded form the Maintenance Data Register.

Tuesday, July 5, 2011

Teleconference was held at 8:00am, with Bob Woodman (Nalcor), Andrew Duplessis (AMEC), Dat Tran (AMEC), Dave Jones (AMEC) and Jonathan Flynn)AMEC). Discussions took place on the information requested from Dat Tran and the decisions made as itemized Monday July 4, 2011.

After the meeting, information was gathered regarding Units 1, 2 and 4 power transformers and generators, and a quick look at the P and C panels in the control room.

Unit 4 was locked out by Nalcor personnel in readiness for our inspection. After a review of the Options Order 11385/11386/11389/11390 sheets, Bob, Dave and Jonathan walked through the isolations to ensure unit was locked out to their satisfaction.

After a satisfactory walk through, a visual inspection complete with photographs, was carried out of the stator, rotor and generator housing.

The top of the stator and rotor windings were in a clean and good condition with some dirt and dust contamination, no insulation damage or loose bindings and wedges.

Photograph 009 – Stator top windings looking clean.

Photograph 013 – Stator top windings showing dusty conditions.

Photograph 016 – Indicates some vibration. See the paint stripped where the pipe slip fits in the bracket.

Photograph 020 – Terminations at one end of stator top windings indicates old dust and dirt contamination although there has been cleaning.

Photograph 023 – Top of stator and rotor showing the air gap. Although cleaned still shows old contamination.

The bottom of the stator and rotor showed no loose wedges and bindings, but showed more dirt and oil contamination.

Photograph 036 – Stator bottom windings showing age and ingrained dust and oil contamination.

Photograph 041 – Oil contamination on the underside of the generator. This area has been cleaned but still shows the old contamination.

Photographs 046 – Stator winding has been cleaned. Rotor does not appear to have been cleaned.

Photographs 047 – Stator bottom winding. Although having been cleaned show oil and dust contamination from the years of service.

Photograph 050 – Oil film near brakes. Can see silhouette of the junction box in the horizontal surface.

The floor and concrete beneath the windings showed no signs of cracking but although being recently cleaned showed many years of oil contamination.

Bob arranged for a meeting with ourselves, Louis Barnes and Don Bartlett to discuss operation of the units and any major failures of the units. It was determined that the stator frames were provided in 4 sections and the cores stacked for site assembly. Major inspections are carried out on a 6 year basis. PDA monitoring was installed on all units in the 1990's. The generators are usually run at base load (60-65 MW). Units 1 and 3 are the first units on and last units off as they provide stator service. All other units are put on line randomly.

There have been no major failures of any of the units. It was thought that Unit 4 was taken off under load at one time, but Nalcor personnel were unsure.

<u>Wednesday, July 6, 2011</u>

Units 1, 3 and 4 maintenance files were looked at and copies of check sheets, reviews and all associated data made.

Maintenance files included all information relevant to the stators, rotors, slip-rings and excitation of units 1, 3 and 4.

Thursday, July 7, 2011

Final discussions took place between Bob, Dave and Jonathan to ensure that as much relevant data had been collected. An electronic copy of all information gathered reports and pictures from annual maintenance on generators was supplied by Nalcor. See information collected during Site Visit in Table 1.

Outstanding information will follow from Nalcor and will include those items in Table 2.

Following the gathering of all information Dave and Jonathan left Nalcor, Bay D'Espoir at approximately 1:00 pm.

Attachments:
Table 1
Table 2
Photos

AMEC Americas Limited
Power & Process

David Jones

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PO Box 9600
St. John's NF
Canada A1A 3C1
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BAY D'ESPOIR WINDING ASSESSMENTS

Information Collected During Site Visit

Table 1

Description	Common	Unit 1	Unit 2	Unit 3	Unit 4
Bay D'Espoir Operating History	×				
Operation Records	×				
Stator Winding Temp, Trending	×				
Generator Plan and Sections	×				
Winding Details	×				
Unit 4, 3-Line Diagram	×				
Voith Unit 2 Rewind Final Documentation			×		
Voith Unit 2 Rewind OM Manual			×		
Voith Unit 2 Rewind Final Test Report			×		
Voith Unit 2 Rewind Drawings			×		
PDA Database	×				
Unit 3 Site Inspection Photographs				X	
2009 Inspection Details		×			
2010 Inspection Details		×			×
2010 Inspection Pictures		×	×	×	
2011 Inspection Pictures		×		×	×
Generator Corrective Work History		×	×	×	×
Generator Rotor Corrective Work History		×	×	×	×
Generator Stator Corrective Work History		×	×	×	×
PD Standard Report (Iris Power)		×		×	×
PD Trend Analyses (Iris Power)		×		×	×
Preventive Maintenance Check sheets		×		×	×
Double Test Sheets		×		×	×
Hi-Pot Test Sheets		×		×	×
Polarization Index Check sheets		×			×
Wedge Inspection				×	×
Hyd. Equipment Register Activity Sheet		×		×	×

BAY D'ESPOIR WINDING ASSESSMENTS

Information to be sent by Nalcor after Site Visit

Table 2

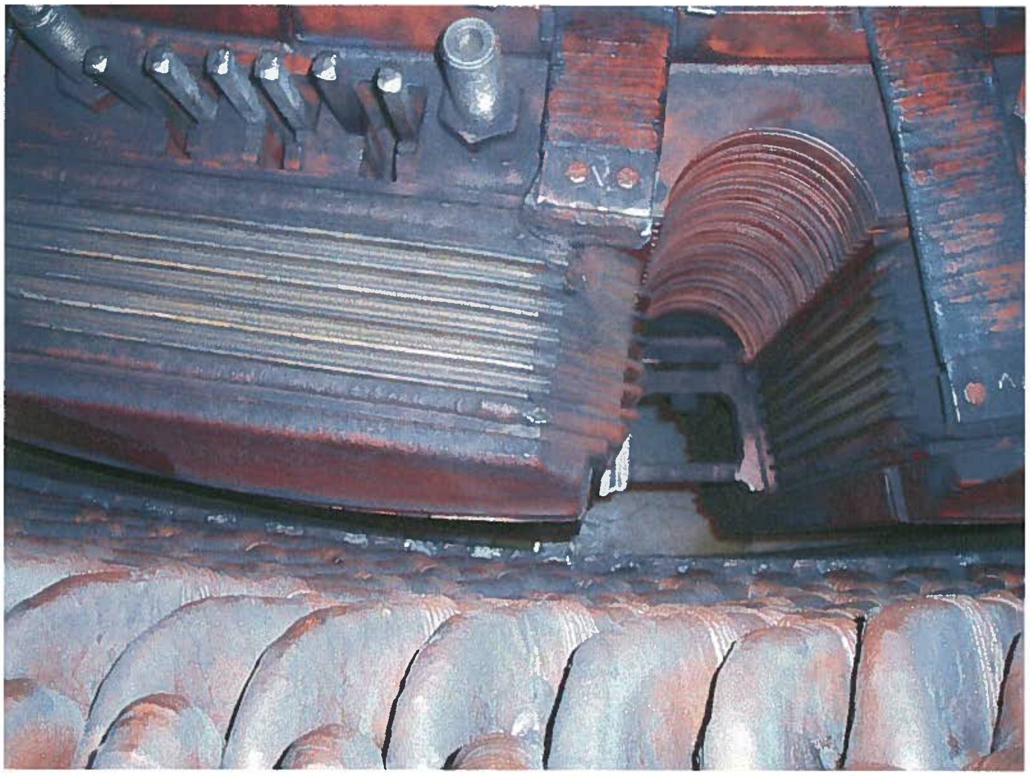
Description
FM Global Project Report
Unit & Stator Winding Damage Report
Operating History Report
Replacement of Stator Windings Report
Analysis of Turbo-Generator Core Inspection Assessment C/W Photographs, Annual Inspector Reports, Ground Fault Reports, etc.
Generator and Stator Exciter Condition Study
Water Cooling Problems
Section of Used Coil

Photograph 009

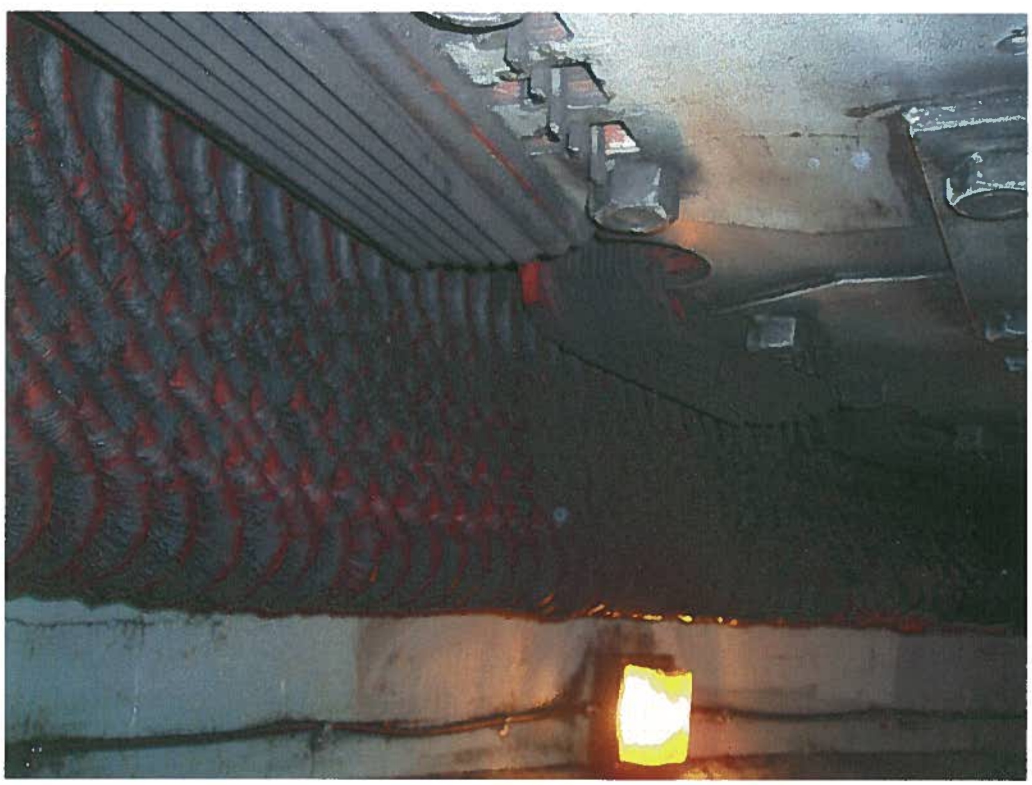
Photograph 013

Photograph 016

Photograph 020

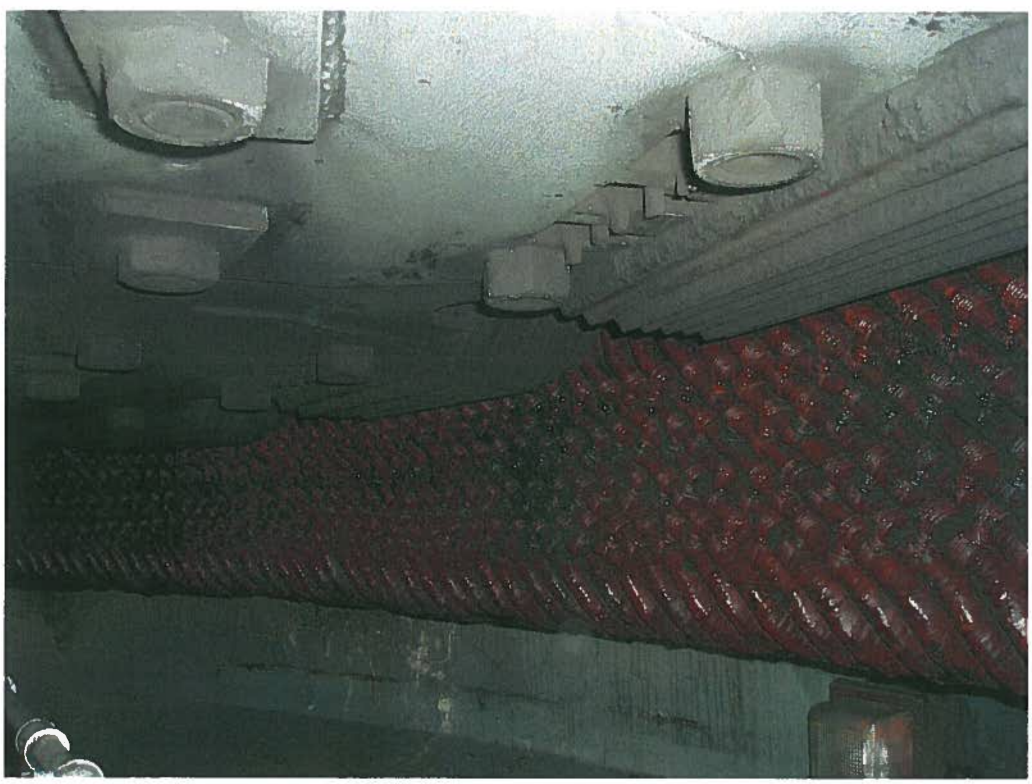


Photograph 023



Photograph 036

Photograph 041



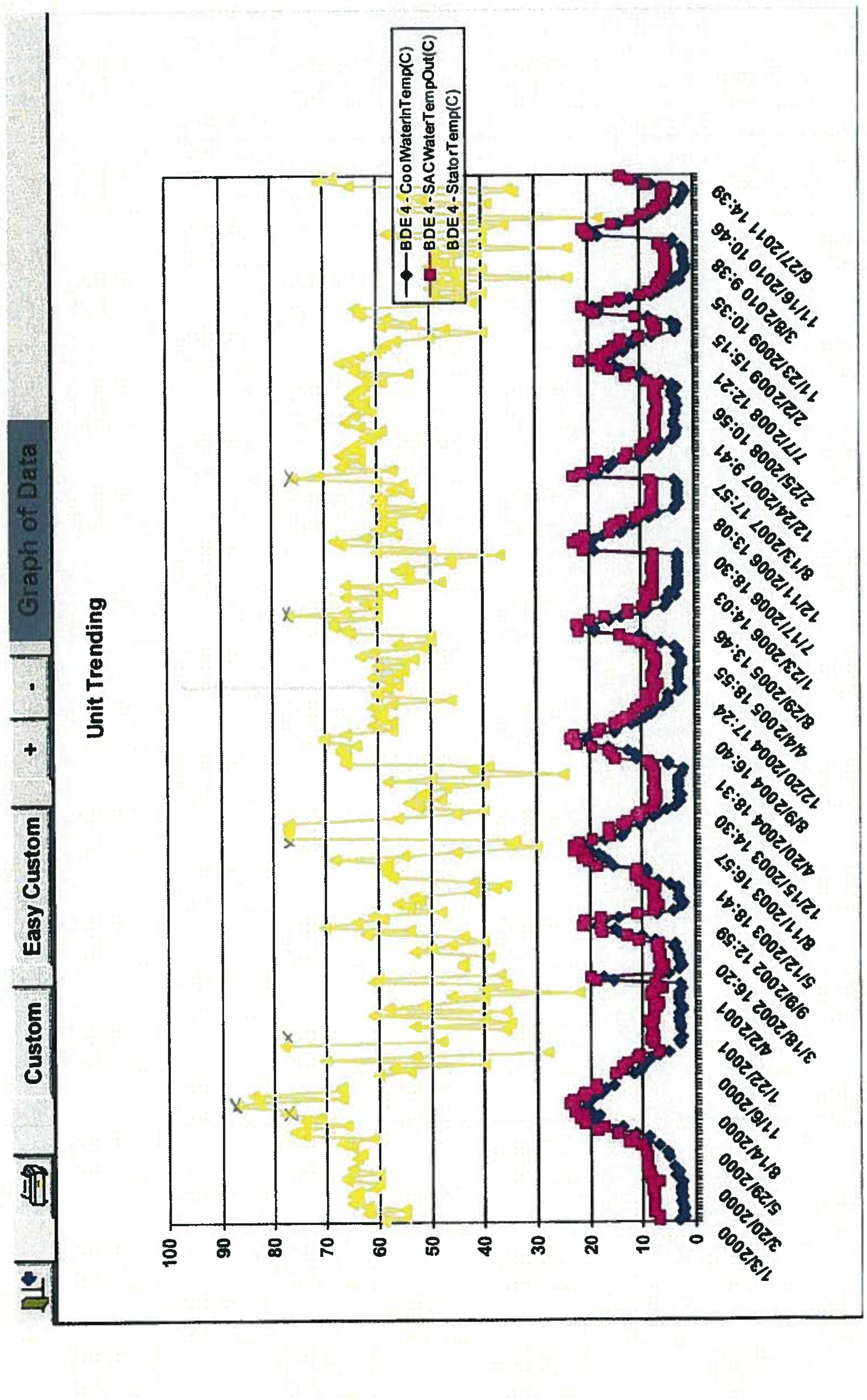
Photograph 046

Photographs 047

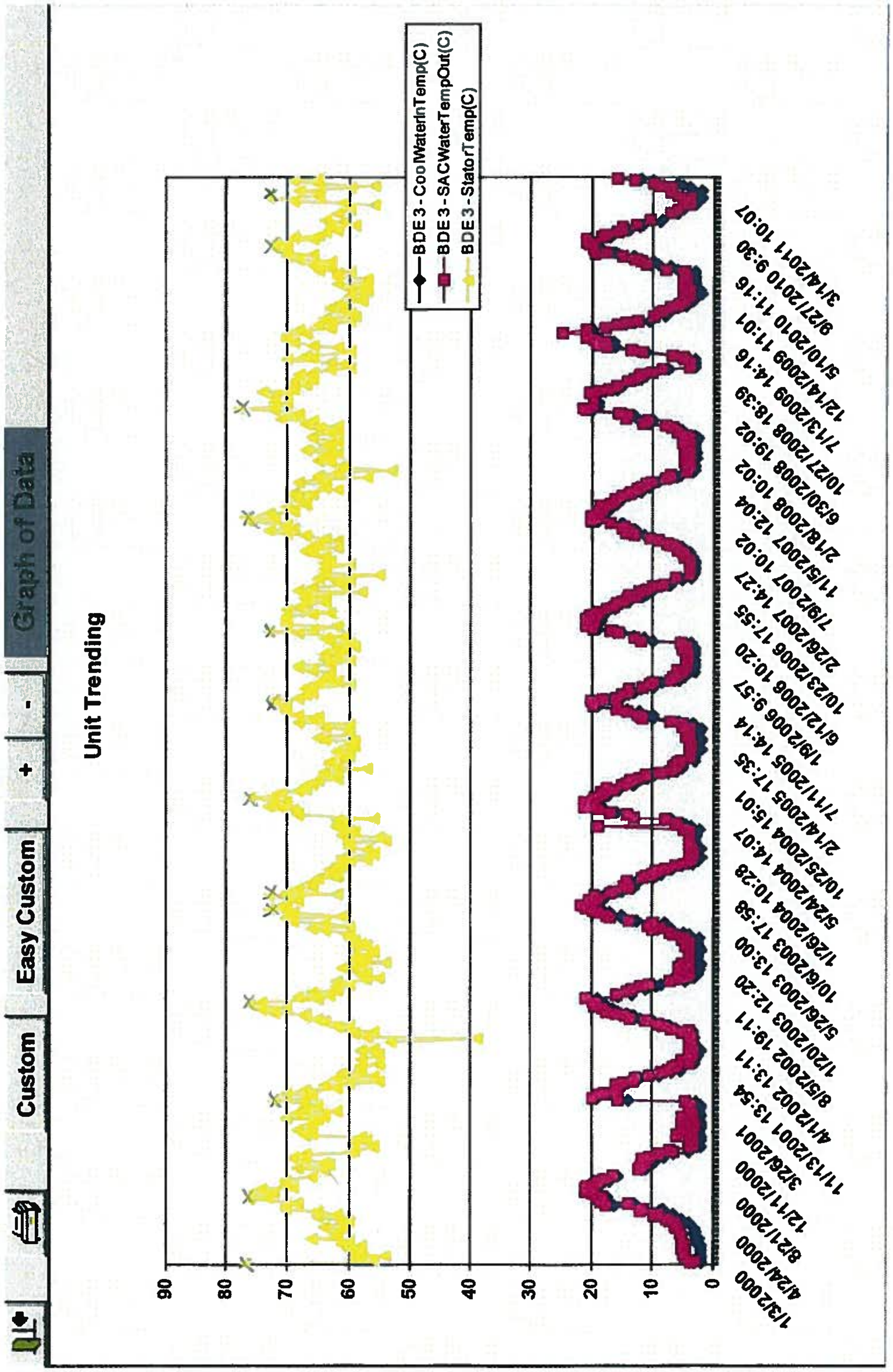
Photograph 050

Appendix B: Operating Temperature

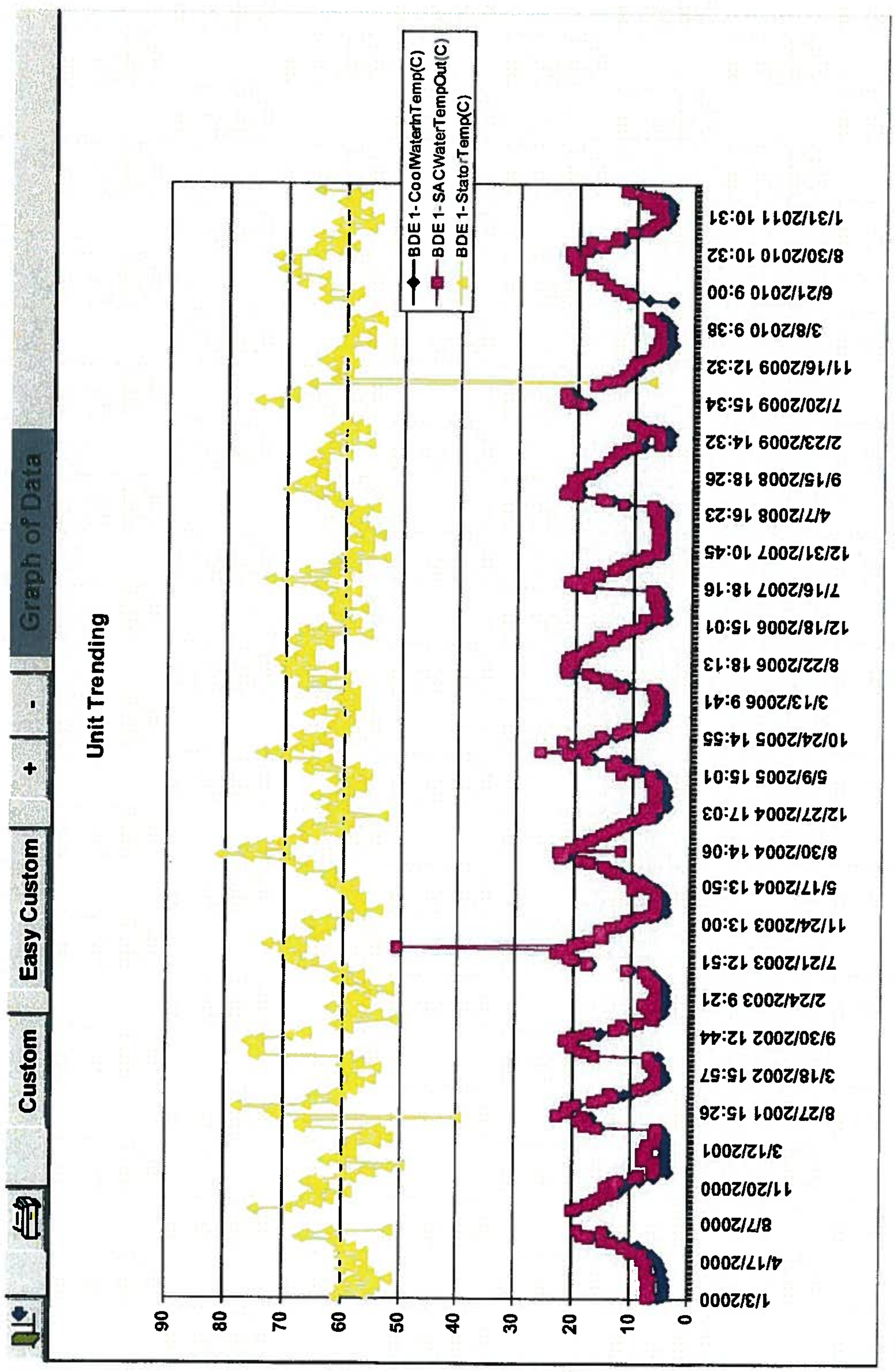
U4 STATOR WINDING T° TRENDING



UNIT 3 STATOR WINDING T° TRENDING



UNIT 1 STATOR WINDING T° TRENDING



Appendix C.1: Doble Test Summary

All Doble test data provided for Units #1, #3 and #4 over the past 30 years were compiled and trends were plotted according to the tests conducted at voltages of 10kV and 2kV for each coil. Analysis of the trends on the tests for each coil is as follows.

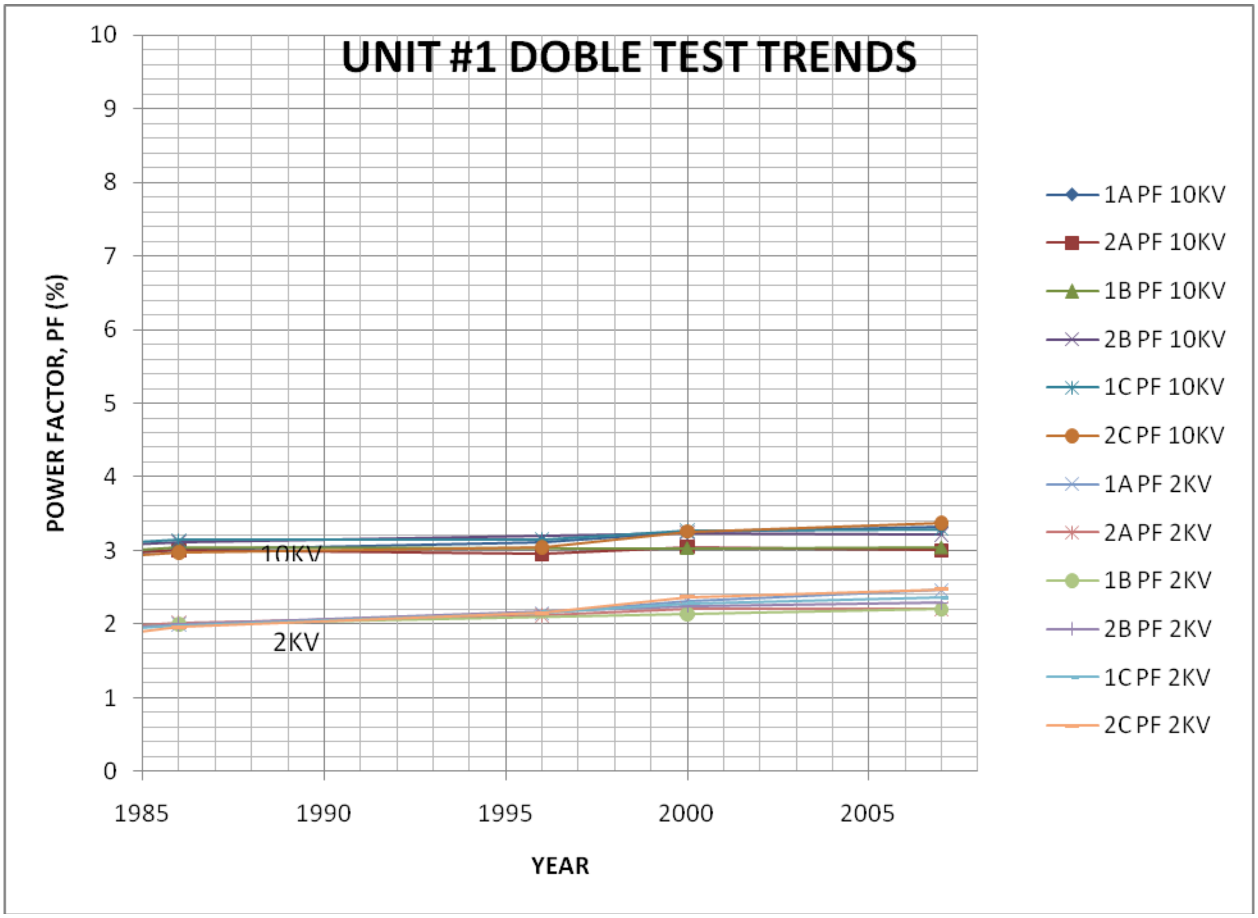
Unit #1 holds a consistent power factor of 3% at a test voltage of 10kV and as well at a test voltage of 2kV with a power factor a little above 2%.

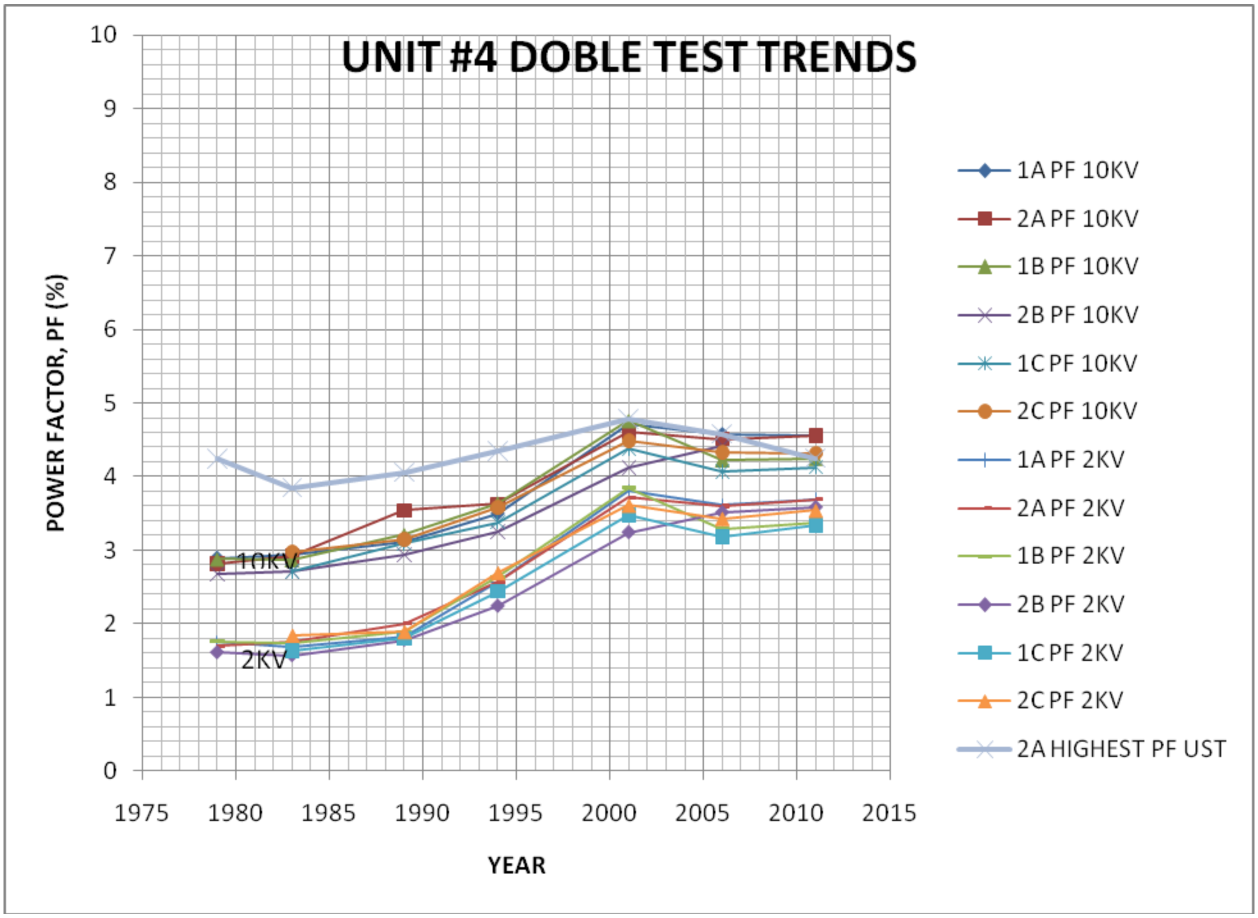
Unit #3 follows a similar trend to Unit #1 until the later tests where the slope is gradually increasing.

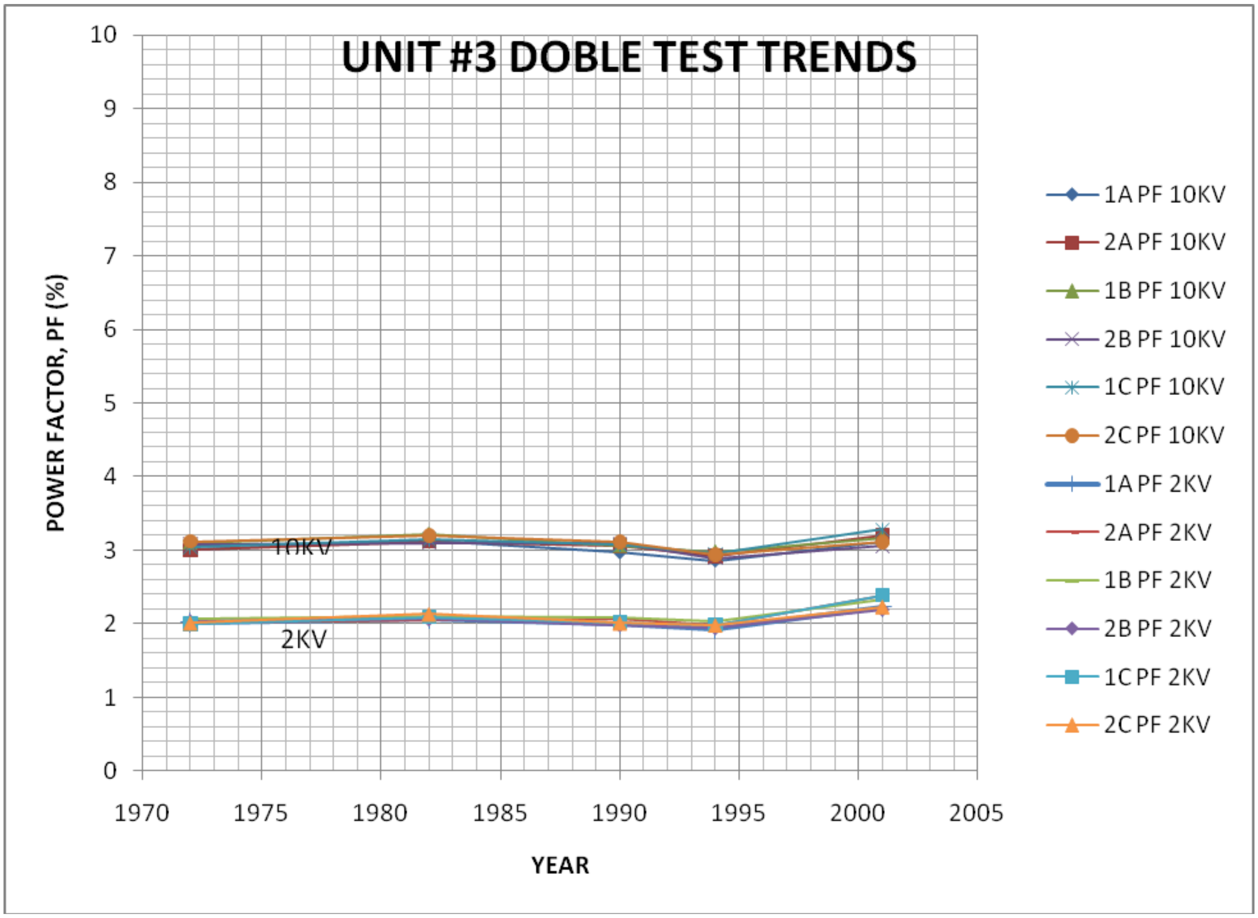
Unit #4 follows consistently linear trends until 1989 when all three phases had similar power factors of 2 and 3 percent at their respective test voltages of 2kV and 10kV. From the most current tests the second coil in Phase A reaches a power factor of 4.6% at a test voltage of 10kV and a power factor of 3.7% at 2kV. The power factor varies from zero to six percent between coils within a single year of tests; this is a sign of deterioration within the winding insulation.

According to these Doble tests, Unit #4 continues to have the worst trends between the three units. Units #1 and #3 have significantly better trends and follow the same power factors at both test voltages throughout the entire period of testing.

Prepared by: Bradley Jones
July 28, 2011


UNIT #1 DOBLE TEST TRENDS
POWER FACTOR, PF (%)
YEAR
10
9
8
7
6
5
4
3
2
1
0
1985
1990
1995
2000
2005
10KV
2KV
1A PF 10KV
2A PF 10KV
1B PF 10KV
2B PF 10KV
1C PF 10KV
2C PF 10KV
1A PF 2KV
2A PF 2KV
1B PF 2KV
2B PF 2KV
1C PF 2KV
2C PF 2KV


UNIT #4 DOBLE TEST TRENDS
POWER FACTOR, PF (%)
YEAR
10KV
2KV
1A PF 10KV
2A PF 10KV
1B PF 10KV
2B PF 10KV
1C PF 10KV
2C PF 10KV
1A PF 2KV
2A PF 2KV
1B PF 2KV
2B PF 2KV
1C PF 2KV
2C PF 2KV
2A HIGHEST PF UST


UNIT #3 DOBLE TEST TRENDS
POWER FACTOR, PF (%)
YEAR
10KV
2KV
0
1
2
3
4
5
6
7
8
9
10
1970
1975
1980
1985
1990
1995
2000
2005
1A PF 10KV
2A PF 10KV
1B PF 10KV
2B PF 10KV
1C PF 10KV
2C PF 10KV
1A PF 2KV
2A PF 2KV
1B PF 2KV
2B PF 2KV
1C PF 2KV
2C PF 2KV

Appendix C.2: PDA Test Summary

To be able to determine how to interpret the PDA test results on each unit from Bay D'Espoir, the document [1] was reviewed. From this document Qm values are classified based on statistics from more than 6000 tests on different machines in order determine how likely it is that the machine has a problem in Table 1. Looking at these statistics with an operating voltage level of 13.8kV, the Qm value would have to be less than 508mV to be within the 90 percentile.

Table 1: Distribution of Qm for Air-Cooled Stators. 80-pF Sensors on the Terminals

Oper. Volts	2-4 kV	6-8 kV	10-12 kV	13-15 kV	>16 kV
25%	7 mV	17 mV	35 mV	44 mV	37 mV
50%	27	42	88	123	69
75%	100	116	214	246	195
90%	242	247	454	508	615

The Qm value is determined by taking the highest PD pulse in mV with a minimum repetition rate of ten pulses per second.

Analyzing the results from the PDA-H tests done in 1992 on the three units of interest, 1, 3 and 4, the Qm value had to be derived from the provided plots. This was determined by taking the highest PD pulse in mV with a minimum repetition rate of ten pulses per second. Summarizing these derived Qm values in Table 2, the majority of the Qm values do not or barely fall within the 90 percentile for all three units.

Table 2: BDE PDA-H Test 1992, Qm Results Summary

	Unit #1 (mV)		Unit #3 (mV)		Unit #4 (mV)	
	"+Qm"	"-Qm"	"+Qm"	"-Qm"	"+Qm"	"-Qm"
Phase A, C1	-	-	1800	1500	2300	2450
Phase A, C2	675	625	2000	1800	1900	2100
Phase B, C1	475	475	450	575	200	675
Phase B, C2	450	440	580	400	700	700
Phase C, C1	620	375	2100	300	1700	1700
Phase C, C2	375	375	1800	400	700	800

From the PDA-IV test done in 2011 shown in Table 3, Unit #1 seems to have Qm values within the 90 percentile for all three phases as well as all three phases in Unit # 3. The Qm values for Phase A, C and B C2 on Unit #4 are well above the 90 percentile, but Phase B C1 is within the 90 percentile.

Table 3: BDE Differential PDA Test 2011, Qm Results Summary (Estimated from PD Trends)

	Unit #1 (mV)		Unit #3 (mV)		Unit #4 (mV)	
	"+Qm"	"-Qm"	"+Qm"	"-Qm"	"+Qm"	"-Qm"
Phase A, C1	138	98	N/A	N/A	1019	1284
Phase A, C2	104	94	368	N/A	N/A	N/A
Phase B, C1	100	100	100	1700	200	200
Phase B, C2	200	400	200	200	680	750
Phase C, C1	200	500	100	100	650	520
Phase C, C2	100	100	400	100	-	-

Possible problems attributed to these high PD levels are as follows (IEEE Std 1434-2000);

1. If a positive polarity PD pulse is high relative to the negative polarity pulse, this may indicate loose stator coils or bars in the slot.

2. Inversely if the negative polarity pulse is dominant, the problem may be traced near the copper strands and indicate a bad bond between the insulation and copper.

Comparing the two sets of PD results it is clear that Unit #4 remains the worst throughout both tests. Unit #3 has improved from high PD values in 1992 through to values within the 90 percentile in 2011. Unit #1 has also improved PD values from being on the edge of the 90 percentile in 1992 to being within the 75 percentile in 2011. Conclusions cannot be made according to these PD values, but these are good indications of potential problems, further investigation will be required in order to establish their significance.

Prepared by: Bradley Jones
July 26, 2011

[1] G. C. Stone and V. Warren. "Objective Methods to Interpret Partial-Discharge Data on Rotating-Machine Stator Windings." *IEEE Trans. Industry Application*, vol. 42, no. 1, pp. 195-200. Jan/Feb 2006.

[2] IEEE Trial-Use Guide to the Measurement of Partial Discharges in Rotating Machinery. *IEEE Std 1434-2000*. April 26. 2000.

Appendix C.3: DC High Potential Test Summary

The DC high potential tests from Units #1, #3 and #4 were all compiled and compared graphically to their respective units. Analysis of the trends between tests and units is as follows.

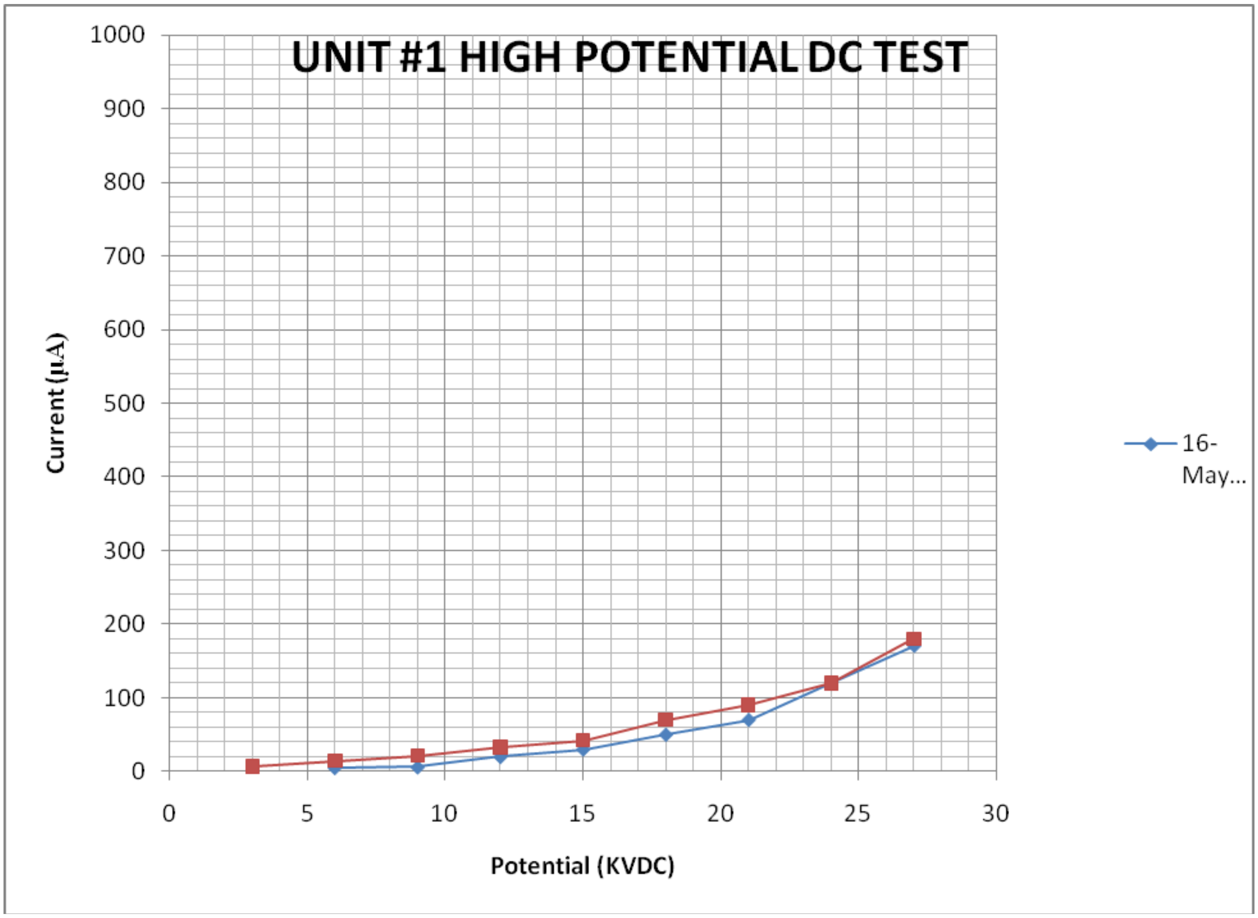
The only hypot tests provided on Unit #1 were completed in 2007, before and after cleaning in May and July respectively. Both tests follow similar a trend, gradually increasing slope with higher test voltages. Significant increases in slope begin to arise at 15kV, increasing by twice the slope in May and by almost three times in July. Both trends keep increasing in slope until the final test voltage of 27kV. Due to the lack of test data, conclusive evidence cannot be taken from these two trends, even though the available data does clearly expose weaknesses within the winding insulation.

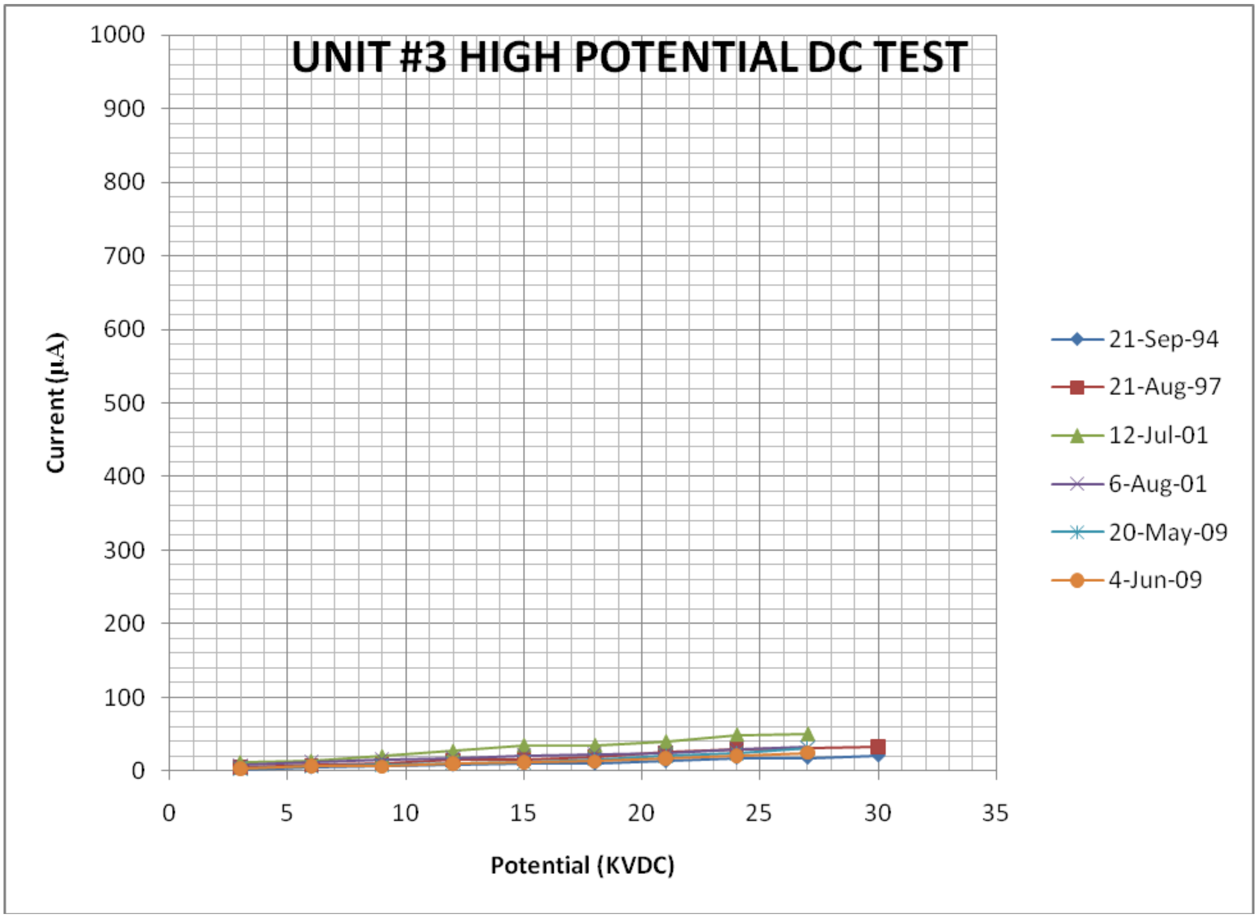
All tests completed on Unit #3 show consistently linear trends which is a good indication of acceptable test results.

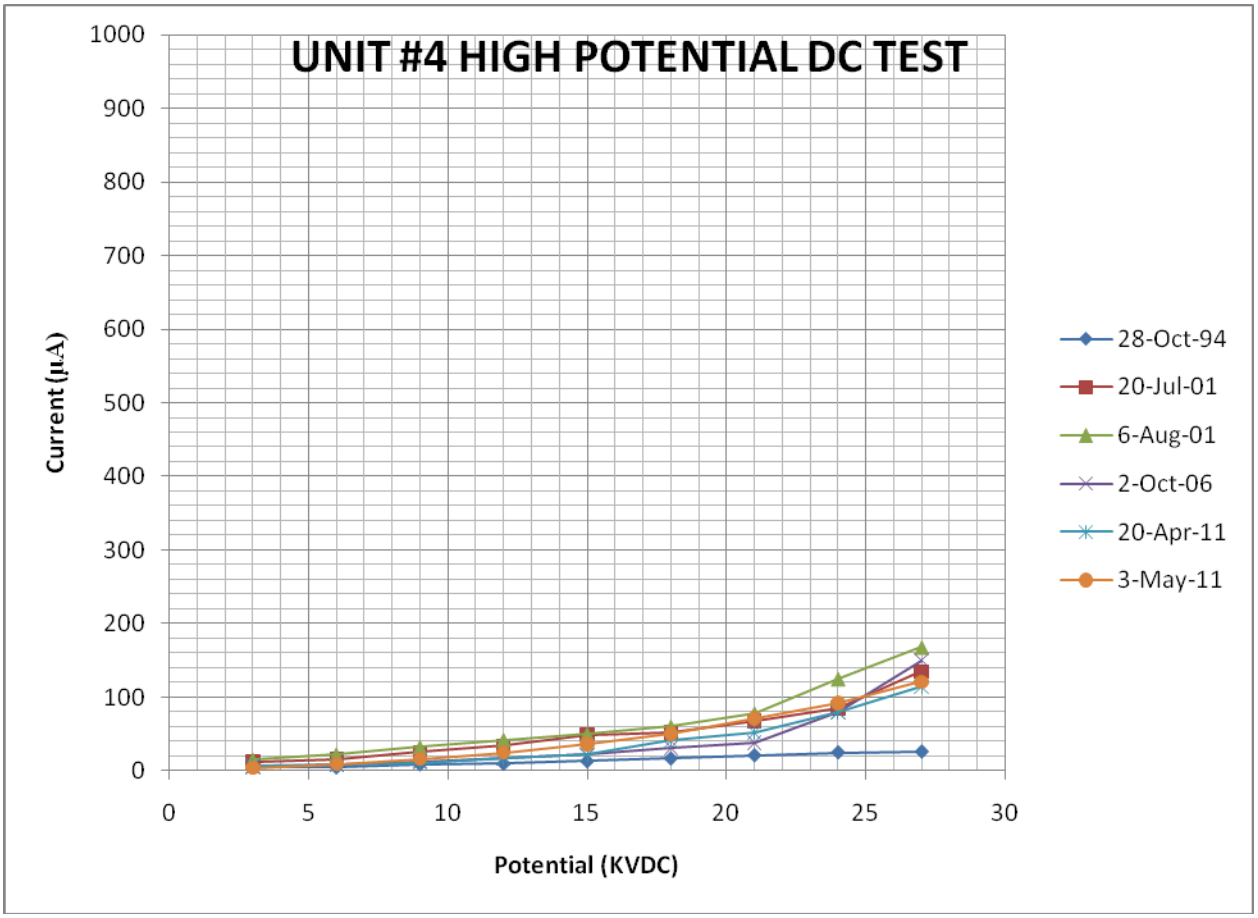
The first hypot test, done on Unit #4 in 1994, follows a linear trend with very small amounts of leakage current. Conversely, the five tests done within the last ten years show results that are not as desirable. The trends seem to remain consistently linear until a test voltage of 15kV when they begin to increase gradually, with slope changes increasing by about 5 times in 2001 and then by about 6 times in 2006. The slope changes are not as sharp in 2011 but leakage current levels are high, peaking at 120µA.

Comparing the three units, Unit #4 consistently shows the worst hypot test data out of the three, therefore would have the most deteriorated winding insulation to ground. Unit #1 would follow, having the next weakest winding insulation, but not conclusive due to the lack of data provided. Unit #3 demonstrates the strongest winding insulation to ground compared to the others.

Prepared by: Bradley Jones
July 28, 2011


UNIT #1 HIGH POTENTIAL DC TEST
Current (µA)
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
Potential (KVDC)
16-
May...


UNIT #3 HIGH POTENTIAL DC TEST
Current (µA)
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
Potential (KVDC)
21-Sep-94
21-Aug-97
12-Jul-01
6-Aug-01
20-May-09
4-Jun-09


UNIT #4 HIGH POTENTIAL DC TEST
Current (µA)
Potential (KVDC)
1000
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
28-Oct-94
20-Jul-01
6-Aug-01
2-Oct-06
20-Apr-11
3-May-11

Appendix C.4: Rotor Pole Voltage Drop Test

UNIT #1, POLE DROP TEST

Deviation = (1-(Voltage/Mean))*100%

	Voltage (V)		Deviation (%)	
Pole #	5/18/2007	5/25/2007	5/18/2007	5/25/2007
1	5	5	2.0	1.8
2	5	5	2.0	1.8
3	5	5	2.0	1.8
4	4.9	4.9	0.0	0.3
5	4.9	4.9	0.0	0.3
6	4.9	4.9	0.0	0.3
7	5	5	2.0	1.8
8	4.9	4.9	0.0	0.3
9	4.9	4.9	0.0	0.3
10	4.8	4.8	2.0	2.3
11	4.9	4.8	0.0	2.3
12	4.9	5	0.0	1.8
13	4.9	4.9	0.0	0.3
14	4.9	4.9	0.0	0.3
15	4.9	4.9	0.0	0.3
16	4.9	4.8	0.0	2.3
17	4.9	4.9	0.0	0.3
18	4.8	4.8	2.0	2.3
19	4.9	5	0.0	1.8
20	4.8	4.9	2.0	0.3
21	4.9	4.9	0.0	0.3
22	4.9	4.9	0.0	0.3
23	4.8	4.9	2.0	0.3
24	4.9	5	0.0	1.8
Total:	117.6	117.9		
Mean:	4.9	4.9		
Applied Voltage:	120	120		

Comments: Considering that the error of the measuring device is about 0.1 V which is equivalent to a 2% deviation, the test results do not exceed this deviation. Therefore the test can be considered acceptable.

Prepared by: Bradley Jones
Date: August 11, 2011

UNIT #3, POLE DROP TEST

	Voltage (V)		Deviation (%)	
Pole #	7/8/1997	8/20/1997	7/8/1997	8/20/1997
1	4.8	4.86	0.00	1.77
2	4.9	5.1	2.08	3.08
3	4.9	5.14	2.08	3.89
4	4.8	4.92	0.00	0.56
5	4.9	4.98	2.08	0.66
6	4.9	4.91	2.08	0.76
7	4.8	4.8	0.00	2.98
8	4.9	4.9	2.08	0.96
9	4.9	4.94	2.08	0.15
10	4.8	4.92	0.00	0.56
11	4.8	4.93	0.00	0.35
12	4.9	4.92	2.08	0.56
13	4.9	5	2.08	1.06
14	4.1	4.84	14.58	2.17
15	4.2	4.85	12.50	1.97
16	4.7	4.97	2.08	0.45
17	4.9	5.01	2.08	1.26
18	4.8	4.9	0.00	0.96
19	4.8	4.97	0.00	0.45
20	5	5.04	4.17	1.87
21	4.9	4.81	2.08	2.78
22	4.8	4.82	0.00	2.58
23	4.8	5.08	0.00	2.68
24	5	5.13	4.17	3.69
Total:	115.2	118.74		
Mean:	4.8	4.9		
Applied Voltage:	119.6	118.0		

Deviation = (1-(Voltage/Mean))*100%

Comments: Looking at the test done in July of 1997, the voltage drops across all of the poles do not add up to the voltage applied, this is due to a dip in voltage at the 17 and 18th pole. This problem is not seen in August 1997, which would imply that either the poles were repaired or the earlier test was faulty.
Considering that the error of the measuring device is about 0.1 V which is equivalent to a 2% deviation, the test results for the latest test do not show anything abnormal.

Prepared by: Bradley Jones
Date: August 11, 2011

UNIT #4, POLE DROP TEST

	Voltage (V)		Deviation (%)	
Pole #	6/21/2006	7/7/2006	6/21/2006	7/7/2006
1	3.77	3.8	23.79	23.13
2	5.1	5.11	3.09	3.37
3	4.51	4.53	8.84	8.36
4	5.22	5.22	5.52	5.60
5	4.73	4.72	4.39	4.52
6	6.42	6.45	29.77	30.48
7	6.27	6.28	26.74	27.04
8	4.83	4.83	2.37	2.29
9	5.35	5.35	8.14	8.23
10	4.71	4.56	4.79	7.75
11	5.2	5.2	5.11	5.19
12	3.51	3.5	29.05	29.20
13	3.47	3.46	29.86	30.01
14	5.06	5.05	2.28	2.16
15	4.7	4.7	4.99	4.92
16	5.19	5.19	4.91	4.99
17	4.57	4.57	7.62	7.55
18	6.57	6.56	32.81	32.70
19	6.42	6.43	29.77	30.07
20	4.53	4.52	8.43	8.56
21	5.13	5.13	3.70	3.78
22	4.75	4.75	3.98	3.91
23	5.21	5.2	5.31	5.19
24	3.51	3.53	29.05	28.59
Total:	118.73	118.64		
Mean:	4.95	4.9		
Applied Voltage:	118.20	118.0		

Deviation = (1-(Voltage/Mean))*100%

Comments: Considering that the error of the measuring device is about 0.1 V which is equivalent to a 2% deviation, only a 2% error can be expected. All of the test results for both sets of data show signs of problems and are not acceptable.

Prepared by: Bradley Jones
Date: August 11, 2011

Appendix D: Generator Major Incidents/Electrical Maintenance

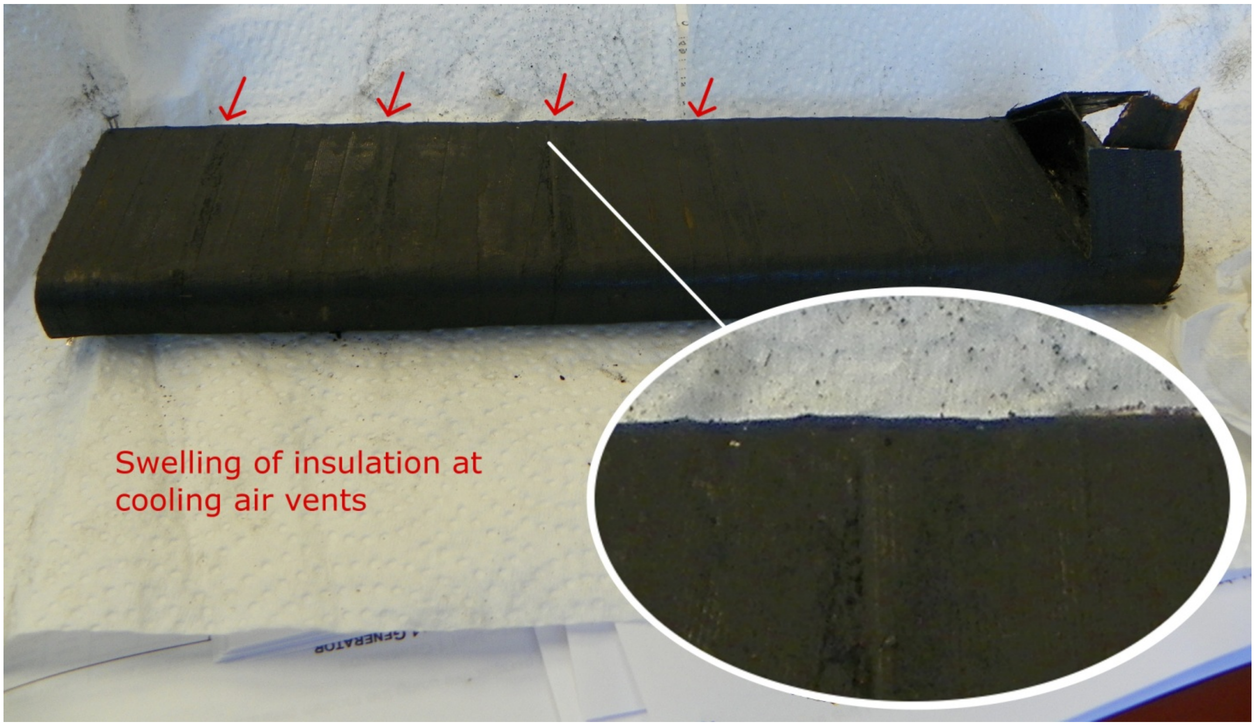
	UNIT #1	UNIT #3	UNIT #4
1967	Commissioned	Commissioned	
1968			Commissioned
1991		Stator re-wedged with piggyback wedges	
1992			Wedge inspection Stator re-wedged with piggyback wedges Generator trip (ground fault on phase A), problem found to be a fault on one of the main leads, the bus was reinsulated and put back into service
1993	Stator re-wedged with piggyback wedges		Inspection: Loose core laminations 12 to 16 shorted laminations Need cleaning and epoxy coating
1994	PM6 - PI test(6.6, after 10min 4000MΩ)	PM6 - PI test(3.85, after 10min 2500MΩ) PM9, Wedge inspection	PM6 - PI test before cleaning(3.6, after 10min 1800), after cleaning(4.5, after 10min 1800MΩ) PM9, Wedge inspection
1995	PM6 (limited time shutdown)	PM6 - PI test(2.7, after 10min 2500MΩ) slip rings dirty Megger test 45MΩ	Inspection
1996			Re-tape rotor jumpers
1997	Stator and rotor test inspection, Result: nothing abnormal PM6 - PI test	PM6 - PI test(4, after 10min 2000MΩ) PM8, 87SP-A trip, Stator and rotor inspection Start up inspection Stator core damaged on phase B between 345 and 346 Exciter replacement	Start up inspection
1998	PM6 - PI test(4.5 stator) Exciter replacement Ashphalt leaking out of stator bars	PM6 - PI test(3.2, after 10min 800MΩ) Stator and rotor inspection Ashphalt leaking out of stator bars	PM6 - PI test(2.46, after 10min 1600MΩ) Inspection Exciter replacement

1999	Replace loose wedges on stator Clean entire stator Clean oil and carbon dust under generator rotor Re-paint the overhead portion of stator	Install piggy back wedges into stator slots Stator core repair Re-tape generator pole leads, stator high side connections and stator neutral connections, Repair and clean rotor pole Re-tape main lead by #2 pole near the connection Replace smoke detectors Reverse polarity on #3 collector rings at exciter end Repair cooling water leaks Split phase protection trip Conduct air gap readings in stationary position, split pahse current problems Adjust poles on rotor	Stator re-wedged with piggyback wedges Re-tape generator rotor pole leads, stator line side connection and neutral leads Rotor cleaned Repairs to four rotor rim keys Re-torque stator core bolts Install shims to tighten endfingers Correct shorted laminations in stator core Repairs to six loose press fingers in stator
2000	PM9 - One failed coil on stator Hypot test at 27kV The faulty coil was replaced Repairs to field leads using burndy connectors Cleaned underneath rotor and turbine pit Repair loose V-block shim between poles #18 & 19	Dry ice cleaning on stator and rotor	PM6 Sections of stator insulation repaired Wedge inspection, 2 slots loose
2001	PM6 - PI test(2.5, after 10min 1500MΩ) turn test on stator	PM6 - PI test(3.37, after 10min 1350MΩ)	PM6 - PI test before cleaning (3.6, after 10min 900MΩ), after cleaning (3.4, after 10min 700MΩ)
2002	PM6 - PI test(4, after 10min 2000MΩ)	PM6 - PI test(3.8, after 10min 950MΩ)	PM6 - PI test(3, after 10min 800MΩ)
2003	PM6 - PI test(3.7, after 10min 1500MΩ)	PM6 - PI test(4.4, after 10min 4400MΩ) PM9	PM6 - PI test(3.4, after 10min 1200MΩ) Unit very dirty on bottom, Cleaned with safe-sol PM9 B2T4 open and closed repeatedly which caused station alarm, During investigation, damage was found on the upper end turns of six stator coils, an in place repair was completed using RTV silicone overtapped with self -amalgamiting electrical insulating tape Start up inspection
2004	PM6 - PI test (2.64, after 10min 2600MΩ). Repair flexible jumper leads that connects the rotor bus lead to the slip ring	PM6 - PI test(3.3, after 10min 2000MΩ)	PM6 - PI test(3.64, after 10min 1200MΩ)

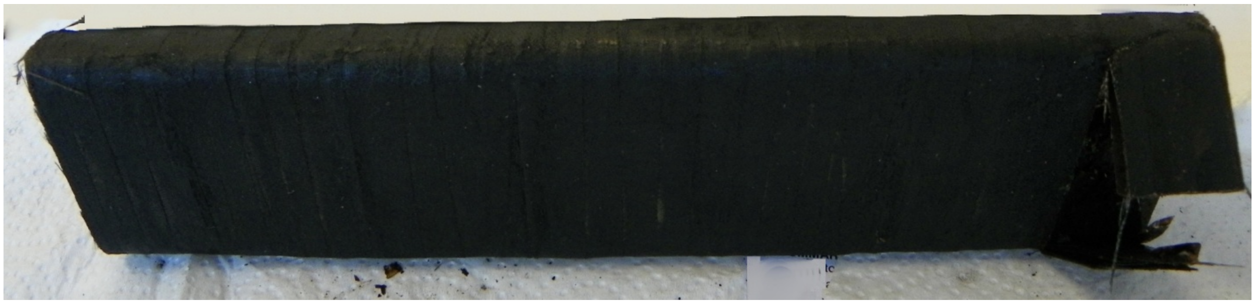
2005	PM6 - PI test(3.33, after 10min 1500MΩ)	PM6 - PI test(3.46, after 10min 2250MΩ)	
2006	PM6 - PI test(5.3, after 10min 800MΩ, still hot) PM9, PDA couplers checked	PM6 - PI test(3.28, after 10min 2300MΩ) Start up inspection	PM6 - PI test in October, before cleaning (2.5, after 10min 1100MΩ), after cleaning (3, after 10min 1200MΩ) PI test in July(1.71, after 10min 650MΩ) PM9, Exciter has a lot of dust Dry ice cleaning on stator and rotor Replaced 2 brushes
2007	PM6, PI test before cleaning(3, after 10min 1800MΩ), after cleaning(2.6, after 10min 800MΩ) PM9, Nothing abnormal on the pole drop test Hypot test - Result: increases from 180 to 230 before and similar after cleaning Slip ring from Unit #2 placed in to Unit #1,PDA connections checked, Stator and Rotor cleaning Wedge inspection	PM6 - PI test(3, after 10min 1800MΩ) Repair two sets of slip rings	PM6 Replaced 9 brushes Detailed inspection of slip ring
2008	PM6 - PI test with IPB(2.29, after 10min 800MΩ), without IPB(1.82, after 10min 500MΩ) Slip ring machining, North upstream SAC cooler leaking	PM6 - PI test(4.6, after 10min 700MΩ) PM8, PM9, Forced trip Slip rings need cleaning Top of rotor cleaned with dry rags Inspection of IPB connection to XFMR, Result: Phase B damaged, broken connection at XFMR	PM6 - PI test(2.91, after 10min 800MΩ) PM8 Two rotor leads need to be re-taped Stator needs cleaning
2009	PM6 - PI test(3.75, after 10min 1500MΩ)	PM6 - PI test(3.18, after 10min 1750MΩ) cooling water replaced Wedge inspection Pre-start up inspection PM9	PM6 - PI test(3.66, after 10min 1100MΩ) Rotor bus corona Cleaned stator
2010	Generator tests	Generator tests	PM6 - PI test(3.55, after 10min 800MΩ) Generator tests

2011			PM6 - PI test(3.27, after 10min 900MΩ) Slip ring brushes replace Loose pole keys on 6 rotor poles and damaged taping on poles Shorted core laminations on stator repaired Re-tape rotor pole leads Wedge inspection Stator and rotor cleaning Start-up inspection

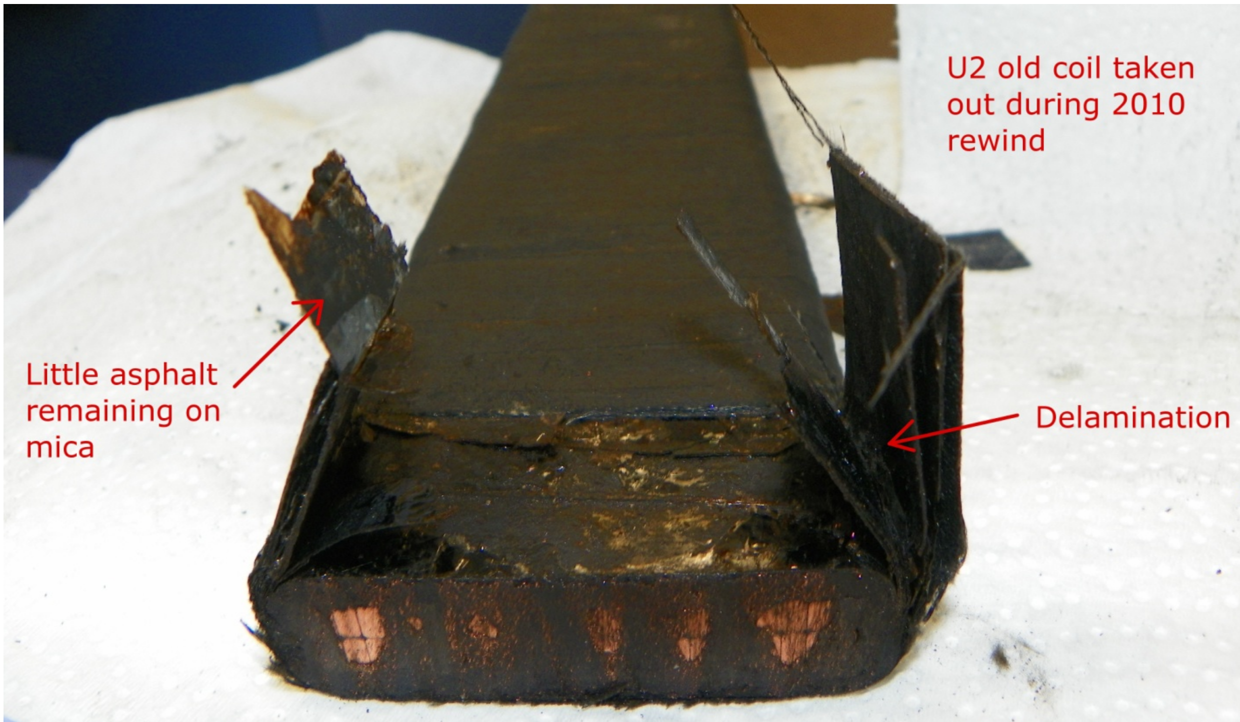
Appendix E: Used Coil Photos



Air vent swell



Bar



Delamitation

Fretting

Appendix F: Qualifications, Dat V Tran

Dat Van Tran, P. Eng.

Senior Engineering Specialist

Professional summary

Mr. Tran has 43 years experience in operation, maintenance, inspection and testing of thermal/hydro/nuclear turbine driven generators and auxiliaries equipment for generating stations (large motors, exciters (rotating or static), UPS systems and vital power systems). He has expertise in testing and troubleshooting large electrical generators, motors and excitation systems (rotating or static).

Professional qualifications/Registration(s)

Professional Engineer #M2379, Association of Professional Engineers and Geoscientists of New Brunswick

Education

BS, Electrical Engineering, University of Saigon, Saigon, South Vietnam, 1964

Languages

English

Employment history

AMEC, Senior Engineering Specialist, Fredericton, NB

Representative projects

Power

Vietnam Power Company

Served as Technical Service Engineer, Operations Shift Engineer, Chief of Operations of the Thuduc Thermal Complex and as Assistant to the Direction of Production.

Dalhousie – Eel River HV-DC Area

Electrical Engineer responsible for providing technical support for Dalhousie Unit No. 1 – 100 MW oil fired fossil generation station and the 320 MW HVDC converter station.

Central Technical Services Electrical Engineer

NB Power's generator and large motor specialist. Provided electrical engineering support for NB Power's Central Technical Services Group which provided technical support to all of NB Power's generating stations.

Senior Specialist Electrical Generation and Control Equipment
As Senior Specialist Electrical Generation and Control Equipment was accountable for developing, monitoring and evaluating maintenance criteria for all rotating electrical equipment and auxiliaries within the plant system and was accountable for troubleshooting and solving major problems in the associated equipment control as well as providing a corporate resource for NB Power. The NB Power system had about 4200 MW of installed capacity with up to 42 generating units ranging in size from less than 1 MW to 680 MW (gross).

Senior Engineering Specialist
Design Engineer for various projects including the Coleson Cove Refurbishment project. Responsibilities as Senior Engineering Specialist include engineering review and equipment selection of replacement motors for a nuclear generating station, generator assessment review for a combined cycle station, and generator/exciter assessment for a generating utility.