SECTION H
Tab 3

Engineering Condition Assessment
of the
Corner Brook Frequency Converter

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TRO Engineering Department
Newfoundland and Labrador Hydro

April 7, 2005

ENGINEERING CONDITION ASSESSMENT

CORNER BROOK FREQUENCY CONVERTER

APRIL 7, 2005

Contents

A. EXECUTIVE SUMMARY

Site inspections of the Corner Brook frequency converter were carried out on October 25th and 26th, 2004 and March 24th, 2005. The purpose of these inspections was to review the general condition of the converter and the facility along with area personnel and to compare the present condition of the unit and facility to the “Condition Assessment of 50/60 Cycle Frequency Final Report”, which was submitted to Hydro in September of 1998 by Acres International Limited.

The key observations and recommendations are:

- The condition of the insulation of the rotors (especially the 50 Hz rotor) was identified by Acres as very low. This issue has not been addressed. The 50 Hz rotor should be rewound as soon as possible. (A thorough assessment of the Grand Falls unit should be performed in order to explore the option of rewinding this unit as a replacement to the Corner Brook unit. This would decrease the length of the outage.) During this rewind, a thorough assessment of the other rotating equipment should be conducted.

- Transformer T1 is nearing the end of its service life. This unit should be rewound or replaced as soon as possible.

- The pedestal bearing was identified by Acres as being partially wiped. This issue has not been addressed. This bearing should be replaced or repaired as soon as possible.

- Acres identified that the oil spill containment and drainage around the main transformers and transformer doors require improvement in order to contain a spill and to eliminate a fire hazard. No deluge system exists for the transformers. These issues should be addressed as soon as possible.

- The ventilation system does not provide adequate cooling for the converter and the transformers. The air being brought into the facility is poorly filtered which is a significant contributor to the accumulation of dust and dirt. The fire doors separating the transformers from the converter must be left open during the summer to prevent overheating. These problems were identified by Acres but have not been corrected. The ventilation system should be upgraded as soon as possible.

- The upgrade of the ventilation system should include an alternate method of bringing air into the facility. This would permit opening of the transformer area to the outdoors.

- Portions of the compressed air system's piping should be replaced. The air receiver should have an inspection opening installed and be inspected for corrosion. If the tank is in good condition, a pressure gauge and automatic water release valve should be installed. These problems were identified by Acres but have not been addressed.

- The existing control system is outdated and, due to the failure of the auto-synchronizer, it is sometimes difficult to synchronize the 50 Hz and 60 Hz systems together. The auto-synchronizer should be replaced.

- There is a Pyrotronics model 302A fire alarm control panel inside the facility. These panels are normally inspected on an annual basis, but there is no evidence of this being done. The control panel, smoke / heat detectors, sirens, and horns should be inspected by a qualified and licensed fire alarm system technician. Annual inspections should be performed in the future.

- The voltage regulator's design is obsolete and has been the source of many maintenance difficulties over the years. Maintaining this system on a long-term basis may be problematic. Installation of a new voltage regulation system, which can be maintained over the long term, should be done within the next couple of years.

- The design of the speed control for the starting motor includes a liquid rheostat, which is a rudimentary and outdated method of varying the resistance of the rotor circuit. Maintaining this system on a long-term basis may be problematic. Installation of a new speed control system (suitable for automatic startup and synchronizing), which can be maintained over the long term, should be done within the next couple of years.

- Replacement of the battery bank should proceed as planned in 2005.

- Painting of the take-off towers and replacement of the 66 kV pin cap and suspension insulators should proceed as planned in 2005.

- Replacement of the entrance insulators should proceed as soon as possible.

- The main lube oil pump is nearing the end of its service life. The cost of replacing this pump is estimated to be $7,000. This work should be budgeted and completed within the next couple of years.

- The facility should be cleaned and painted, but this work should not begin until the ventilation problems are addressed.

- An assessment of the Grand Falls converter should be done. Also, a listing of usable spare parts from the Grand Falls frequency converter should be created. Spare part requirements for the Corner Brook unit should be identified and compared to spare parts available. Any deficiencies should be addressed.

- The condition of numerous components and subsystems (i.e.: compressors, protection relays, battery charger, etc.) should be evaluated. If spare components are available from the Grand Falls unit, they should be in shipped to Corner Brook.

The following table summarizes significant repairs / replacements which should be completed over the next couple of years. These cost estimates are derived from several sources, including the original Acres report and recent discussions with local companies and suppliers. Estimates based upon the Acres report have been indexed to the appropriate year using the Gross Domestic Product (GDP) Implicit Price Deflator, which is included in the Appendix. It is likely that during the bidding process for this work, the tendered prices will be less than these estimates.

TASK	COST ESTIMATE	YEAR
Rewind or Replace Transformer T1	$480,000 (**)	2006
Ventilation System Upgrade	$120,000 (***)	2006
Transformer Area Modifications	$6,000 (**)	2006
Replace Pedestal Bearing	$6,000 (***)	2006
Address Compressed Air System Deficiencies	$12,000 (***)	2006
Rewind 50 Hz Rotor	$600,000 (***)	2007
Evaluate Condition of Rotating Equipment	$50,000 (**)	2007
Oil Spill Containment	$412,000 (***)	2007
Replace Auto-Synchronizer	$20,000 (**)	2007
Replace Lube Oil Pump	$7,000 (**)	2007
Replace / Repair Doors	$12,000 (**)	2007
Repair Concrete and Masonry Walls	$5,000 (**)	2007
Clean / Paint Walls and Roof Trusses	$40,000 (**)	2007
Replace Voltage Regulators	$200,000 (**)	2008
Replace Starting System (Liquid Rheostat)	$200,000 (**)	2008
Rewind 60 Hz Rotor (*)	$610,000 (***)	2008

(*) – dependant upon evaluation
(**) – new estimate
(***) – estimate based upon Acres report, escalated to project year and rounded

B. INTRODUCTION

1.0 Corner Brook Frequency Converter Site Inspections

An on site inspection of the Corner Brook frequency converter was carried out on October 25th and 26th, 2004. During this site inspection, discussions were held with area Operations personnel.

The purpose of this inspection was to review the general condition of the converter and the facility along with area personnel and to compare the present condition of the unit and facility to the "Condition Assessment of 50/60 Cycle Frequency Final Report", which was submitted to Hydro in September of 1998 by Acres International Limited.

An additional site inspection was carried out on March 24th, 2005.

2.0 Grand Falls Frequency Converter Site Inspection

An on site inspection of the Grand Falls frequency converter was carried out on October 27th, 2004. During this site inspection, discussions were held with area Operations personnel.

The purpose of this inspection was to review the general condition of the converter and the facility along with area personnel. Since this unit is no longer in service, discussions centered on its use as a source of spare parts and components for the Corner Brook unit.

C. ACRES REPORT UPDATE

The following observations and recommendations were obtained from the executive summary of the Acres report. These observations and recommendations are followed by TRO Engineering comments *(in italics)*.

1.0 Dust and Dirt Within the Facility

The entire facility is covered with dust and dirt and accumulated residue from the pulp mill operation. The ventilation system is faulty and the building shell has numerous cracks, which allow penetration of debris. The entire facility requires cleaning, particularly the converter itself. The ventilation system should also be brought up to current standards.

Dust and dirt continue to be a problem at the facility. This has been alleviated by some degree due to the paving of the dirt road immediately adjacent to the converter, but the problem persists. The facility has been cleaned, but dust and dirt quickly reaccumulates. There have been no improvements to the ventilation system.
The ventilation system requires upgrading such that properly filtered air enters the facility ($120,000 estimate).
The facility should be cleaned and painted once the ventilation system improvements are completed ($40,000 estimate).

2.0 Rotor Windings

The insulation resistance value of the rotor windings is very low, in the order of 300 kohms. These low values are indicative of a failure within the next few years, but the failure could occur at any time. The rotors should therefore be rewound. Because the existing windings are asbestos insulated, the rewind will cost more than usual.

This issue has not been addressed.
Readings of the insulation values of the 50 Hz rotor since 1998 remain very low (approximately 200 to 300 kohms.) The readings for the 60 Hz rotor, unlike the 50 Hz rotor, improved after cleaning.
The Acres report included a budget estimate of $500,000 to rewind each rotor.
The existing equipment was supplied by Westinghouse.

Figure 1 – 50 Hz Rotor (2005)

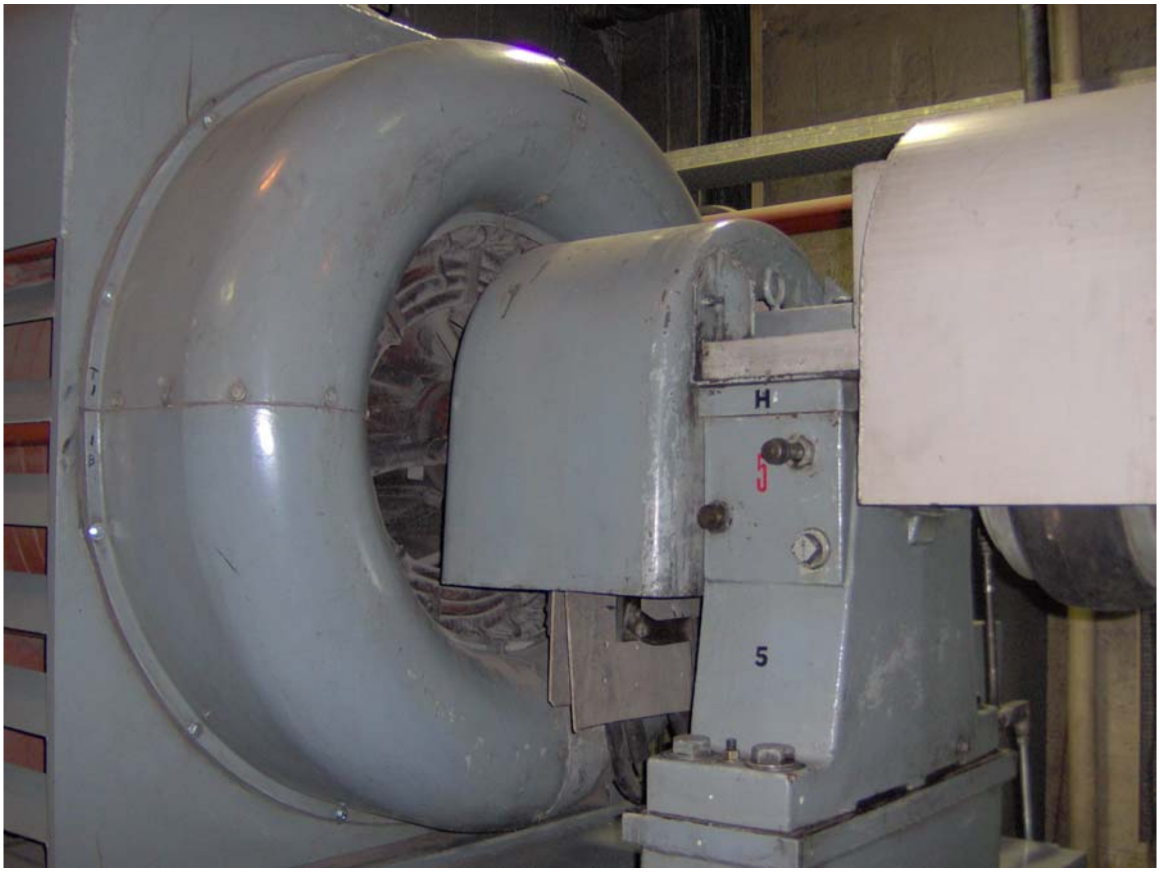


Figure 2 – 60 Hz Rotor (2005)

3.0 Oil Spill Containment

The oil spill containment and drainage around the main transformers and the transformer doors require improvement to contain any spill and to eliminate any fire hazard.

This issue has not been addressed.
Acres estimated that the cost of installing an oil spill containment system and fire protection system for the transformer area is $345,000.
At present, there are large oil filled transformers contained inside a building with no fire protection system and no way to remove oil should a problem occur.
There is a Pyrotronics model 302A fire alarm control panel inside the facility. These panels are normally inspected on an annual basis, but there is no evidence (certificate or sticker from a certified fire alarm system technician) of this being done. The batteries inside the control panel appear to have been installed in 1984. TRO Engineering has asked for details and is awaiting a response from Corner Brook Pulp and Paper.
The control panel, smoke / heat detectors, sirens, and horns should be inspected by a qualified and licensed fire alarm system technician. Annual inspections should be performed in the future.

4.0 Cooling System Water Leak

The cooling system associated with the voltage regulator (starting motor) has a water leak that occurs only on shut down or startup. This is known to the maintenance forces and they routinely drain the accumulated water after a shut down or startup. The water level after a shut down or startup is, however, only slightly below the main incoming leads, which are bare. Although it is unlikely, the potential exists for a short to occur. The leak should be fixed or static voltage regulators, which have a relatively low cost and greater flexibility, should be installed.

The cooling system leak has been repaired.

5.0 Pedestal Bearing

The pedestal bearing has been wiped and should be replaced.

This issue has not been addressed.
It is incorrect to state that this bearing has been wiped. This bearing has been partially wiped. A wiped bearing would likely cause damage due to contact between the shaft and the bearing shell. A machine cannot be operated with a wiped bearing.
The bearing should be replaced as soon as possible. It is running at higher than normal temperatures, as evidenced by the condition of the oil, and bearing failure is possible. This could cause shaft damage and a lengthy outage.

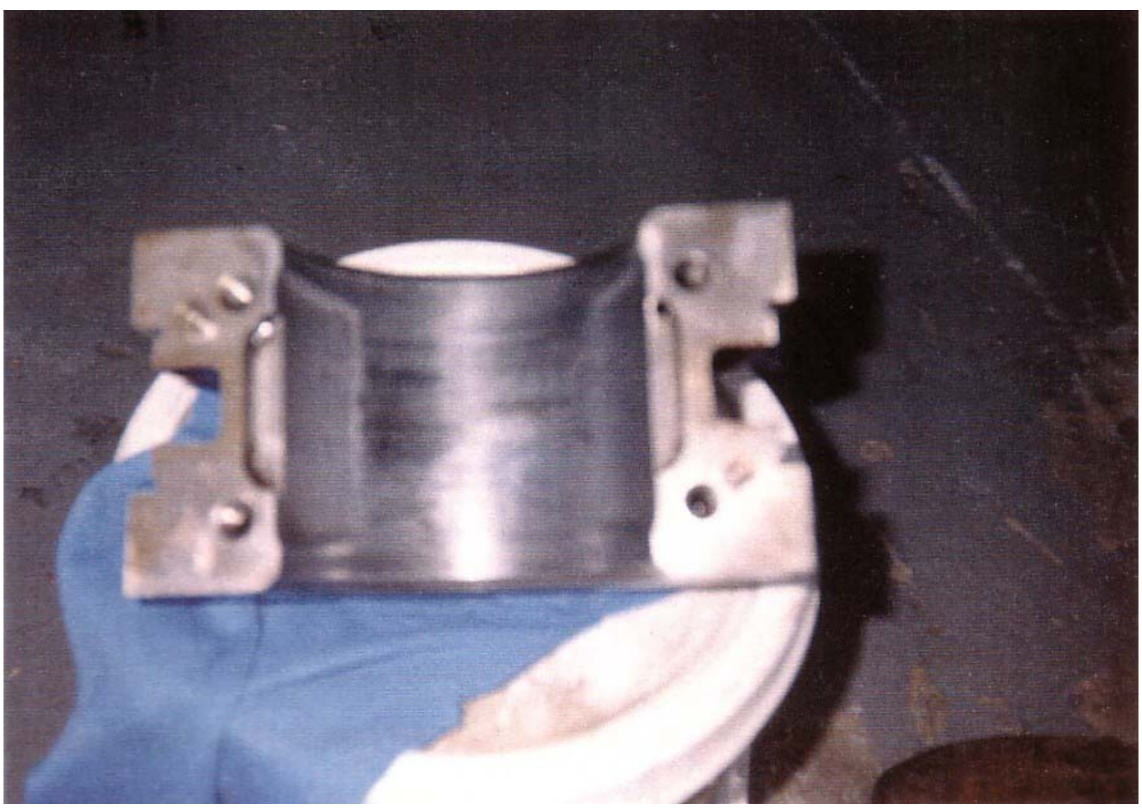


Figure 3 – Top Half of the Pedestal Bearing (1998)

6.0 Building Repairs

The building requires repair. Concrete and bricks have fallen from the roof and building sides and damaged the bushings and post insulators. Building cracks have allowed entrance of the wood debris associated with operation of the paper mill. The ceiling in the stairwell is temporarily repaired using a sheet of plywood. This should be permanently repaired.

Repairs have been made to the roof and stairwell ceiling. Caulking has been applied to building cracks when possible to decrease the ingress of dirt and dust. The overall condition of the building remains poor.
Repairs to the concrete and masonry ($5,000 estimate) should be done as soon as possible.

Figure 4 – Example of Crack in Wall (2005)

Figure 5 – Example of Crack in Wall (2005)

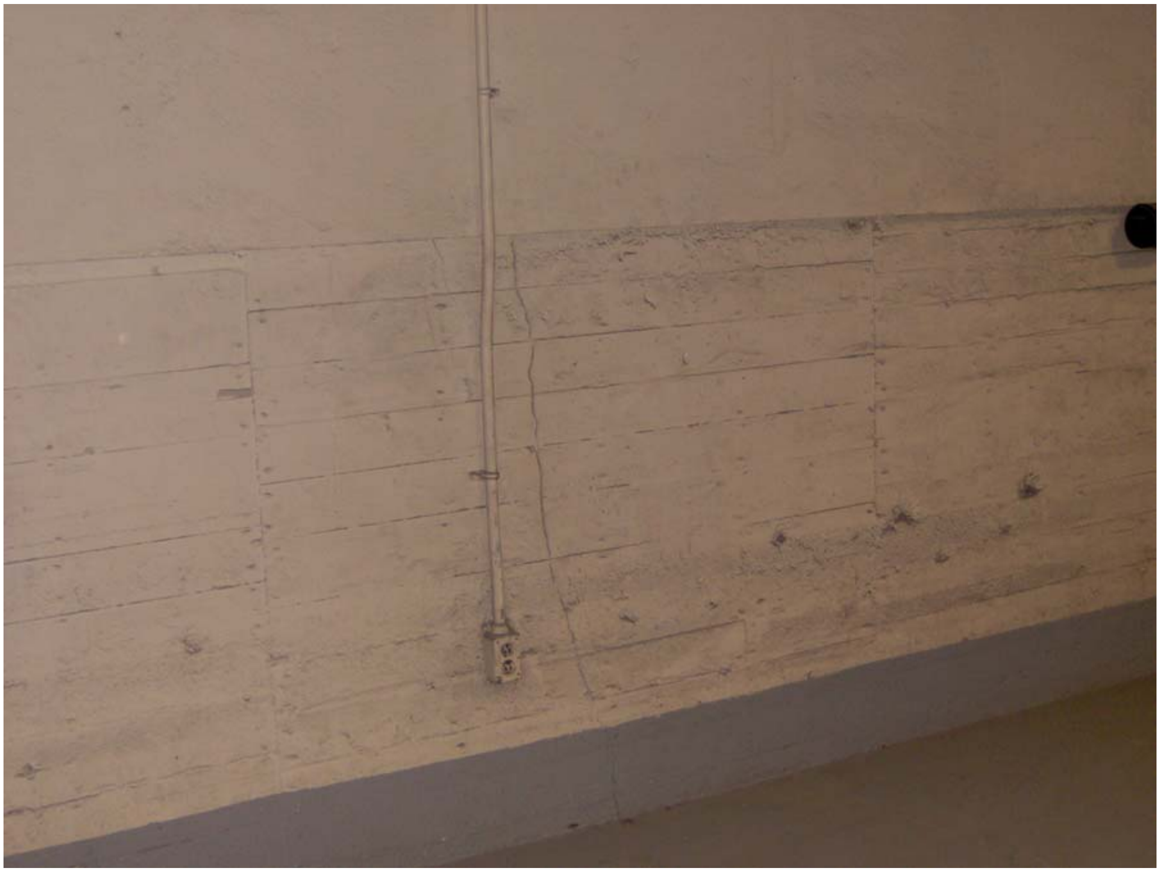


Figure 6 – Example of Crack in Wall (2005)

7.0 Neutral Grounding Transformers

The neutral grounding transformers are oil insulated and should be replaced by dry type transformers.

This issue has not been addressed.
The risk of an oil leak from these transformers is small. A dry type transformer would be more susceptible to problems caused by the accumulation of dust and dirt.

Figure 7 – Neutral Grounding Transformer (2005)

8.0 Lighting

The lighting in the building, particularly the emergency lighting, should be upgraded.

There have been significant improvements, including the addition of a new AC distribution panel and several HID (high intensity discharge) fixtures. Operations personnel indicate that the present lighting levels are adequate.
Emergency lighting should be installed in the transformer vaults, the converter area, the switchgear area, and the stairway.

9.0 Batteries

The batteries should be enclosed and measures taken to control and exhaust hydrogen gases.

An overhead shield and lighting has been installed. The hydrogen gases from the bank are not being exhausted. The battery bank is scheduled for replacement in 2005 under a capital project ("Replace Battery Banks – Various Stations and Lines"), which also includes the replacement of several other battery banks. The total project cost is $165,700. The cost of replacing the Corner Brook frequency converter's battery bank is roughly $40,000. The building's ventilation system, in addition to providing cooling air for the transformers and converter, exhausts hydrogen gases from the battery bank.

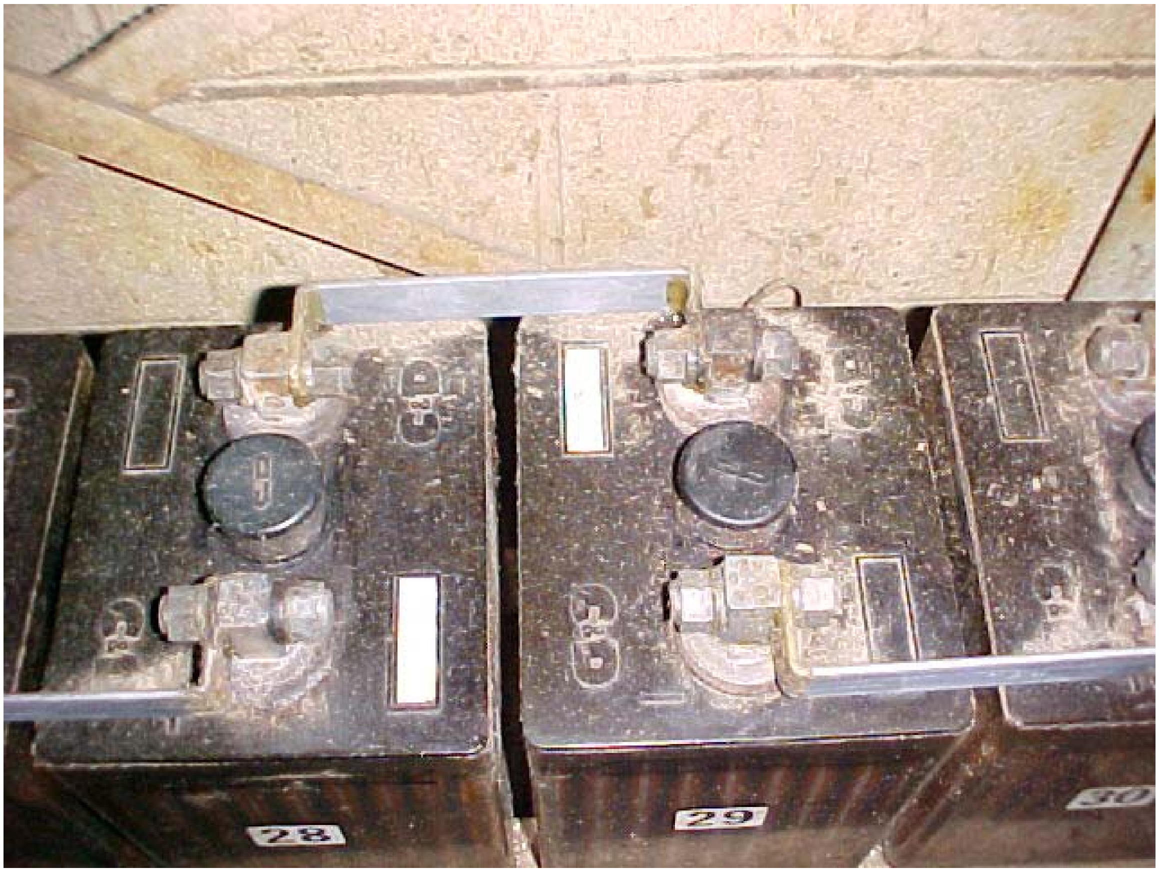


Figure 8 - Close-up of Battery Bank (2001)

Figure 9 – Battery Charger & DC Panel (2005)

Figure 10 – Battery Bank {Scheduled For Replacement} (2005)

10.0 Building Insulation – Asbestos

The building insulation contains asbestos fiber. Whereas this asbestos does not seem to be friable, it would be best to remove it, if only to allow personnel entering the building freedom from wearing respirators.

The building and piping asbestos insulation has been removed. The chamber of the liquid rheostat is asbestos lined and is still in service.
This site has been identified under Hydro's Asbestos Abatement Program and is scheduled to be inspected this summer. The results of the inspection will determine the course of action required by Hydro.

Figure 11 – Liquid Rheostat (2005)

Figure 12 – Liquid Rheostat Asbestos Warning Sign (2005)

D. DEVELOPMENTS SINCE THE 1998 ACRES REPORT

1.0 Transformer T2 Failure and Rewind

On February 20th, 2002 transformer T2 experienced an internal fault. The unit was removed, shipped to Burlington, rewound and reinstalled. The cost of these repairs was approximately $266,287. The total cost of the project for Hydro due to the failure of the transformer was approximately $467,000.

Transformer T2 was rewound such that it could be used on the 50 Hz side of the frequency converter (i.e.: it could replace transformer T1 if necessary). The Corner Brook mill has a spare transformer that could subsequently replace T2.

2.0 Transformer T1

During the replacement of transformer T2, it was decided to replace the oil in transformer T1 in order to extend the life of this unit and to reduce the risk of failure. At the time, the oil was in very poor condition (poorer condition than T2 which failed) and it was recognized that replacing the oil would provide a low cost extension of the life for the unit.

Replacement of the oil was a life extension plan, not a life renewal measure. Transformer T1 is nearing the end of its service life. The high acidity has quite possibly allowed the formation of sludge inside the unit. This would lead to reduced cooling of the windings. Furan levels indicate severe paper degradation. There is also a strong possibility that because of the overheating and insulation breakdown the coils may be loose. Loose coils may lead to mechanical failure particularly during startup.

Test results (dissolved gas analysis, transformer condition assessment and insulating fluid evaluation) for transformer T1 indicate that heating and arcing are present and that the condition of the paper insulation has been reduced.

It is recommended that transformer T1 be rewound (coils and new insulation) as soon as possible. Rebuilding this unit will ensure that the physical requirements (connections to the existing bus, etc.) are suitable for this particular application.

The cost of rewinding transformer T1 would be approximately $480,000.

The latest transformer oil test results for T1 and T2 are attached as an appendix.

3.0 Towers and Insulators

Operations are beginning to address the condition of the steel take-off towers and insulators this year. The take-off towers will be painted (cost estimate = $6400) and the 66 kV pin cap and suspension insulators will be replaced (cost estimate = $19,450).

The entrance bushings for the 500 mcm conductor to transformer T2 are damaged and should also be replaced (cost estimate = $12,200 for each of the twelve bushings). These bushings are not scheduled for replacement this year.
TRO Operations authored a report on the equipment on top of the frequency converter building. This report is attached as an appendix.

Figure 13 – Towers and External 66 kV Bus (2005)

4.0 Potential Relocation of the Grand Falls Frequency Converter to Corner Brook

In an April 2000 memo, TRO Engineering estimated that the cost to relocate the Grand Falls frequency converter to Corner Brook would be approximately $360,200. This estimate covered off-loading only and installation costs were not included. This estimate was accurate to within 25%.

A suitable location to store the Grand Falls unit in Corner Brook would have to be determined.

A copy of the memo is attached as an appendix.

5.0 Additional Issues

In addition to the items identified in previous sections of this report, various other components and systems throughout the facility require repair and improvements. TRO Engineering has prioritized these additional issues and categorized them as either “Top Priority”, “Secondary Priority”, or “Further Investigation / Information Required”.

5.1 Top Priority

- No deluge system exists for the transformer vaults. The fire protection doors are kept open during the summer to prevent overheating of the facility. An alternate method of providing intake air should be provided as part of the ventilation system upgrade. Subsequently, the transformer area’s outside wall and filter could be removed which would permit normal cooling of the transformers. The exisiting fire doors could be removed and replaced by concrete block. The fire rating of the remaining walls of the transformer vaults would be verified. It is estimated these modifications would cost $6,000. These modifications should not proceed until the ventilation system improvements are completed.
- The voltage regulator’s design is obsolete and has been the source of maintenance difficulties over the years. Maintaining this system on a long-term basis may be problematic. Installation of a new voltage regulation system, which can be maintained over the long term, should be done within the next couple of years. It is estimated that replacement of the voltage regulation system would cost roughly $200,000. A detailed estimate should be generated and the work would proceed, if justified.
- The design of the speed control for the starting motor includes a liquid rheostat, which is a rudimentary and outdated method of varying the resistance of the rotor circuit. Maintaining this system on a long-term basis may be problematic. Installation of a new speed control system (suitable for automatic startup and synchronizing), which can be maintained over the long term, should be done within the next couple of years. It is estimated that a variable speed drive to replace the liquid rheostat would cost roughly $200,000. A detailed estimate should be generated and the work would proceed, if justified.
- The bearing on the starting motor has an oil leak. This should be investigated and replaced if necessary.
- The emergency exit door from the upstairs switchgear area was damaged during a fire and should be repaired.
- The main lube oil pump is nearing the end of its service life. The cost of replacing this pump is estimated to be $7,000. This work should be budgeted and completed within the next couple of years.
- Due to the age of the unit, operating problems with components (like the auto-synchronizer), and the retirement of key Operations personnel, the operating instructions should be reviewed and updated.

Figure 14– Emergency Exit from Switchgear Floor (2005)

Figure 15– Main Lube Oil Pump (2005)

Figure 16 – Frequency Converter Switchgear (2005)

Figure 17 – Frequency Converter Switchgear (2005)

Figure 18 – Frequency Converter Switchgear (2005)

Figure 19 – Frequency Converter Switchgear (2005)

Figure 20 – Frequency Converter Switchgear (2005)

5.2 Secondary Priority

- A listing of usable spare parts from the Grand Falls frequency converter should be created. Spare part requirements for the Corner Brook unit should be identified and compared to spare parts available. Any deficiencies should be addressed.
- The main door to the converter area is in poor condition and should be replaced (budget estimate is $5,000). The four personnel doors are in poor condition and should also be replaced (budget estimate is $4,000). The existing fireproof transformer doors require upgrading (budget estimate is $2,000).
- It is estimated that the cost of installing washroom facilities would be $10,000. This work should proceed, if justified.
- It is estimated that the cost of installing permanent electrical backup heating would be $30,000. This work should proceed, if justified.
- The existing battery charger is nearing the end of its service life. The cost of replacing this unit is approximately $10,000. This work should proceed, if justified.
- Annunciation and remote annunciation requirements should be reviewed.
- Voice communications are difficult throughout the facility due to the noise levels.

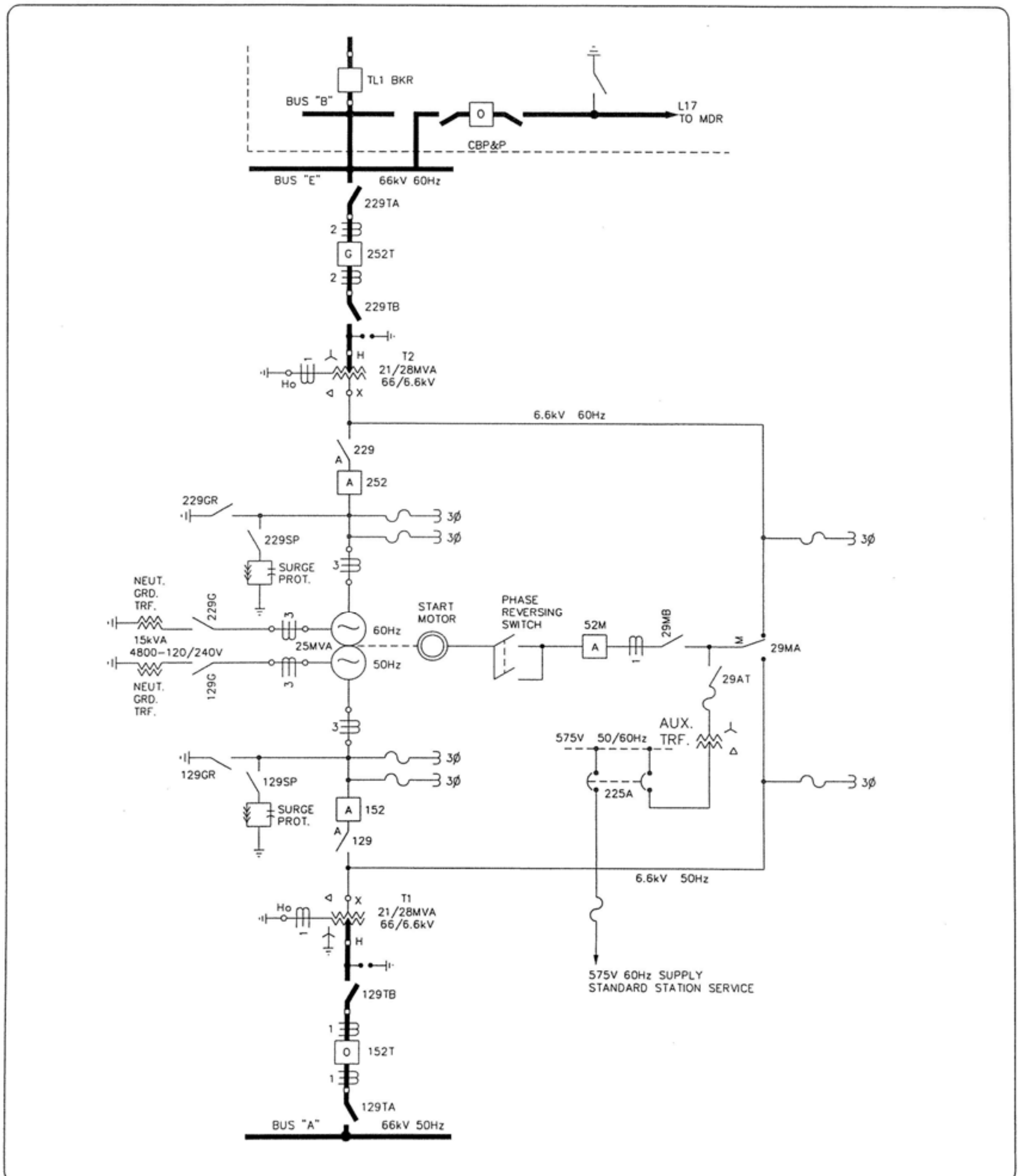
Figure 21 – Main Door To Converter Area (2005)

5.3 Further Investigation / Information Required

- The existing control system is for the most part manual. The auto-synchronizer is out of service, is not repairable, and should be replaced. It is estimated that modernization of the entire control system would cost roughly $600,000. This estimate is based upon replacement of most of the protection and control equipment, including the regulators, synchronizer, and additional monitoring equipment for load, winding temperatures, etc. There are options available, dependant upon various factors, especially the expected life cycle of the converter. The estimate of $600,000 is based upon the installation of a reasonable and modern protection and control system, which would be acceptable for the next 20 years or so. If necessary, cost estimates for different alternatives can be explored.
- Modernization of the control system such that automatic (and possibly remote) startup and shutdown of the converter by Deer Lake Power or Corner Brook Pulp and Paper would permit the customer to operate the unit as required and contact Hydro only if a problem occurs. Cost estimates should be generated (this work would likely include modernization of some or all of the control system) and the work would proceed, if justified.
- The condition of the air operated disconnect switches should be reviewed. Overhauls of the operating mechanisms may be required due to recurring air leaks.
- Isolation of breakers 129, 229 and 29 MB is not adequate. The supply and drain valves for 229 are located inside the door of 252. In order to make 229 a guaranteed device the individual performing the switching is exposed to 6.9 kV and the pneumatic controls inside the breaker switchgear enclosure. Work procedures are in place to address these inadequacies. This situation should be reviewed and an estimate to modify the air control system created.
- The condition of breaker 152T (a 69 kV OCB which is about 39 years old) should be reviewed.
- The operating solenoid of disconnect 129SP is not operational. An estimate for repair should be completed.
- Disconnects 129SP and 229SP contain PCB filled capacitors.

E. APPENDICES

1.0 System Operating Diagram - Corner Brook Frequency Converter



DRAWN BY TT	NEWFOUNDLAND AND LABRADOR HYDRO	DWG NO
APPROVED BY WR	SYSTEM OPERATING DIAGRAM CORNER BROOK FREQUENCY CONVERTER	REV NO 4
DATE 02-09-23		

2.0 Transformer Oil Test Results

TJ | H2b
ANALYTICAL SERVICES INCORPORATED

Dissolved Gas Analysis

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400
St John's, NF A1B 4K7
P.O. Number: 52675-000 OP

Equipment Type : Transformer
Location : CB CONVERTER
Mfg. Date: 01/01/1966
MVA : 66000
Fluid type : Mineral Oil
Breathing :
Analysis Date: 5/19/04
Report Print Date: 5/20/2004

Equip Desc. : CBF-T1
Manufacturer : Moloney
Serial Number : 230815
Equipment ID : 230815
kV: 66
Fluid Volume : 1880
Cooling :
Report Number: 5005911

	Sample Date :	04/20/2004	03/25/2003	02/28/2002
	Laboratory No. :	5005911	5003701	5001787
	Container No. :	TJC 099	TJC 354	TJC 569
	Sample Point :	BOT MAIN		
	Sampled By :	Rex Cook		
	Temperature :	60	4	10
H2	Hydrogen (ppm) :	24	33	29
CH4	Methane (ppm) :	9	12	161
C2H6	Ethane (ppm) :	7	7	126
C2H4	Ethylene (ppm) :	11	4	64
C2H2	Acetylene (ppm) :	0	0	2
CO	Carbon monoxide (ppm) :	940	801	1849
CO2	Carbon dioxide (ppm) :	11418	7521	11117
N2	Nitrogen (ppm) :	78249	95687	99886
:	Oxygen (ppm) :	17906	23921	5546
	Total (ppm) :	108563	127984	118780
	TDCG (ppm) :	991	856	2230
	TDCG Rate (ppm/day) :	0.3	-3.5	0.0
	CH4 / H2 :	0.37	0.36	5.60
	C2H2 / C2H4 :	0.00	0.00	0.03
	C2H2 / CH4 :	0.00	0.00	0.01
	C2H6 / C2H2 :	9999.99	9999.99	70.69
	C2H4 / C2H6 :	1.64	0.54	0.50
	CO2 / CO :	12.15	9.39	6.01
	C2H2 / H2 :	0.00	0.00	0.07
	H2 / C2H6 :	3.43	4.71	0.23
	C2H4 / C2H2 :	9999.99	9999.99	32.00

Dissolved Gas Diagnostics

Key Gas Method : Possible Cellulose Decomposition,
Doernenburg Ratios : Not in table
Rodgers Ratios (3) : Not in table
Rodgers Ratios (4) : General Conductor Overheating
CO2 / CO :
IEEE Std. C57.104 -1991 Condition : 2
Sampling Interval : Quarterly
Operating Procedure : Exercise caution. Analyze for individual gases. Determine load dependence.

TJH2B Analytical Services , Inc. 335-25th Street S.E. Calgary, AB T2A 7H8 Canada Phone: (403) 282-8542 Fax: (403) 282-8593

Sacramento, CA (916) 361-7177 / Jefferson, LA (504) 734-9722 / Sun Prarie, WI (608) 825-2022 / Kennett Square, PA (610) 925-0688

Glen Waverly, Australia +61 3 9574 9467 / Chester, United Kindom +44 0 151 339 5100

Transformer T1 – Dissolved Gas Analysis

TJ | H2b
ANALYTICAL SERVICES
INCORPORATED

Insulating Fluid Evaluation

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400
St John's, NF A1B 4K7
P.O. Number: 52675-000 OP

Equipment Type :	Transformer	Equip Desc. :	CBF-T1
Location :	CB CONVERTER	Manufacturer :	Moloney
Mfg. Date:	01/01/1966	Serial Number :	230815
MVA :	66000	Equipment ID :	230815
Fluid type :	Mineral Oil	kV :	66
Breathing :		Fluid Volume :	1880
Analysis Date :	5/19/04	Cooling :	
Report Print Date :	5/20/2004	Report Number:	5005911

	Sample Date :		04/20/2004	03/25/2003	02/28/2002
	Laboratory No. :		5005911	5003701	5001787
	Container No. :		TJC 099	TJC 354	TJC 569
	Sample Point :		BOT MAIN		
	Sampled By :		Rex Cook		
	Temperature :		60	4	10
D1533	Moisture/Water Content	(ppm) :	15	8	8
D971	Interfacial Tension	(dynes/cm) :	32.0	28.3	24.4
D974	Acid Number	(mg KOH/g) :	0.050	0.030	0.197
D1500	Color Number	:	2.5	<3.0	<7.5
D1524	Visual Examination	:	Clear & Bright	Clear & Bright	Clear & Bright
D877	Dielectric BV	(kV) :			
D1816	Dielectric BV	(kV) :	26@1mm	25	28
D924	Power Factor	(% at 25 C) :	0.122	0.088	0.758
D924	Power Factor	(% at 100 C) :			
D2668	Oxidation Inhibitor	(%) :			0.068
	Specific Gravity	:			
D88	Viscosity	(SUS) :			
D97	Pour Point	(C) :			
D92	Flash Point	(C) :			
D92	Fire Point	(C) :			
D1807	Refractive Index	:			
D1275	Corrrosive Sulfur	:			

Insulating Fluid Diagnostics

	New Oil	ASTM D3487	IEEE Group I	<69	>69<288	>345	IEEE Group II		IEEE Group III	
Moisture :	Acceptable	35 max	Acceptable	35 max	25 max	20 max				
Interfacial Tension :	Warning	40 min	Acceptable	24 min	26 min	30 min	Acceptable	24 min	Acceptable	16 min
Acid Number :	Warning	0.03 max	Acceptable	0.2 max	0.2 max	0.1 max	Acceptable	0.2 max	Acceptable	0.5 max
Color Number :	Warning	0.5 max								
Visual Examination :	Acceptable	clear & bright								
Dielectric BV D877 :		30 min		26 min	26 min	26 min				
Dielectric BV D1816 :	Warning	28 min	Acceptable	23 min	26 min	26 min				
Power Factor @ 25 C :	Warning	0.05 max								
Power Factor @ 100 C :		0.30 max								
Oxidation Inhibitor :		0.3 max								
Specific Gravity :		0.91 max								
Viscosity @ 40 C :		66 max								
Pour Point :		-40 max								
Flash Point :		145 min								
Fire Point :										
Refractive Index :										
Corrosive Sulfur :		noncorrosive								
Comments :										

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Transformer T1 – Insulating Fluid Evaluation

TJ | H2b
ANALYTICAL SERVICES INCORPORATED

Transformer Condition Assessment TCA™

David Hicks				Date :	03-08-2002
Newfoundland Labrador Hydro	Location :	Corner Brook		Report Number :	5001787
	Bank & Phase :	Bottom- T1		Fluid volume :	1880
P.O. Box 12400St.	Serial Number :	230816		Fluid type :	Mineral Oil
St John's, NF A1B 4K7	Manufacturer :	Moloney		Preservation :	
	Date Mfgd :	07/01/1966		Cooling :	
	Size (kVA) :	28000		Core & coil wt. :	
	Rating kV:	66		Impedance :	

		Sample Date :	02/28/2002
		Laboratory No. :	5001787
		Container No. :	TJC 569
		Temperature :	10
H2	Hydrogen	(ppm) :	29
CH4	Methane	(ppm) :	161
C2H6	Ethane	(ppm) :	126
C2H4	Ethylene	(ppm) :	64
C2H2	Acetylene	(ppm) :	2
CO	Carbon monoxide	(ppm) :	1849
CO2	Carbon dioxide	(ppm) :	11117
N2	Nitrogen	(ppm) :	99886
O2	Oxygen	(ppm) :	5546
		Total (ppm) :	1.8780
		TDCG (ppm) :	2231
		SHL (%) :	11.10
		ETCG (% in blanket) :	1.37
Particles		5 to 15 um :	3626865
Particles		15 to 25 um :	681470
Particles		25 to 50 um :	246825
Particles		50 to 100 um :	4900
Particles		> 100 um :	100
D1533	Moisture	(ppm) :	8
D1816	Dielectric BV	(kV) :	28
D974	Acid Number	(mg KOH/g) :	0.197
D971	Interfacial Tension	(dynes/cm) :	24.4
D1500	Color Number	:	<7.5
D924	Power Factor	:	0.758
D2668	Oxidation Inhibitor	(%) :	0.068
5 HMF	5 hydroxymethyl-2-furaldehyde	(ppm) :	0.028
2 FAL	2 furaldehyde	(ppm) :	0.521
2 ACF	2 acetylfuran	(ppm) :	0.468
5 MEF	5 methyl-2-furaldehyde	(ppm) :	<0.010
2 FOL	2 furfurol	(ppm) :	<0.010
	Estimated DP	:	429-512

Following information will help us to evaluate in-depth TCA

1. Load Dependency
2. Previous DGA preferably with loading
3. System event
4. Maintenance Activity
5. Operational Activity

Transformer Condition Assessment Diagnostic Evaluation

TCA Assessment : Potential 3
Sampling Interval : Retest in three months. Establish trends and confirm condition.
Operating Procedure : *Consider treatment to remove oxidation products.*
Comments : Heating and arcing are indicated. Cellulose may be involved.
Field Comments : Fluid oxidation is advancing. Paper condition is reduced to approximately 53% tensile strength.

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Jefferson, LA 70121
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◆3098 Happy Valley Road
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Kennett Square, PA 19348
(610) 925-0688

◆ 335- 25th Street SE , Calgary, Alberta, Canada T2A 7H8 Ph: (403) 282-8542 Fax: (403) 282-8593

Transformer T1 – Transformer Condition Analysis

TJ | H2b

Dissolved Gas Analysis

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400St.
St John's, NF A1B 4K7
P.O. Number: 37293-000 OP

Equipment Type :	Transformer	Equip Desc. :	T2
Location :	CBF	Manufacturer :	Moloney
Mfg. Date:	01/01/1966	Serial Number :	230814
MVA :	66000	Equipment ID :	230814
Fluid type :	Mineral Oil	kV:	66
Breathing :		Fluid Volume :	1600
Analysis Date:	8/13/2002	Cooling :	OA/FA/FOA
Report Print Date:	8/23/2002	Report Number:	5002808

	Sample Date :	08/07/2002
	Laboratory No. :	5002808
	Container No. :	TJC 827
	Sample Point :	Main TK
	Sampled By :	T K
	Temperature :	25
H2	Hydrogen (ppm) :	0
CH4	Methane (ppm) :	1
C2H6	Ethane (ppm) :	1
C2H4	Ethylene (ppm) :	1
C2H2	Acetylene (ppm) :	0
CO	Carbon monoxide (ppm) :	10
CO2	Carbon dioxide (ppm) :	231
N2	Nitrogen (ppm) :	38959
O2	Oxygen (ppm) :	14721
	Total (ppm) :	53924
	TDCG (ppm) :	13
	TDCG Rate (ppm/day) :	0.0
	CH4 / H2 :	9999.99
	C2H2 / C2H4 :	0.00
	C2H2 / CH4 :	0.00
	C2H6 / C2H2 :	9999.99
	C2H4 / C2H6 :	1.62
	CO2 / CO :	22.34
	C2H2 / H2 :	9999.99
	H2 / C2H6 :	0.00
	C2H4 / C2H2 :	9999.99

Dissolved Gas Diagnostics

Key Gas Method : All gases are within normal limits
Doernenburg Ratios : Not in table
Rodgers Ratios (3) : Not in table
Rodgers Ratios (4) : Not in table
CO2 / CO :
IEEE Std. C57.104 -1991 Condition : 1
Sampling Interval :
Operating Procedure : Transformer is operating satisfactorily

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Transformer T2 – Dissolved Gas Analysis

TJ | H₂b

Insulating Fluid Evaluation

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400St.
St John's, NF A1B 4K7
P.O. Number: 37293-000 OP

Equipment Type :	Transformer	Equip Desc. :	T2
Location :	CBF	Manufacturer :	Moloney
Mfg. Date:	01/01/1966	Serial Number :	230814
MVA :	66000	Equipment ID :	230814
Fluid type :	Mineral Oil	kV :	66
Breathing :		Fluid Volume :	1600
Analysis Date :	8/13/2002	Cooling :	OA/FA/FOA
Report Print Date :	8/23/2002	Report Number:	5002808

Sample Date :	08/07/2002
Laboratory No. :	5002808
Container No. :	TJC 827
Sample Point :	Main TK
Sampled By :	T K
Temperature :	25

D1533	Moisture/Water Content	(ppm) :	6
D971	Interfacial Tension	(dynes/cm) :	29.3
D974	Acid Number	(mg KOH/g) :	0.019
D1500	Color Number	:	<1.5
D1524	Visual Examination	:	Clear w/ part.
D877	Dielectric BV	(kV) :	
D1816	Dielectric BV	(kV) :	19
D924	Power Factor	(% at 25 C) :	0.087
D924	Power Factor	(% at 100 C) :	
D2668	Oxidation Inhibitor	(%) :	0.139
D129	Specific Gravity	:	
D88	Viscosity	(SUS) :	
D97	Pour Point	(C) :	
D92	Flash Point	(C) :	
D92	Fire Point	(C) :	
D1807	Refractive Index	:	
D1275	Corrosive Sulfur	:	

Insulating Fluid Diagnostics

		ASTM D3487	IEEE Group I	<69	>69<288	>345	IEEE Group II		IEEE Group III	
Moisture :	Acceptable	35 max	Acceptable	35 max	25 max	20 max				
Interfacial Tension :	Warning	40 min	Acceptable	24 min	26 min	30 min	Acceptable	24 min	Acceptable	16 min
Acid Number :	Acceptable	0.03 max	Acceptable	0.2 max	0.2 max	0.1 max	Acceptable	0.2 max	Acceptable	0.5 max
Color Number :	Acceptable	0.5 max								
Visual Examination :	Warning	clear & bright								
Dielectric BV D877 :		30 min		26 min	26 min	26 min				
Dielectric BV D1816 :	Warning	28 min	Warning	23 min	26 min	26 min				
Power Factor @ 25 C :	Warning	0.05 max								
Power Factor @ 100 C :		0.30 max								
Oxidation Inhibitor :	Acceptable	0.3 max								
Specific Gravity :		0.91 max								
Viscosity @ 40 C :		66 max								
Pour Point :		-40 max								
Flash Point :		145 min								
Fire Point :										
Refractive Index :										
Corrosive Sulfur :		noncorrosive								
Comments :										

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Transformer T2 – Insulating Fluid Evaluation

3.0 Memo – Relocation of Grand Falls Unit to Corner Brook

HYDRO

INTER-OFFICE MEMORANDUM

D.J.H. 00-04-10

TO: G. J. Holden

FROM: G. O'Keefe

DATE: April 10, 2000

SUBJECT: Grand Falls Frequency Converter – Relocation to Corner Brook

---

In response to your request, following is an estimate of the cost to relocate the GFFC & Controls to Corner Brook. Costs at Corner Brook cover off-loading only, and no installation costs are included.

The Direct "order of magnitude" costs are cash flowed over a one-year period to give the total estimated cost. The summary of these costs presented in the same form as the budget proposal format is:

Construction/Service Contracts	$189,000
Materials Supply	$ 10,000
Construction/Internal	$ 10,000
Engineering	$ 15,000
Project Management	$ 29,000
Corporate Overheads	$ 27,800
Interest During Construction	$ 700
Contingency (25%)	$ 63,000
Escalation	$ 11,900
Total	$ 360,200

These are "order of magnitude" estimates based on file information, photos, and telephone information from our field staff. There is no detailed breakdown of these estimates. If detailed estimates are required, then much more extensive engineering work (including field investigations) would be required. This would require 2-3 weeks to complete. This is not in our work plan now.

These estimates are accurate to within 25%. The information should be used for internal resource material, only. More detailed and extensive information would be prepared for outside distribution.

Glenn O'Keefe
Supervising Electrical Engineer (Acting)

GOK/rh

A:\Memo G. Holden - Grand Falls Frequency Converter.doc

4.0 Corner Brook Frequency Converter Annual Operating Costs

Corner Brook Frequency Converter Work Order Direct Cost - 2000 to 2005						
	2004	2003	2002	2001	2000	Annual 5 Yr Ave
CBFTS	$29,800.00	$8,240.00	$79,388.00	$6,847.00	$14,374.00	$27,729.80
CBFCS	$36,455.00	$48,263.00	$61,430.00	$34,437.00	$100,173.00	$56,151.60
Total	$66,255.00	$56,503.00	$140,818.00	$41,284.00	$114,547.00	$83,881.40

5.0 Electric Utility Project Escalation Indexes

TABLE 1

ELECTRIC UTILITY PROJECT ESCALATION INDEXES

(1997 = 1.000)

	GDP Implicit Price Deflator [2]	Canadian CPI [2]	Newfoundland & Labrador CPI [2]	Hydraulic & Thermal Plant Construction [1]	Distribution & Transmission Construction [1]	Operating & Maintenance (O&M) [2]	
						Materials ~75% Labour ~25%	Materials ~50% Labour ~50%
1990	0.8885	0.867	0.861	0.858	0.847	0.904	0.919
1991	0.9147	0.915	0.915	0.871	0.835	0.924	0.933
1992	0.9267	0.929	0.924	0.891	0.840	0.933	0.939
1993	0.9401	0.946	0.940	0.908	0.865	0.943	0.946
1994	0.9508	0.948	0.951	0.935	0.911	0.951	0.951
1995	0.9720	0.968	0.965	0.961	0.972	0.967	0.962
1996	0.9880	0.984	0.980	0.980	0.982	0.985	0.982
1997	1.0000	1.000	1.000	1.000	1.000	1.000	1.000
1998	0.9960	1.009	1.002	1.022	1.041	1.002	1.007
1999	1.0130	1.027	1.017	1.038	1.061	1.020	1.027
2000	1.0540	1.055	1.047	1.063	1.086	1.056	1.059
2001	1.0650	1.082	1.058	1.084	1.094	1.078	1.091
2002	1.0750	1.106	1.084	1.105	1.109	1.097	1.120
2003	1.1120	1.137	1.116	1.143	1.147	1.140	1.168
2004	1.1265	1.158	1.134	1.160	1.167	1.164	1.203
2005	1.1490	1.183	1.156	1.185	1.192	1.189	1.230
2006	1.1697	1.206	1.178	1.208	1.217	1.212	1.255
2007	1.1896	1.230	1.199	1.230	1.241	1.234	1.281
2008	1.2098	1.255	1.221	1.253	1.265	1.257	1.306
2009	1.2303	1.280	1.248	1.277	1.293	1.282	1.335
2010	1.2513	1.306	1.275	1.302	1.320	1.307	1.364
2011	1.2725		1.303	1.328	1.349	1.332	1.394
2012	1.2942		1.332	1.354	1.378	1.358	1.425
2013	1.3162		1.362	1.380	1.408	1.385	1.457
2014	1.3385		1.391	1.407	1.438	1.412	1.488
2020	1.4942		1.580	1.589	1.639	1.594	1.701
2025	1.6416		1.747	1.759	1.826	1.765	1.897

Note: 1. 2003 is forecast.
2. 2004 is 1st forecast year.

Source: Statistics Canada
Conference Board of Canada
Gov't of Nfld & Labrador Dept. of Finance

Mar-04
C:\paustrea\ESCL\EUCPI\[EUCPI_Forecast for Spring 2004.xls]Table1
Economic Analysis Section, System Planning Dept.

[redacted]

6.0 M. Zaichkowsky Report – Towers / Insulators

Engineering Assessment of Steel Take-Off Towers and Miscellaneous Equipment on top of the Frequency Converter Building at Corner Brook Pulp and Paper Ltd.

1. TAKE – OFF TOWERS.

There are currently 2 steel towers on top of the Frequency Converter Building that support conductors between the Frequency Converter and No. 1 Substation. Each tower is approximately 25' high x 18' wide x 6' deep, and is fabricated from steel angle, plate, and tower bolts. All of these components are hot dip galvanized.

Take Off Towers and External 66 kv Bus associated with the Frequency Converter at Corner Brook Pulp and Paper.

Both towers are in good condition, including the bolted connections and leg anchors. Approximately 80 percent of the surface area of both towers is lightly corroded with some signs of mild pitting. Although maintenance of these steel towers is not urgent, it is recommended that a protective coating be applied to prevent any further deterioration of the structural steel. A two to three year delay in carrying out this maintenance would be acceptable.

Take Off Tower for T1, bolted connection, leg to horizontal brace, light corrosion.

Take Off Tower for T2, leg anchor, light corrosion and mild pitting.

As a protective coating, it is recommended that a good quality zinc or aluminium rich self priming paint be used. Surface preparation shall be in accordance with the SSPC-SP-2 standard (hand tool cleaning). Hydro currently stocks a high quality product that would be suitable for use on the towers. This product is Galvacon GC-243 cold galvanizing compound, however, it is quite expensive at $232.00 per gallon.

2. PROTECTIVE STRUCTURE – 66 KV BUS LEADING TO T2

Last year, in order to facilitate the removal of T2 from the Frequency Converter Building, part of the protective structure that prevents the incidental contact between the 66 kv Bus and Mill Personnel/Equipment was removed. For safety reasons it is recommended that this structure be reinstated to its original condition as soon as possible. See drawing No. 401-S-16-Rev. 2.

Protective Structure for T2 External 66 kv Bus, steel frame and wire mesh removed.

3. ENTRANCE INSULATORS FOR 500 MCM CONDUCTOR LEADING TO T2.

Both A and C phase entrance insulators for the 500 MCM Conductor leading to T2 have sustained considerable physical damage, resulting in reduced leakage distances and an increased probability of flashover. It is recommended that both A and C phase insulators be replaced as soon as a suitable substitute can be found. The existing insulators are vintage 1966, Canadian Porcelain, 69 kv, 350 BIL, catalogue No. 1216. Dave Hicks of TRO Engineering has been contacted for assistance in locating the replacement insulator.

Damaged A phase entrance insulator.

Damaged C phase entrance insulator.

4. PINCAP AND SUSPENSION INSULATORS.

The current 66 kv Bus arrangement on the frequency converter building is supported by C.O.B. pincap and suspension insulators. These types and make of insulators have been failing at an ever increasing rate in many of our terminal stations, distribution, and transmission lines. Therefore, it would be prudent to consider changing out these insulators within the next several years. The pincap insulators are vintage 1966, C.O.B., catalogue No. 37769 (double units), 36 units would require replacement. The suspension insulators are vintage 1966, C.O.B., ball and socket type, catalogue No. 32436. 12 strings of 5 units would require replacement. Hydro currently stocks suitable station post and suspension type insulators for this work.

C.O.B. pincap insulators, 66 kv Bus CBPPL frequency converter building.

Mike Zaichkowsky
09/10/03

7.0 Acres International – Condition Assessment of (Corner Brook) 50/60 Cycle Frequency Converter Final Report

Newfoundland and Labrador Hydro
P.O. Box 12400
Hydro Place, Columbus Drive
St. John's, Newfoundland A1B 4K7

Condition Assessment of
50/60 Cycle Frequency Converter
Final Report

September 1998

P12869.00

Acres International Limited
St. John's Newfoundland

ACRES

October 6, 1998
P12869.00

Newfoundland and Labrador Hydro
P.O. Box 12400
Hydro Place, Columbus Drive
St John's, Newfoundland. A1B 4K7

Attention: Mr. David Hicks, P.Eng.

Dear Mr. Hicks: **Frequency Converter Condition Assessment**

We are pleased to forward four copies of our final report of the above project. This report, which reflects your review of our draft reports, presents the findings of our site inspections and recommendations for rehabilitation of the converter and associated facilities. Our estimate of the cost to refurbish the facility is approximately $2.6 million. Almost one-half of this cost is due to rewinds of the converter rotors, and the accuracy of the estimate is therefore strongly affected by the accuracy of this cost component. While we have made efforts to achieve an accuracy of 10 percent in our overall estimate, we believe that the influence of this component will more reasonably result in an accuracy of 15 percent overall since the associated cost is based on a supplier budget quote. It is likely that during the bidding process for this work, the tendered price will be less than this estimate.

We are pleased to have had the opportunity to carry out this work and would be available to assist you in implementation of the refurbishment if required.

Yours very truly,

R.J. Gill, P.Eng.
Vice President, Atlantic Region

RJG:sjc

Enclosure

cc R. Bustrean

ACRES INTERNATIONAL LIMITED
4th Floor, Beothuck Building, 20 Crosbie Place, St. John's, Newfoundland, Canada A1B 3Y8
Telephone 709-754-1710 Facsimile 709-754-2717

Vancouver, Calgary, Winnipeg, Niagara Falls, Toronto, Halifax, Sydney

Table of Contents

Executive Summary

Executive Summary

Acres International was retained by Newfoundland and Labrador Hydro (NLH) to carry out a condition assessment of NLH's 50/60 Hz frequency converter at Corner Brook Pulp and Paper Limited. A site inspection was carried out during the week of August 16 to 22, 1998, a review of available maintenance records and drawings was conducted, and discussions were held with other frequency converter users.

The main observations and recommendations arising from the work are:

- The entire facility is covered with dust and dirt and accumulated residue from the pulp mill operation. The ventilation system is faulty and the building shell has numerous cracks, which allow penetration of debris. The entire facility requires cleaning, particularly the converter itself. The ventilation system should also be brought up to current standards.

- The insulation resistance value of the rotor windings is very low, in the order of 300-kohms. These low values are indicative of a failure within the next few years, but the failure could occur at any time. The rotors should therefore be rewound. Because the existing windings are asbestos insulated, the rewind will cost more than normal.

- The oil spill containment and drainage around the main transformers and the transformer doors require improvement to contain any spill and to eliminate any fire hazard.

- The cooling system associated with the voltage regulator (starting motor) has a water leak that occurs only on shut down or startup. This is known to the maintenance forces and they routinely drain the accumulated water after a shut down or startup. The water level after a shut down or start up is, however, only slightly below the main incoming leads, which are bare. Although it is unlikely, the potential exists for a short to occur. The leak should be fixed or static voltage regulators, which have a relatively low cost and greater flexibility, should be installed.

- The pedestal bearing has been wiped and should be replaced.

- The building requires repair. Concrete and bricks have fallen from the roof and building sides and damaged the bushings and post insulators. Building cracks have allowed entrance of the wood debris associated with operation of the paper mill. The ceiling in the stairwell is temporarily repaired using a sheet of plywood. This should be permanently repaired.

- The neutral grounding transformers are oil insulated and should be replaced by dry type transformers.

- The lighting in the building, particularly the emergency lighting, should be upgraded.

- The batteries should be enclosed and measures taken to control and exhaust hydrogen gases.

- The building insulation contains asbestos fiber. Whereas this asbestos does not seem to be friable, it would be best to remove it, if only to allow personnel entering the building freedom from wearing respirators.

- A number of minor repair items, such as replacement of relay case covers, should be carried out.

The recommended sequence of execution of these recommendations is as follows:

1. Remove the building insulation asbestos.

2. Improve building lighting.

3. Repair the building, improve the drains and replace the insulators as required

4. Clean the converter facility thoroughly, particularly the converter itself.

5. Make necessary converter improvements, including rewinding the rotors, monitoring of the coupling and replacement of the bearings as necessary.

6. Make necessary improvements to the facility including the ventilation system, the compressed air system, the oil lubrication system, the fire control system and the oil spill containment system.

7. Make other repairs and improvements as necessary including those to the voltage regulator, the switchgear, and auxiliary transformer replacement.

It is believed that the work, if properly planned and expedited, should be completed within a two to three month period. The major item of work would be the rotor rewind, which would require the rotors be removed from site to a suitable workshop.

The estimated cost to carry out the full rehabilitation is $2.6 million, almost 50 percent of which is attributable to the rewind of the rotors. The level of accuracy of the estimate overall is ±15 percent.

Once refurbished, the facility should be maintained appropriately and a suitable level of spare parts should be kept in inventory.

Introduction

1 Introduction

In August, 1998, Newfoundland and Labrador Hydro (NLH) retained Acres International Limited to carry out a condition assessment of NLH's 50/60 cycle frequency converter located at Corner Brook Pulp and Paper.

The work included a review of the maintenance records at NLH's Stephenville office in addition to the inspection of the converter facility at Corner Brook. This report presents the findings of the assessment and costs to upgrade the facility.

Methodology

2 Methodology

2.1 Data Acquisition

Prior to any machine inspections or other work, maintenance records, relevant drawings and other data believed pertinent was obtained from NLH offices in St. John's and Stephenville. The latter office is responsible for maintenance of the Corner Brook converter. This data was examined before the machine inspection and testing took place.

In addition to obtaining data and drawings showing the machine and structural and mechanical systems, discussions were held with owners of other rotating converters regarding their experience with their converters. Further discussions were held with suppliers of thyristor static converters and with service companies to determine costs of repair and rehabilitation.

2.2 Machine Inspection and Observations

The machine was shut down for the period of August 18 to August 21, 1998. During that period, the condition of the machine stators and rotors was assessed to the extent possible without removal of the rotors. The electrical machine inspection consisted of visually examining the windings and the ties to ensure the windings and insulation were in adequate condition. In addition, the windings were meggared to determine their insulation resistance to ground. The machine bearings and condition of the bearing oil were inspected.

In addition to the above the condition of the switchgear, the relays and meters and the AC and DC auxiliary systems were inspected and noted. The air filtration systems were observed along with the environmental control systems, such as transformer oil spill containment and asbestos in the building ceilings.

The structural condition of the building was also assessed. The findings in each case are recorded in Section 3 of this report.

2.3 Analysis

After the machine inspection, the readings obtained and the observations made were compiled and analyzed. Where necessary, prices were obtained from outside parties for possible rehabilitative services. These budgetary prices, and estimated costs obtained through Acres own internal sources, were added together to provide estimates for the necessary rehabilitation of various options for repair or rehabilitation of the machine, the building in which it housed and any of the ancillary mechanical systems.

In addition to the above, the samples of residue obtained from the machine during the inspection were sent out for laboratory analysis. The results are discussed in Section 4 of this report.

Also in this section, the typical life spans of equipment similar to that at the frequency converter facility at Corner Brook are presented on the basis of statistical data compiled on equipment that undergoes normal operation and maintenance procedures.

2.4 Operations and Maintenance

Discussions were held with two owner operators of rotating frequency converter. The information obtained is discussed in Section 5.

2.5 Conclusions

Section 6 makes a recommendation for the manner in which NLH should proceed if it wishes to rehabilitate the facility in order to continue to operate the facility for a further 10 years at a minimum.

Observations

3 Observations

3.1 Summary of Review of Maintenance Records

3.1.1 Brown Boveri Metalclad Circuit Breakers

Maintenance records show that these breakers and the metalclad switchgear have not caused any problems; however, this gear is old and planning for replacement should be periodically reviewed to ensure replacement is planned on a timely basis.

The values obtained in the tests performed on the breakers, ductor tests, and anecdotal evidence of interruption severity were reviewed. Apparently nothing untoward has happened to the gear as far as can be obtained from questioning the maintenance staff or reviewing the records. However, the records are scanty, particularly for the early years of use, and none of the present maintenance staff remembers all the incidents that happened with the gear.

3.1.2 Exciter and Pilot Exciter

No specific maintenance problems have been observed with this equipment. The equipment is, however, old and planning for replacement should be started.

3.1.3 Starting Motor

There appear to be no specific references to the starting motor in the maintenance records.

3.1.4 Voltage Regulator

A number of problems have occurred and continue to occur with the voltage regulator. Specifically, the major problems noted in review of the maintenance records are listed below.

- A June 2, 1981 memo describes a fault that occurred and includes a Brown Boveri recommendation that a major overhaul be performed every five years.

- There are numerous references to oil and water leaks and the resultant repairs. It is estimated that two barrels of water are discharged during each startup and shutdown due to a leak in the water coolers.
- There seems to be no record of periodic maintenance in any recognizable program format.

3.1.5 Transformers

- T1 maintenance records show routine maintenance and no sign of problems.
- T2 records show an incident in 1990 with gas buildup and loose connections found during the resultant trip. No other significant problems were observed. Routine maintenance is performed.

3.1.6 Batteries

Batteries appear to be serviced regularly and records show charge in excess of two volts. The current set of batteries was installed in 1981, replacing the original set, for which records still exist. No problems have been noted with the batteries. It is noted, however, the recommended yearly deep discharge does not appear to have been performed at any time.

3.1.7 50/60 Hz Converter

Numerous maintenance records detail problems that have occurred with various parts of the converter. In particular, problems have been observed with the following components.

- High temperatures and oil problems with bearings
- Uneven wear and pitting of slip rings
- Failure of louvers to operate
- Shorts, flashovers and high incidence of brush failures
- Low rotor field winding insulation strength

The stator winding insulation strength does not seem to have deteriorated significantly over time as is the case with the field winding insulation strength.

A number of major cleaning exercises have occurred. Montreal Armature cleaned the converter in 1975, Westinghouse did the same in 1984 and a third cleaning was handled by NLH staff in 1989. In all cases failure to correct the root cause of the contamination meant the dirt continued to accumulate after the cleaning was completed and thus required repetition of the cleaning. It is probable, however that, without the cleaning the machine would not now be operating.

The maintenance records highlight the poor environment in which the machine operates and the particle deposits that exist on all the equipment.

3.2 Electrical Observations During Inspection Shutdown

3.2.1 Emergency Lighting

Ground Floor

1. No emergency lighting exists in the transformer vaults or the voltage regulator vault.

2. In the converter area, three unprotected light bulbs are attached to the cable tray on the left side; none were found on the right side (as viewed from the pilot exciter).

3. None were observed elsewhere.

Stairway and Stair Landings

Emergency lighting appeared to need augmentation by being better oriented and also by having an additional light at the bottom of the stairway.

Switchgear Floor

1. Two lights were observed in each of the front and back of the duplex panels.
2. Two lights were observed in the duplex panel corridor.
3. No other emergency lights were observed anywhere else on the second floor.

3.2.2 Main Lighting

Ground Floor

Lighting levels were not measured but were found to be inadequate for most tasks; for inspection of the converter a flashlight had to be used.

Stairway and Landings

Lighting appeared adequate.

Switchgear Floor

Lighting levels were not measured but appeared somewhat low, probably because some bulbs needed replacement.

3.2.3 Transformer Vaults

1. No deluge system exists for the transformers; none was required at the time of the installation, unlike current requirements.

2. Drains in both vaults are blocked. This was apparently done to stop water from backing up into the vault area from outside.

3. Fire protection doors do not close easily and seem not to be a fabricated fit. No system was found to automatically close the doors in case of a fire. This is a potential hazard, and would not be acceptable under current design practice.

4. The air intake seems inadequate, and the intake filters are partially clogged and need cleaning. The air intake filters are adjacent to a dirt road which provides plant access.

5. The vault area needs to be cleaned of dust and dirt.

6. The air intake for converter cooling is drawn past the transformers and, now heated, into the converter area. No separate air supply system for the converter is available.

3.2.4 Voltage Regulator

1. Panel and equipment appear to be in reasonable operating order, but the equipment design is antiquated.

2. The regulation equipment is water cooled. A leak exists in the equipment on startup and shut down. During the inspection, a water pool was found in the center of the unit at a point just below the main three phase lead connections (bare). A flashover would almost certainly have occurred if the equipment had been started before the water was drained.

3. Water, probably from the above leak, also appeared in the cable ducts from the units to the right hand wall.

3.2.5 Bus Duct

60 Hz Side

1. The micarta bus insulation (sleeving) is cracked on the vertical sections and also on the horizontal section under the switchgear room floor.

2. A mild steel nut is installed on the left hand connection; an extra long bolt is installed on the right hand connection.

3. Minor conductor bird caging was observed off the center phase flexible connection, probably due to bus and converter loads being at different heights and different centers.

4. Flexible connectors do not exhibit evidence of fraying or separation.

5. Supports and bracing appear adequate.

50 Hz Side

Micarta insulation shows evidence of cracking similar to the 60 Hz insulation. All other findings on the 50 Hz portion of the bus duct are the same as for the 60 Hz portion except for the nut and bolt problem.

3.2.6 Pilot Exciter

1. No visible damage or defect is apparent.

2. Wear on the commutator and brushes appears even.

3. No visible access was available to the stator or rotors for all motors and exciters, except what could be seen with the brushgear covers removed. The condition of most of the windings could not be directly observed.

4. The machine is covered in dust and dirt.

3.2.7 60 Hz Exciter

No visible damage or defect was observed nor is there any problem apparent with the brushes or commutator. Again the exciter could not be directly observed for the most part. It also is dust and dirt encrusted.

3.2.8 60 Hz Motor

1. All leads are dirt encrusted. Insulation however does not show signs of distress, fraying or other problems.

2. There was indication of burning and flashover between the center and right phase, when looking directly at the brush rings. The right hand connection is incorrectly located on the inside position between phases.

3. Bolts should be shorter.

4. Machine is covered in dust and dirt.

5. The machine windings could not be properly inspected due to the lack of access.

3.2.9 50 Hz Exciter

1. No visible signs of damage or problems; however, the lack of access to the windings is the same as for the other machines.

2. The machine and leads are covered with dust and dirt and require a good cleaning.

3.2.10 50 Hz Motor

There are no obvious sign of problems, except for the dust and dirt covering motor and leads, similar to the condition of the 60 Hz motor.

3.2.11 60 Hz Converter

1. Insulation on the leads appears satisfactory as does the bracing.

2. Inter-turn coil connections are free of fretting and fraying and are without visible damage.

3. Stator wedges, as far as they could be observed, are tight

4. Laminations show signs of top varnish becoming worn and embrittled. Signs of varnish peeling exist.

5. The machine in general and the rotor poles are heavily covered with dust and dirt, baked on.

6. Collector bar insulation to pole connection leads is bared and becoming embrittled as well.

7. A white deposit on three pole bases exists at the base plate to winding corner, opposite the drive end. Samples were taken and chemically analyzed and found to be composed of cellulose and water.

8. Despite a lack of access because the rotor could not be removed during the limited inspection period available, the stator and poles showed no signs of distress, other than dirt encrustation. No visible indication, nor odor, of burning existed. The machine, except for the dirt encrustation, appeared sound.

The following test values were obtained when the 60 Hz machine stator insulation was meggared using a 5000-V meggar.

Phase	1 Minute	10 Minutes
Phase A	350 Mohms	425 Mohms
Phase B	350 Mohms	415 Mohms
Phase C	320 Mohms	370 Mohms

The above values compare well with the maintenance records and are within the acceptable range.

The rotor was also meggared from the slip rings and the value obtained was 300 Kohms. This value is not satisfactory and is suggestive of a failure within a few years.

Photo number 1 illustrates the dirt on the machine windings and rotor. This photo is typical of the state of the machine and surroundings.

3.2.12 50 Hz Converter

1. All of the observations made concerning the 60 Hz machine hold true for the 50 Hz machine.

2. The poles of this machine are even more heavily encrusted with dirt than the 60 Hz machine.

3. The pole connections exhibit cracked and embrittled insulation.

4. One anomaly stood out on the left hand side when viewed from the 60 Hz machine. At the 8:00 o'clock position, two laminations are connected by a substance, which runs over the winding wedges and which has the appearance and consistency of a metal. It could not be chipped with a fingernail. It appears to be a tear drop or melt but no incidence of high temperature or burning is exhibited on the machine.

The following test values were obtained when the 50 Hz stator insulation was meggared.

Phase	1 Minute	10 Minutes
Phase A	650 Mohms	1475 Mohms
Phase B	880 Mohms	1475 Mohms
Phase C	900 Mohms	1900 Mohms

The above values again compare well with the maintenance records and are within the acceptable range for such a machine.

The 50 Hz machine rotor was meggared at the slip rings and the value found was 200 Kohms. Again this value is indicative of a failure within a few years.

3.2.13 Neutral Cabinet Current Transformers

1. The neutral lead at the top of the panel on the 60 Hz cabinet has been cut approximately from the connecting clamp and the insulation removed. This should be rectified.

2. On the 50 Hz cabinet the neutral lead exhibits evidence of burning for a distance of 4 cm from the connecting clamp. It is apparent that at some time in the past, excessive current was passed through this wire for a prolonged period. This is possibly due to a wiring error that caused neutral current from more than one circuit to pass through the wire; alternatively a wrong ratio setting may have been used on one or more relays. In any case the reason for this anomaly should be researched and the problem rectified if necessary.

3.2.14 Bearing Pump Disconnect Switch Boxes, Bearings 1, 2, 3 and 4

Each box shows evidence of oil tracking across the mechanical protective sheath of the cable, entering at the top of the panel, running down wire and staining the panel bottom. The wire insulation is not of a type subject to petroleum deterioration. Deterioration is visible at No. 4 and to a lesser degree at No. 2 and No. 3. All the cabinets require cleaning. The oil in these panels should be removed and care should be taken to ensure oil is not reintroduced into the panel by tracking down the source of the oil contamination and correcting the problem.

3.2.15 Neutral Grounding Panels

1. Both cabinets require cleaning as they are covered inside and out with dust and dirt.

2. The transformers are oil filled and may contain PCBs. The units do not have nameplates, thus the insulant composition is not known. Present day practice is to use dry type transformers indoors. It is understood NLH plan to sample the oil in the transformers.

3.2.16 Switchgear

60 Hz and 50 Hz Regulator Panels

Oil is leaking from the top cover. The technician responsible for the converter unit advised that the panel operates suitably. The source of the oil leaks should be traced and repaired. Such leaks are minor and cost little to repair.

Auxiliary Panel

The load break switch exhibits no visible evidence of burning or arcing on either the fixed or moving portions. The insulation on top of the transformer requires replacement. Air ducts appear to be free of obstruction.

50/60 Hz Phase Reversing Switch

No pitting, burn marks or arc marks are apparent.

60 Hz Frequency Converter, Breaker No. 252

The auxiliary relay in the upper front of the cell requires a new cover; glass is missing from the cover fittings. The NLH maintenance crew did not have the applicable instruction book and neither this breaker nor the 50 Hz breaker (No. 252) was withdrawn for inspection.

50 Hz Frequency Converter, Breaker No. 152

No defects were visible.

Converter Ground Switch

The left-hand phase, when viewed from the front of the panel, shows signs of arcing. Insulator is broken and requires replacement. The moving portion of the switch shows damage due to arcing. Similarly, the center phase shows signs of burning at the incoming bus joint. The right hand phase shows slight damage, with a burn mark at the fixed contact.

Photo number 3 illustrates the arcing and burning found in this cubicle.

Auxiliary Transformer Primary Fused Load Break Switch

The upper chamber, containing the load break switch, shows heavy dirt and dust deposits on the insulators and fuse holders.

60 Hz Load Break Switch
The pivot point of the load break switch shows minor burn marks. Insulators of phases 1 and 3 have a stain, possibly oil, on the upper segments. A short bolt is installed on the main bus riser joint of phase 3.

50/60 Hz Starting Motor Breaker
The auxiliary relay cover requires replacement, as the existing cover glass is missing.

50 Hz Auxiliary Standby Supply
The 3 phase molded case circuit breaker requires replacement. Only two poles of the breaker will positively close when the handle is operated. The third pole will eventually close when the handle is fiddled sufficiently.

General Switchgear Comments
The panels all require cleaning to remove dirt and dust. None of the relays checked showed signs of pitting or burning. All the relays, meters and controls are of the old electro-mechanical type that is two generations older than the current standard. There are burn marks on and in some of the panels, and some relay covers are broken and not replaced. The relay's condition can deteriorate and eventually fail under such circumstances.

3.2.17 Battery and Battery Charger

1. The battery charger panel requires cleaning.

2. The terminals at cells 57 and 58 are staring to corrode.

3. The stand appears to be sound.

4. The batteries are about 17 years old. Normally batteries are replaced at between 20 to 25 years of age. Scheduling for battery replacement should be considered at this time.

3.2.18 High Voltage Bus from Transformers to Mill Switchyard

1. Phases 1 and 3 60 Hz exit bushings are damaged and require replacement.

2. Similarly, the 50 Hz exit center and right phase bushings are damaged and require replacement. According to the NLH personnel on site, the damage was caused by concrete falling from the converter building side and roof.

3. Support structures at the wall exit have minor corrosion, but the structure at the roof lines appear to be heavily corroded.

4. The standoff insulators appear in suitable condition, without chipping or damage.

5. Phase 3 of the 50 and 60 Hz wall bushing entries into the mill building are damaged and require replacement.

6. Phase 2 of the same group of wall entry bushings has been repaired and probably should be replaced.

Photo number 3 illustrates the damaged bushings outside the converter building.

3.3 Mechanical Observations

3.3.1 Bearings

1. The machine has five journal type bearings which are numbered on the exterior of the housings. All bearings are split babbitt type with oil lubrication. Bearings 1 to 4 are the main bearings and are connected to a recirculating oil filtering and cooling system. Bearing 5 is a pedestal bearing located between the exciter and the induction motor uses a self contained oil bath for lubrication.

2. The housings for bearing 2, 4 and 5 were removed and the top half of the bearings lifted to expose the shaft and top half bearing surface.

3. The bearings and shaft for both main bearings were found to be in excellent condition. There were no significant score marks on the bearing surface or the shaft, the oil color was good and there was no evidence of sludge or dirt of any kind around the bearing, shaft or housing.

4. Bearing 5 was found to be in poor condition. The top half of the bearing was scored, the oil was black and sludge had built up around the housing. The

shaft was jacked and the bottom half of the bearing removed. The bottom half was found to be in worse condition than the top. The bearing was partially wiped with sludge deposits caked to the surface.

5. Measurements of the shaft journal surface were taken with a micrometer by CBPP personnel and recorded as 4.995 (+ 0.004 on induction motor side).

6. The metal labyrinth seal was worn and leaking. Measurements were taken of the seal diameter and recorded as 6.250 + 0.008 at 0° and + 0.032 at 90°.

7. There was a very small amount of scoring on the shaft journal surface.

8. The bearings are monitored for alarm conditions only.

Photo number 4 shows the scoring that has occurred on the failed bearing number 5.

3.3.2 Flexible Shaft Couplings

1. The main shaft couplings are Dodge Para Flex PX200.

2. There are side wall cracks both circumferential and radial on both sides of the two couplings.

3.3.3 Oil Lubrication System

1. The existing oil lubrication system is located in a concrete sump adjacent to the converter. The oil is contained in a single rectangular steel reservoir which supports the pumps, heat exchanger and piping. A small turbine pump is located in the concrete sump which is connected to the drainage system.

2. Only a visual inspection of the components was performed. There is evidence of corrosion on the cold water supply to the heat exchanger. The top of the oil reservoir is damp with oil. The floor of the sump was damp with water. The pressure switch on the cold water line did not appear to be working

3. There are two pumps, one driven with an AC motor and the other driven with a DC motor. A temporary AC driven pump is currently installed awaiting replacement.

3.3.4 Fire Protection System

1. The existing fire protection system is connected to a 6 inch fire main inside CBPP. There is not a separate fire department connection at the converter building.

2. The system in the converter building is connected to two manual shut off valves. The valve handles are located in the unheated stair well and the pipes and valve bodies which are located on the opposite side of the wall are heat traced but are not insulated.

3. There is a single fire hose reel and the hose is in poor condition.

4. The converter is connected to the fire water lines but the transformer rooms are not sprinklered.

5. There is a separate nitrogen extinguisher system on a wheeled cart.

3.3.5 Compressed Air System

1. The existing compressed air system is located in an open room adjacent to the fire protection valves. The system consists of two compressors, one after cooler, one air receiver, a control panel and associated piping.

2. The existing piping system does not meet current standards for pressure piping systems.

3. All the major equipment is original except one of the compressors. The maintenance personnel were pleased with the equipments operation and stated it worked better than some of the newer systems that have been purchased recently.

4. The air receiver does not have an automatic water release valve or inspection opening.

3.3.6 Ventilation System

1. The cooling and general ventilation air is delivered to the converter building from the adjacent CBPP building via ductwork. The air is exhausted from the

building using a forced air fan mounted inside a duct located above the main entrance. Large screened openings are located in the walls behind each transformer.

2. As the building is under negative pressure, there is a buildup of dust and dirt inside the converter building and a large build up of dirt and wood fiber collecting around cracks in the exterior walls, especially in the adjoining Wood Room.

3. The intake air screens in the transformer areas are clogged with debris.

3.3.7 Roof and Floor Drains

1. Roof drain down pipes are located in the two transformer areas. The piping near transformer T1 is the original malleable iron.

2. In the converter area there are two floor drains.

3. The drainage system is blocked causing water to back up and flood the floor under the transformers and converter. When flooding occurs, water travels across the floor and enters the concrete sump where the lubrication oil reservoir is located.

4. Freezing of the roof drains has caused the failure of the down pipes near transformer T1.

5. The piping for transformer T2 was replaced with plastic. The drain lines from both the roof drains and the voltage regulators are connected to drainage piping located under the concrete floor.

3.4 Structural Observations

1. The building housing the converter is part of the paper mill buildings and was renovated in 1966 for that purpose. Two of the walls adjoin the paper mill, one of which is the Woodroom, and the other two are exterior walls. There is an interior metal staircase connecting the converter level with the upper floor where the switchgear is located.

2. The masonry walls are cracked in numerous locations which allow debris to enter the building. These cracks appear old and probably occurred when the building originally settled. The steel structure is in good condition except the column in the stairwell. This column is corroding because of the damp atmosphere and failure of the steel surface treatment. There is also spalling of the concrete in this area due to corrosion of the rebar.

3. In addition to the structural steel and concrete problems, in the stairwell, the metal stair is in poor condition. Some of the welds connecting the stair pans were repaired and many more are corroded and failing.

4. The exterior walls are weathered and have small areas of missing concrete and holes.

5. The exterior door to the stairwell is not working properly.

6. The flat roof does not appear to be leaking but is covered with patches of moss.

7. The steel beams supporting the second floor are coated in an asbestos based fire retardant.

8. The overhead crane rail connection to the roof truss has only two bolts in the connection. The crane trolley is attached to a 4 ton chain hoist but there is no safe working load marked on the crane.

Photo number 5 is indicative of the type of structural deterioration inside the building.

3.5 Environmental Observations

From an environmental viewpoint, the most important defects in the facility are the suspected PCB contaminated auxiliary transformers, the lack of oil spill containment for the main transformers, the batteries and asbestos fire retardants.

3.5.1 Auxiliary Transformers

Two small neutral grounded auxiliary transformers are believed to contain oil with PCB's. It is understood that NLH is checking these units and may replace them. Under current standards, the use of oil filled transformers inside a building would be considered unacceptable. These transformers should be replaced with dry or silicon type transformers if the facility is to be retained for any significant period.

3.5.2 Main Transformers

The main transformers illustrate a number of environmental problems.

1. The fire doors appear not to operate properly; they seem not to seal completely.

2. The spill containment and drainage system needs improvement to meet current standards.

3. The existing floor drains are blocked preventing water drainage.

4. There is no fire extinguishing system in the transformer area; nor is there an oil-water separator to separate the oil from the water in the case of a spill.

5. Should a major fault occur within a transformer, the likely resulting fire would be difficult to control.

These defects in the plant design should be remedied soon to ensure environmental compliance and also to remedy a serious fire hazard. The system as it stands is an insurance liability as there are large oil filled transformers contained inside a building with no fire protection system and no way to remove oil should a problem occur.

The cooling air circulation problem should be remedied at the same time. It would be best to provide a new cooling air system for the transformers and the converter. In this manner, the cooling would be more efficient and the transformer vaults could be sealed so that if a fault occurred, oil and/or fire would not leak into the adjoining converter hall.

3.5.3 Batteries

The batteries are not separated from the remainder of the equipment on the switchgear floor creating two hazards. Firstly the problem of hydrogen generation by the batteries is not handled separately; and, secondly if a battery were to explode, a remote but real possibility, there is nothing to prevent the acid from damaging nearby equipment or possibly injuring personnel. Normally batteries are installed in their own separate enclosures so as to isolate the hydrogen and explosive hazards from the remainder of the building.

3.5.4 Building Asbestos Insulation

The building contains asbestos fire retardant on the underside of the switchgear floor. At the present, personnel entering the building are required to wear respirators while working in the converter area. Samples of the dirt contaminants on the converter were laboratory tested and no trace of asbestos was found in the samples, however. (The building asbestos insulation is entirely separate and not related to the asbestos insulation found on the rotor wire insulation. The latter asbestos was an integrated insulation compound that was occasionally used on high grade insulation compounds before 1970.)

Assessment of the Facility

4 Assessment of the Facility

4.1 Overview of the Problems Observed

The problems observed with the frequency converter facility may be summarized as follows.

The Converter
The main problems with the converter are dirt and dust contaminated windings, low insulation resistance of the rotor windings, and a failing pedestal bearing, bearing number 5, near the exciter.

The Transformers
Problems with the transformer relate to the fact that the transformers are oil filled and are situated within a building without a proper fire control (sprinkler) system and suitable oil spill containment system.

The Voltage Regulator
The voltage regulator has a water leak and should be repaired or the regulator replaced.

The Ventilation System
The problem with the ventilation system is that the air filters are inadequate to prevent dust and debris from entering the converter facility and thus contaminating the entire facility. Converter cooling air has already been drawn past the transformers and thus been partially heated; hence, the full cooling effect of the air is not available.

Lighting
The emergency lighting system needs improvement so that adequate lighting is available in all areas during a power failure. The main lighting system also is not adequate in all areas, in particular around the converter itself.

The Structure
The building is old and, while not failing structurally, suffers from loose concrete and debris falling from the roof edge and the walls, especially in the unheated stairwell. There are also a number of cracks in the walls that require repair, if only to reduce the amount of dust and debris entering the building. Plywood is also temporarily attached to the stairwell ceiling; permanent repairs should be carried out.

The Battery

The batteries are not properly shielded from the surrounding equipment. A battery explosion could seriously damage surrounding equipment. In addition, no separate facility for evacuating hydrogen evolved from the batteries is in place.

Oil Lubrication System

There appears to be corrosion in the system, on the cold water supply to the heat exchanger. The ac driven pump is awaiting replacement and is temporarily replaced. The pressure switch on the line should be replaced.

Fire Protection System

The water system is not to current standards and does not extend to the transformer area. The fire reel hoses are in poor condition.

Compressed Air System

The compressed air piping system does not meet current standards. No automatic water release valve or inspection opening is provided.

Roof and Floor Drains

The drainage system is blocked thus allowing water to flood the floor. Water also enters the sump where the lubrication oil reservoir is located. Freezing of the roof drains has caused a failure of one of the down pipes.

Other Problems

Numerous other problems exist in the converter facility. They include the necessity to repair relay covers and to make minor repairs to equipment, and the need to clean the facility throughout so as to remove the dust and dirt that covers the entire facility and is a contaminant to the converter equipment in particular. Normally, if the equipment were to be installed today, a modern programmable relay, metering and control system would be installed; but, as the existing system has worked satisfactorily for many years, it does not seem necessary to replace the existing system if the remainder of the equipment is not also planned for replacement.

Year 2000 Problem

Since the facility was constructed before the advent of microprocessors, all the equipment would be of the electro-mechanical type and thus would not be expected to have any so-called Y2K problems. However, this study does not cover the SCADA control system terminal which could have such problems.

4.2 Assessment Detail and Estimate

4.2.1 Converter

Except for the bearing problem, it appears that all other problems with the converter are the result of poor ventilation. It is recommended that the ventilation system be upgraded and then the machine be repaired, in that order. It is believed the minimum repairs to the machine are to clean all parts including the 50 and 60 Hz main portions of the machine, the 50 and 60 Hz exciters and the pilot exciter. Given the low winding resistance of the 50 and 60 Hz rotors, they should be rewound.

In addition to cleaning the main portions of the machine, it is recommended that the exciters, the induction motors and the pilot exciter also be cleaned as the exciters and the motors could not be meggared during the inspection. Other problems may be found when the exciters and motors are tested after cleaning. From their general appearance, however, it is likely this would not be the case.

The main bearings are in excellent condition; further inspection of bearings 1 and 3 is not necessary. Bearing 5 needs to be replaced soon. NLH noted that a similar bearing is in inventory at NLH's Bishop's Falls maintenance facility; however, there is some doubt as to whether the bearing will fit properly. This should be carefully checked before proceeding with the replacement. If the bearing is suitable, it is recommended that it be cleaned and polished and bearing housing flushed clean and new filtered oil installed prior to machine startup. Actual bearing temperatures should be monitored and recorded.

The work involved in installing and running a new bearing in is not trivial. Firstly, the bearing may have to be made to fit, if it is slightly out of tolerance. Secondly, the bearing must then be run in for a significant period, while the temperature is monitored closely to ensure a bearing wipe is not underway. This can take a period of days.

An oil sample was taken of the faulty bearing during the inspection; however, since the bearing will be replaced, it will not be necessary to test the oil.

It is expected that the costs for these modifications and improvements would be as follows.

Rewind both rotors	$1,365,000
Clean the facility*	$ 75,000
Install 2 dry type transformers	$ 45,000
Replace faulty bearing	$5,000**
Oil testing and bearing temperature monitoring	$ 10,000
TOTAL	**$1,500,000**

* The cleaning is to cover the entire facility and not just the converter and associated machines

** The low cost for this work is based on the assumption that a replacement bearing exists in NLH's inventory. There will be lost revenue for down time while the bearing is being replaced and run in; but, the only direct cost at this time will be for the labor of replacement, which is minimal.

These costs and all other costs estimates include an allowance for engineering, and contingency. Further details of the estimates are provided in an appendix to this report.

4.2.2 Transformers

No known problems exist with the transformers themselves. Instead the problems are associated with the lack of fire protection and spill containment for the transformer. An estimate of the cost to provide spill containment and a fire protection/sprinkler system is provided below.

Despite the fact that no known problems exist with the transformers, power transformers normally have a 40 year life which is within the 10 year horizon that this report covers. Given the fact that the transformer maintenance records show no serious incidents and that they are presently more than 30 years of age, it is expected the transformers will last for the ten year period.

Cost of fire protection system (using existing water supply)	$120,000
Cost of spill containment with oil/water separator	$225,000
TOTAL	**$345,000**

4.2.3 Voltage Regulator

The voltage regulator problem is a water leak in the cooling circuit. The leak should not be difficult to fix; however, it would require study to find the cause which occurs on startup and shut down only. The cost of engineering analysis to resolve the problem could be significant; thus no estimate to repair the unit is provided. However, the cost of not fixing the leak could be prohibitive; if the maintenance crews forget to drain the water after shut down or start up, a flashover will occur if the water level rises high enough to contact the main leads.

As an alternative to providing a cost for repair, a cost for replacement of what is an antiquated voltage control system is provided instead. This system would use two static AVRs, suitably switched as required depending on which machine was driving or driven. This system would replace the present voltage regulator and drivers.

Cost for supply and installation of two new AVRs	$150,000
Cost of removal of existing equipment	$ 50,000
TOTAL	**$200,000**

4.2.4 Ventilation System

A separate ventilation system should be installed so that only clean, dry air is brought into the facility supplying sufficient air to the converter and the transformers. If the transformers were kept in sealed compartments, a lower standard of cleanliness could be allowed for the transformers than for the converter. In any case, some structural modifications would be required to supply air for the transformers and the converter. Estimated costs to provide for this are provided below.

Cost of new air handling system	$ 50,000
Cost of structural modifications	$ 50,000
TOTAL	**$100,000**

4.2.5 Lighting

The lighting system in the converter facility, including both the main and emergency systems, is not adequate. Augmentation of both systems is required in certain areas, particularly the stairwells and the converter area. The cost of bringing the system up to proper standards is estimated to be $20,000. It is assumed that no new ac main supply panel board augmentation is required to carry out the improvement in lighting.

4.2.6 Structural Requirements

The structure appears to be basically sound. However, the structure has numerous superficial deficiencies, including cracks in the walls and loose mortar and bricks that fall from the roof and walls. These deficiencies can be repaired without excessive costs. Because of the loose mortar and bricks that have fallen from the walls and the roof, significant damage has been caused to the insulators and wall bushings of the converter building. The wall bushings and standoff insulators should all be replaced.

In the stairwell the steel column should be sand blasted and painted, the concrete wall repaired and the metal stair replaced. Immediate repairs are required to the stair pans to ensure safety. The door to the stairwell should be replaced and the stairwell should be ventilated and heated to avoid deterioration due to moisture buildup. The crane and the support structure should be inspected and the safe working load established.

In addition to the above, the mill building has also had some problems and some of the wall bushings and associated insulators have been similarly damaged. Estimated costs for the repair of this work are also included below. It should be noted, however, that both buildings belong to CBPP and any damage to NLH equipment due to building deficiencies or failures should presumably be the responsibility of the paper mill.

Repair of converter building structural steel and concrete	$ 15,000
Stair replacement	$ 10,000
Door replacement	$ 1,000
Heating and ventilation in stairwell	$ 4,000
Stairwell roof repairs	$ 8,000

Crane inspection	$ 5,000
Replace NLH insulators (converter building)	$100,000
Repair of mill building	$ 30,000
Replace NLH insulators (mill building)	$ 60,000
TOTAL	**$233,000**

4.2.7 The Battery

The battery is about 17 years of age and should be replaced within the next 10 years. An estimated cost for a new battery is included. In addition, a vented enclosure should be placed around the batteries to protect personnel and associated equipment from the effects of a faulted battery cell.

New battery	$25,000
Battery enclosure	$10,000
TOTAL	**$35,000**

4.2.8 Oil Lubrication System

The oil reservoir should be removed and inspected for pitting and corrosion. Replacement may be required as the sump has been filled with water on several occasions and the area is generally damp. The sump should be made water tight and an oil water separator installed on the discharge from the sump pump. All leaking fittings and valves should be repaired or replaced and the pressure transducer on the cold water line should be replaced. Corroded piping should be cleaned and painted or replaced.

The estimated cost to carry out this work is as outlined below:

Rehabilitate or replace existing tank	$15,000
Repair or replace mechanical equipment	$ 3,000
Line concrete sump, and repair piping	$ 4,000
TOTAL	**$22,000**

4.2.9 Compressed Air System

The piping should be upgraded in particular the copper piping should be removed. The air receiver should have an inspection opening installed and be inspected for internal and external corrosion. If the tank is found to be in good condition a pressure gauge and automatic water release valve should be installed.

The estimated cost for carrying out this work is estimated below.

Upgrade piping	$ 5,000
Modify air receiver	$ 5,000
TOTAL	**$10,000**

4.2.10 Roof and Floor Drains

New floor drains are required to remove the water from the building. Water from floor drains and cooling water systems should be separated from roof drains and sent through an oil water separator before discharge to the sewer. Freezing of roof drains should be monitored and the down pipes heat traced and insulated if the problem persists.

The estimated cost of making these modifications is $30,000.

4.2.11 Other Problems

Numerous other small problems exist within the facility and the switchgear. These, however, should not require individually a significant amount to repair. It is not expected for instance to replace the protection or control systems at this time, although repair to many of the cubicles is required along with replacement of some relay case doors.

Allowance for repairs to remainder of electrical gear $105,000

4.2.12 Total Estimate

The total estimated cost to repair the facility is $2.6 million. Some of these costs, such as the expected replacement to the battery, may be deferred for a period. Others, particularly the cost of the building repairs and associated replacement of insulators, should be borne by the paper mill. An argument could also be made for the paper mill to carry some of the cost of cleanup.

The estimated cost of replacement of the frequency converter with similar technology is $10 million; however, this estimate is somewhat misleading because it is highly unlikely a rotating frequency converter would ever be built today. Frequency converter requirements are presently fulfilled by using thyristor based technology, similar to the high voltage ac to dc converters used for long distance transmission facilities, such as the Nelson river lines in Manitoba. At the time of writing, an estimate for such a facility was still being awaited from ABB.

4.2.13 Accuracy of Estimate

The Terms of Reference for this work stipulated a target accuracy in the estimates of ±10 percent. Since the single major item in the estimates is the rewind of the rotors, the accuracy in the budget quote for this work would have a significant effect on the overall accuracy of the total estimate. It is believed that the accuracy of the estimate for the rewind is ±15 percent although experience suggests that the eventual bid price is usually lower than the budget quote. A more likely level of the accuracy for this part of the estimate is therefore plus 10 percent minus 15 percent.

The accuracy of the estimate for the remaining items of work ranges from 10 to 20 percent; therefore, a reasonable overall accuracy in the total estimate is considered to be ±15 percent.

4.3 Repair Sequence

In order to effectively rehabilitate the converter facility, the following sequence should be followed.

1. Remove the building asbestos.

2. Improve building lighting.

3. Repair the building, improve the drains and replace the insulators as required.

4. Clean the converter facility thoroughly.

5. Make necessary converter improvements, including rewinding the rotors, monitoring of the coupling and replacement of the bearings as necessary.

6. Make necessary improvements to the facility including the ventilation system, the compressed air system, the oil lubrication system, the fire control system and the oil spill containment system.

7. Make other repairs and improvements as necessary including those to the voltage regulator, the switchgear, and auxiliary transformer replacement, etc.

The program outlined below is a minimum program that must be carried out to ensure the complete rehabilitation of the converter facility. Any restricted program will not ensure the complete rehabilitation of the facility and will probably lead to early higher costs again. Undoubtedly some items such as lighting rehabilitation may be considered not completely essential to continued operation of the converter; but such an understanding would be erroneous because the poor lighting in the facility can lead to errors that can mean incorrect operation and severe damage.

It is believed that this work could be completed in about 45 days, assuming suitable shift work as necessary to get the most intensive portions of the work done as expeditiously as possible.

The estimate provided here does not allow for unforeseen circumstances, such as the machines being in worse condition than they appeared to be. As noted previously, the machines were inspected only as far as possible without the rotors being removed. Other problems may exist which could not be detected during the inspection, but which could for instance require a stator restacking or rewind at an increase in estimated cost of approximately $1,000,000. Given the meggar test results, however, such an additional cost would be unlikely.

4.4 Estimated Repair Times

If some component of the converter were to fail, the facility would have to be shut down for varying periods of time while the component was repaired or some way of operating the facility without the failed component was found. Table 4.1 contains a listing of the possible failures, some of the consequences of the failure and an estimate of the time to repair the faulty component.

As may be understood from examining this table, the range of possible consequences for each type of failure and the possible range of failures are so wide as to be make it difficult to state exactly the extent of any failure and thus the range of consequences. From our examination of the facility, the most likely serious electrical problem would be a rotor winding failure. The consequences of such a failure are difficult to predict because a simple failure may not be of serious concern. The faulted turn could possibly be bypassed and the machine operated almost normally until the machine could be rewound. Acres does strongly recommend that the machine rotors be rewound as soon as possible as the meggar tests show very low rotor insulation resistance and incipient failure. From a mechanical viewpoint it is recommended that the pedestal bearing be replaced before total bearing failure occurs and the machine cannot be operated.

4.5 Remaining Life Evaluation

4.5.1 Description of the Application of Iowa Curves

An estimate of the remaining life that might be expected for similar equipment to that at Corner Brook was prepared using comparative data published by the US Bureau of Reclamation and industry accepted generic survivor curves as published by the University of Iowa.

Studies by the University of Iowa have defined a number of basic mortality curves for various types of capital plant. The curves have three basic shapes defined as L, S and R types. The significance of these curve shapes is that in comparing them to a standard Bell curve, S curves are Bell curves, i.e. symmetrical, which means that items of a particular type of plant expire at the same rate on each side of the peak (average) expiry age. L curves are skewed to the left and R curves are skewed to the right, which means in practical terms that L rated items of equipment mostly expire early, with some long lived items making up the balance. For R rated items, very few items of plant expire early,

Table 4.1

Estimated Repair Times

Component	Replacement Component	Procurement Time	Component Cost (000s)	Installation Time*	Failure Consequence	Time to Repair
Rotor winding	Rotor windings	4-5 mths	$500	2 wks	Machine inoperative and damaged	1 wk - 3 mths
Rotor structure	Rotor	4-6 mths	$600	2 wks	Machine inoperative and damaged	1 wk - 2 mths
Stator winding	Stator windings Stator	3-4 mths 3-4 mths	$400 $1000	2 mths 3 mths	Machine inoperative and damaged	1 wk - 3 mths
Stator lamination failure	Stator restack	2-3 mths	$500	3 mths	High losses and arcing	2 wks - 3 mths
Exciter failure	Exciter	3 mths	$100	1 wk	Machine inoperative	1 mth
Starter motor	Motor	1 mth	$50	3 days	Cannot start converter	2 wks
Voltage regulator	Regulator	1 mth	$75	3 days	Cannot regulate voltage	1 mth
Relay failure	1 Relay All relays	2 mths 4 mths	$15 $200	2 days 2 wks	Inconsequential to total immobilization	Up to 1 mth
Switchgear failure	1 breaker All cells	2 mths 6-8 mths	$30 $800	3 days 1 mth	Inconsequential to total failure	Up to 4 mth
Main transformer	Transformer	10 mths	$500 each	2 wks	Facility inoperative	1 wk to 10 mths
Auxiliary transformer	Transformer	3 mths	$25	3 days	Probably inconsequential	3 mths to replace
Converter bearing	Bearing	1-2 mths	$30	1 wk	Inconsequential to inoperative	Up to 2 mths

Notes:

* It is believed the installation times are minimum and assume that forces are made ready in advance for the required work.

1. The timings given in column Procurement Time and Time to Repair are generally different. The Time to Repair column assumes that some time is available to arrange a repair contract before the component fails completely. The Procurement Time column assumes the worst possible delays and no pre warning of possible failure.

but there is a mass die off shortly after the average date is attained. To complicate matters, there is a number of each curve type noted above, for instance R0, R1, R2, etc. The significance of this number is that it defines the slope of the curve, the higher the number the steeper the curve slope. In practical, terms this would mean the death rate would be spread out over a longer time for a lower rated curve than for a higher rated curve.

Typical Iowa curve designations are composed of 3 parts, the first being the average lifetime, e.g. 40 standing for 40 years and the second being the basic curve shape, e.g. R for right skewed. The last part is representative of the degree of spreading the curve base has, i.e. a 1 curve is much wider than a 3 curve. A typical curve could be designated 40 R2, which means an item which has an average life of 40 years and a right skewed mortality rate, i.e. the item tends to expire slowly at first but at a sharper rate after the average lifetime is reached.

The other part of the analysis consists of matching a utility's observed mortality rate for an item of equipment to one of the curve shapes and to define an average life. Except for the very largest organizations, such an exercise is meaningless because in order for the observations to have statistical meaning the population must be large, in the order of 1000 as a minimum. For this analysis, we will apply curve shapes and life data found to be reasonable by the US Bureau of Reclamation and the Western Area Power Administration. It is understood that similar information is available from other utility organizations.

4.5.2 Application to NLH Corner Brook Facility

The following table lists the equipment items for which analyses have been done and the curves used to evaluate the remaining life expectancies and the forecast future life of each item under normal plant operating and maintenance conditions.

Item	Curve Number	Present Age	Life at Mortality	Predicted Additional Life
Stator	50L0	30	65	35
Rotors	50S1	30	56	26
Exciters	45S2	30	49	19
Transformers	40R3	30	48	18
Switchgear	35R4	30	38	8

Item	Curve Number	Present Age	Life at Mortality	Predicted Additional Life
Building	50S1	30	56	26
Building Roof	20L1	30	36.5	6.5
CM&R Panel	35S0	30	46	16
Station Service Transformer	35R3	30	39.5	9.5
Surge Arrestors	25R4	30	32	2
Battery Charger	20S3	30	31.2	1.2
Battery	25S2	10	25	15

It must be emphasized the above analyses are strictly on a statistical basis. In effect, the equipment is treated statistically as if it were a part of the USBR plant. Experience with individual items of equipment may be longer or shorter than the above expectations given the operating environment and maintenance history. Given the levels of maintenance and the poor performance of the filters and air leaks in the building shell, the life expectancies of the equipment in the Corner Brook facility are lower than the above predictions. In addition, some anomalies exist in the curves used in the above table. Some items of equipment have artificially low life expectancies. Among such items are the surge arrestors and battery chargers. The life expectancies of the surge arrestors are lower than expected because USBR companies tend to change out arrestors with better arrestors having been placed on the market. Battery chargers in the USBR tend to get changed out early along with batteries; thus their true life expectancies are not reflected herein. Conversely the CM&R panel life expectancies do not reflect change outs of relays for the more modern relays now on the market. The life expectancy only reflects the probable life of the panels and not the equipment in them.

4.5.3 Conclusions of Remaining Life Predictions

The above predictions are, as noted, of a statistical nature only. The facility components should, if they had been operated and maintained in a manner commensurate with standard practices, reach the ages predicted. However, the facility has been operated without adequate filtering, which has allowed accumulation of dust and dirt over the entire frequency converter facility. This means the life expectancy of the machines should be less than the above predictions. Implementation of the remedial program outlined in this report should, however, lead to a significant improvement in this life expectancy.

Operations and Maintenance

5 Operations and Maintenance

In order to compare the operating and maintenance practices associated with the converter facility at Corner Brook, Acres staff contacted two companies that own and operate rotating frequency converters. These are Ontario Hydro, which operates a major facility near its Sir Adam Beck II hydro plant to convert between 25 Hz and 60 Hz and Elkem, which operates a small converter, rated at 6-MVA, 2 phase 62.5 Hz to 3 phase 25 Hz in Ohio. The practices followed by each company are described below.

5.1 Ontario Hydro

The Ontario Hydro converter, rated at 54-MVA, situated near the Beck II station in Niagara Falls, has been operating for a number of decades. Prior to being located at the Beck II site, it had been located elsewhere on the Ontario Hydro system. When questioned about their operating experience, Ontario Hydro advised they maintained the facility as they would if it were a thermal generator. The machine operates continuously as the demand for power on the 25 and 60-Hz systems exists all the time. There is generation throughout the province for 60 Hz power. For 25 Hz power generation exists both in the south at Beck and at some nearby small plants as well as in the north at Abitibi Canyon. The converter operates almost all the time except for periodic maintenance shut downs according to their regular maintenance schedule.

5.2 Elkem

Elkem operates its converter almost 100 percent of the time to convert whatever power it can generate at 62.5 Hz to 25 Hz power, which it uses in its silicon smelters. According to Elkem it does virtually no maintenance on any of the generators it owns and operates. It is difficult to describe the Elkem system. Basically it operates about 235-MVA of hydro and thermal generation, mostly at 25 Hz except for a maximum of 6-MVA at 62.5 Hz, in and around Gauley Junction in West Virginia. It is also tied to Allegheny Power and operates a static frequency converter from 60 Hz to 25 Hz at the same time. It uses mostly 25 Hz power in its silicon production process but also has furnaces that operate at 60 Hz.

It is Elkem's practice to operate its power system until components either fail or show immanent signs of doing so. Elkem has stated that it almost never does maintenance on the rotating converter and appears not worried if the converter should fail. The generating plants supplying power to the converter are themselves more than 80 years old and in questionable health, given their lack of maintenance. The power that Elkem uses because of the furnaces has a high harmonic content (up to 30%); and again, because the furnace power demand varies considerably over time the level of generation required at any one time fluctuates dramatically. The fact that the rotating converter (as well as other equipment) has operated satisfactorily on this type of system for decades is a tribute to the original equipment builders.

5.3 NLH Recommended Operation

Given the two examples of rotating frequency converter operation, it is not recommended that NLH emulate the practices of Elkem. Even Elkem personnel are becoming concerned over their method of maintaining their increasingly aged plant, and, they plan to institute a maintenance program in the near future, to the extent that they can remove machines from service given the almost incessant demand for steadily more power in their system.

Ontario Hydro operates and maintains its converter in a more intelligent fashion given the long term requirements for 25 and 60 Hz power in the system. It is noted, however, that Ontario Hydro has the luxury of having sufficient generation available at both the 25 and 60 Hz level to meet power requirement at either frequency.

It is understood that NLH also uses its thermal generator maintenance program as a model for the maintenance program followed for the frequency converter. It is recommended that this practice continue. The maintenance sequences required for the converter facility have been reviewed and are considered adequate. The addition of monitoring equipment such as partial discharge monitors could help in the overall operation of the facility, but, it is more important to repair the facility so that the conditions under which the converter machinery operates are conducive to prolonged life.

It is noted, however, that not all the repairs that would have been expected to be completed, such as replacement of relay covers, seem to be carried out in a timely manner. It is suggested that the performance of the maintenance forces be audited occasionally to ensure that such "run of the mill" repairs are carried out more expeditiously.

5.4 Non Destructive Testing and Monitoring

The frequency converter facility has not been fitted with any of the more modern test or monitoring facilities. Chief among such test and monitoring facilities now available in the market are:

- Transformer incipient fault monitoring.
- Machine air gap monitoring.
- Machine partial discharge measurement facilities.
- Vibration monitoring facilities.

Of the above facilities, the second the air gap monitor is unlikely to be used as it is more commonly used on water wheel generators, particularly where there is concern about the stator going out of round due to concrete alkaline aggregate reaction. No cost estimates have been obtained for such equipment, but it is understood that each can be purchased from more than one supplier at present, generally speaking, for prices in the order of $10,000 to $30,000 per unit.

In addition to the above, it is suggested that a modern generator protection package be purchased for both portions of the converter. Such packages are available from numerous suppliers including ABB and Alsthom. The cost for such packages can vary widely but is in the order of $50,000 each.

5.5 Spare Parts Inventory

As far as could be determined, there is no spare parts inventory for the frequency converter. Apart from the spare bearing that apparently exists in stores at Bishop's Falls, virtually nothing exists that could be put to use in an emergency. The use of this bearing is also questionable because of some uncertainty over its dimensions. As a minimum, the following spare parts should exist for both frequency converters. Not all of these spares need be dedicated to the converters; some could be system spares to be used anywhere in the system. Such system wide spares could include relays and breakers for the metalclad switchgear.

- Spare rotor coil
- Spare stator winding and end pieces
- Spare metalclad breaker, truck mounted
- Spare CT suitable for installation into metalclad gear
- Spare relays of each type used in facility

- Tape, clamps, cable, bus materials, repair materials
- Spare bearings of each type used

If the voltage regulator is replaced, spare cards for the new voltage regulators should be obtained as recommended by the eventual supplier. Similarly, spare parts should be obtained from any supplier of replacement equipment.

As the existing equipment has all been supplied by Westinghouse, it is believed that Westinghouse Service would be the best supplier of spare parts. As is well known, Westinghouse Service is now part of Siemens Corporation, and it is understood that Siemens has all the records to which Westinghouse Service originally had access.

The switchgear was supplied by Brown Boveri Company, now part of ABB. It is our understanding that ABB can supply any spare parts required for gear it may have supplied in past years. However, ABB has closed its only switchgear manufacturing facility in Canada and some of the equipment and parts formerly relatively readily obtainable from the facility are now difficult to obtain.

5.6 Unit Rating and Capability

It is understood the converter unit is not presently run at its nameplate capacity. In discussing the problem with maintenance personnel, it was found that the stator air cooling ducts are partially blocked thus reducing the cooling effect of the available air. It is believed that a thorough cleaning including flushing of the debris from the ducts will allow the machine to operate at its design rating. The expected cost for this work is included in the cost estimate provided for the cleaning of the facility. However, without a significant effort to repair the building and the ventilation/filtration system, nothing that is done in the way of cleaning will have a lasting effect.

The converter unit is presently operating at approximately 20 MVA maximum output, about 2/3 of its rating. It is understood that this output is the maximum available if the machine is to stay within its operating temperature range. It is believed the machine should be able to operate up to its rating of 28 MVA if it were cleaned. No further action should be required other than to ensure a sufficient flow of clean cooling air at adequate temperatures by rehabilitating the filters and ventilation system.

Conclusions

6 Conclusions

This report has detailed the deficiencies found in the converter facility at Corner Brook. A program has been recommended, with associated estimated costs, to carry out the rehabilitation of the facility. It is believed the option of replacing the entire facility with a static converter or another rotating converter is not attractive as long as the existing facility has significant life remaining. The recommended steps to rehabilitate the facility are:

1. Remove the building insulation asbestos. (It is understood that NLH is proceeding to do this)

2. Improve building lighting.

3. Repair the building, improve the drains and replace the insulators as required.

4. Clean the converter facility thoroughly, particularly the converter itself.

5. Make necessary converter improvements, including rewinding the rotors, monitoring of the coupling and replacement of the bearings as necessary.

6. Make necessary improvements to the facility including the ventilation system, the compressed air system, the oil lubrication system, the fire control system and the oil spill containment system.

7. Make other repairs and improvements as necessary including those to the voltage regulator, the switchgear, and auxiliary transformer.

These steps are repeated in Table 6.1 along with associated costs and estimated time to repair.

Table 6.1
Recommended Repairs, Costs and Repair Times

Step Number	Action	Associated Costs	Required Time
1	Remove building asbestos	$75,000 (not in estimate)	2 weeks
2	Improve building lighting	$20,000	2 weeks (concurrent)
3	Repair building, drains, insulators	$263,000	3 weeks (concurrent)
4	Clean facility	$75,000	3 weeks (concurrent)
5	Make converter repairs	$1,445,000	2-3 months
6	Improve ventilation, compressed air and fire control systems, etc.	$467,000	2 months (concurrent)
7	Other repairs and improvements	$330,000	2 months (concurrent)
TOTAL		**$2,675,000**	**2-3 months**

It must be emphasized that the above program is a minimum program. Deletions or omissions of any part of the program will mean the entire program is compromised.

It is believed that the work should, if properly planned and expedited, be completed within a two to three month period. The major item of work would be the rotor rewind, which would require the rotors be removed from site to a suitable workshop. Once repaired, the facility should be maintained appropriately and a suitable level of spare parts should be kept on hand.

Appendix A
Cost Estimate Details

Converter Improvements

Items	Unit Cost	Number	Totals
Rewind both rotors	500000	2	1000000
Associated NLH Labor	25000	2	50000
Clean facility	50000	1	50000
New bearing	3000	1	3000
Dry type transformers	15000	2	30000
Oil test and monitor new bearing	6000	1	6000
Subtotal			1139000
Engineering			91120
Project Management			56950
Owner Administration			28475
Interest during construction			34170
Subtotal			1349715
Contingency			161965.8
Total			**1511681**
Rounded			**1,500,000**

Transformer Area Improvements

Items	Unit Cost	Number	Totals
Fire protection system	60000	1	60000
Oil - water separator	100000	1	100000
Concrete works	33000	1	33000
Labor associated	50000	1	50000
Subtotal			243000
Engineering			19440
Project Management			12150
Owner Administration			6075
Interest during construction			7290
Subtotal			287955
Contingency			57591
Total			**345546**
Rounded			**345,000**

New Automatic Voltage Regulators

Items	Unit Cost	Number	Totals
New AVRs	50000	2	100000
Labor to install	5000	2	10000
Remove Existing Volt Reg	32000	1	32000
Subtotal			142000
Engineering			11360
Project Management			7100
Owner Administration			3550
Interest during construction			4260
Subtotal			168270
Contingency			33654
Total			**201924**
Rounded			**200,000**

Ventilation System Improvements

Items	Unit Cost	Number	Totals
New filter system	25000	1	25000
Labor to install	10000	1	10000
Structural Modifications	35000	1	35000
Subtotal			70000
Engineering			5600
Project Management			3500
Owner Administration			1750
Interest during construction			2100
Subtotal			82950
Contingency			16590
Total			**99540**
Rounded			**100,000**

Lighting System

Items	Unit Cost	Number	Totals
New Lights	4000	1	4000
Labor to install	10000	1	10000
Subtotal			14000
Engineering			1120
Project Management			700
Owner Administration			350
Interest during construction			420
Subtotal			16590
Contingency			3318
Total			**19908**
Rounded			**20,000**

Structural Improvements

Items	Unit Cost	Number	Totals
Repair converter structure	10000	1	10000
Stair replacement	7000	1	7000
Door replacement	1000	1	1000
Heating and Ventilation in Stairs	3000	1	3000
Stairwell roof repairs	6000	1	6000
Crane Inspection	3000	1	3000
Replace insulators, converter bld	60000	1	60000
Repair mill building	10000	1	10000
Replace insulators, mill bld	45000	1	45000
Associated labor	31000	1	31000
Subtotal			176000
Engineering			14080
Project Management			8800
Owner Administration			4400
Interest during construction			5280
Subtotal			208560
Contingency			25027.2
Total			**233587.2**
Rounded			**233,000**

Battery System

Items	Unit Cost	Number	Totals
New battery	15000	1	15000
Labor to install	3000	1	3000
Battery screen	6500	1	6500
Subtotal			24500
Engineering			1960
Project Management			1225
Owner Administration			612.5
Interest during construction			735
Subtotal			29032.5
Contingency			5806.5
Total			**34839**
Rounded			**35,000**

Oil System Improvements

Items	Unit Cost	Number	Totals
Rehabilitate tank	5000	1	5000
Repair/replace mech equip	1000	1	1000
Line concrete sump	2500	1	2500
Labor associated	7000	1	7000
Subtotal			15500
Engineering			1240
Project Management			775
Owner Administration			387.5
Interest during construction			465
Subtotal			18367.5
Contingency			3673.5
Total			**22041**
Rounded			**22,000**

Compressed Air System

Items	Unit Cost	Number	Totals
Upgrade piping	2000	1	2000
Modify air receiver	2000	1	2000
Associated labor	3000	1	3000
Subtotal			7000
Engineering			560
Project Management			350
Owner Administration			175
Interest during construction			210
Subtotal			8295
Contingency			1659
Total			**9954**
Rounded			**10,000**

Roof/Floor Drains

Items	Unit Cost	Number	Totals
Drain Materials	10000	1	10000
Labor to install	11000	1	11000
Subtotal			21000
Engineering			1680
Project Management			1050
Owner Administration			525
Interest during construction			630
Subtotal			24885
Contingency			4977
Total			**29862**
Rounded			**30,000**

Other Areas

Items	Unit Cost	Number	Totals
Repair/replace swtgear comps	35000	1	35000
Misc repairs	15000	1	15000
Associated labor	24000	1	24000
Subtotal			74000
Engineering			5920
Project Management			3700
Owner Administration			1850
Interest during construction			2220
Subtotal			87690
Contingency			17538
Total			**105228**
Rounded			**105,000**

Appendix B
Photographs

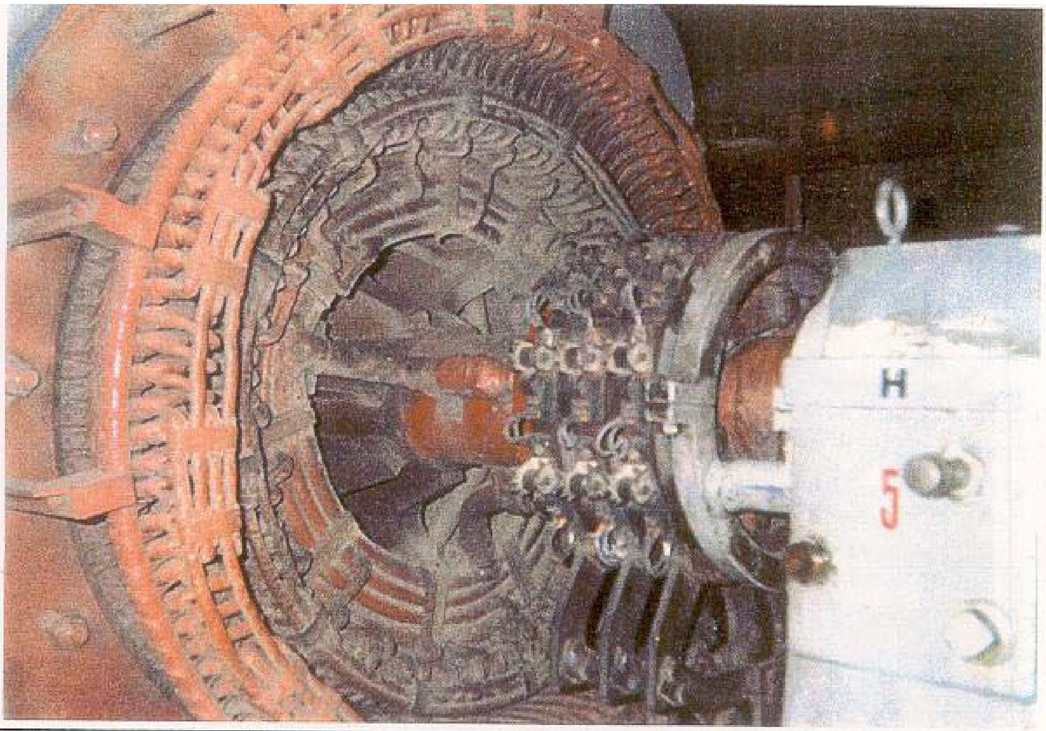

Photo 1: Dust and dirt on the machine windings and rotor - August 19, 1998

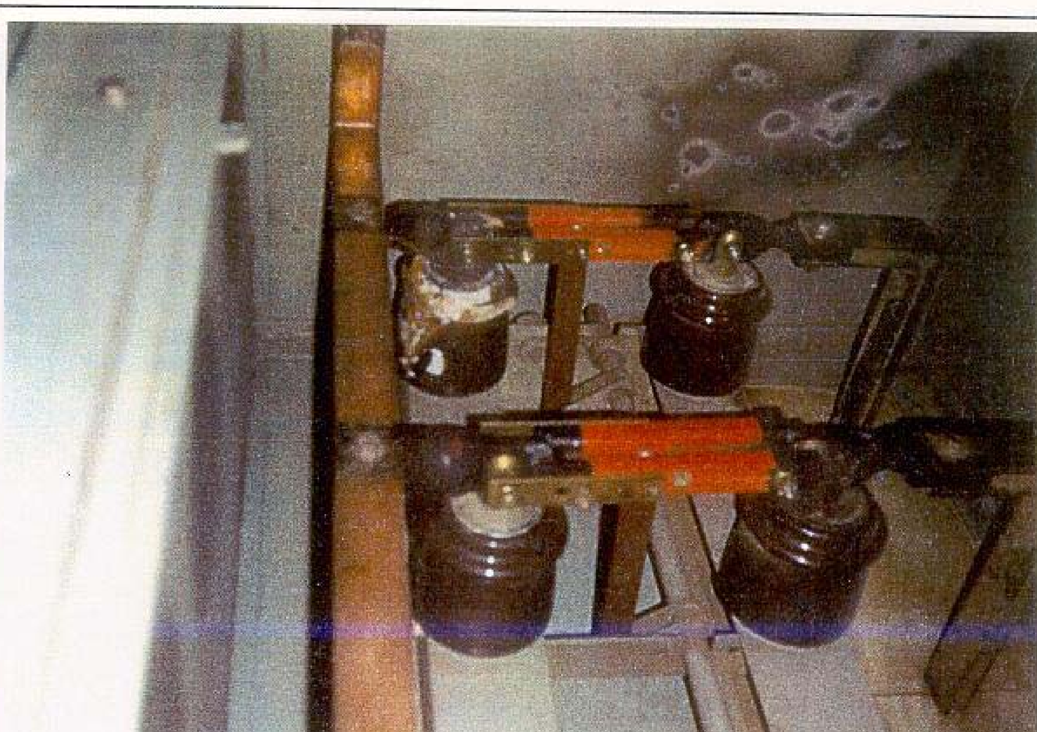

Photo 2: Arcing and burning found in cubicle - August 19, 1998

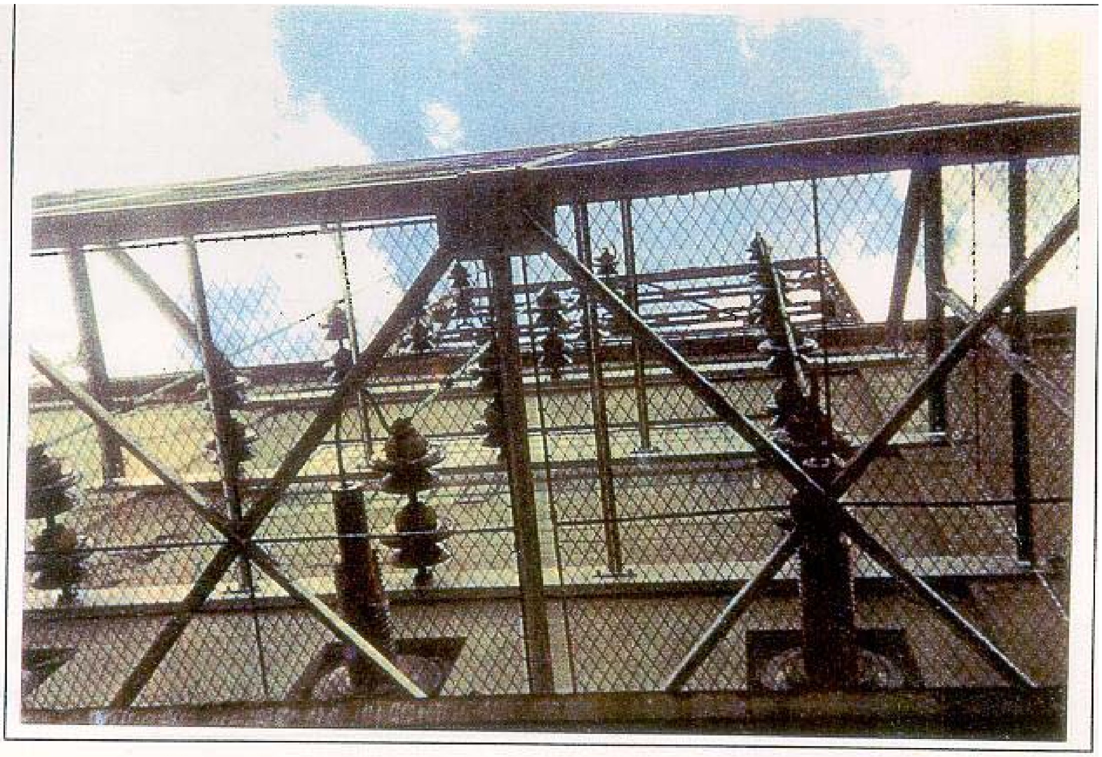

Photo 3: Damaged bushings outside the converter building - August 19, 1998

Photo 4: Shows scoring that has occurred on the pedestal bearing which has failed - August 19, 1998

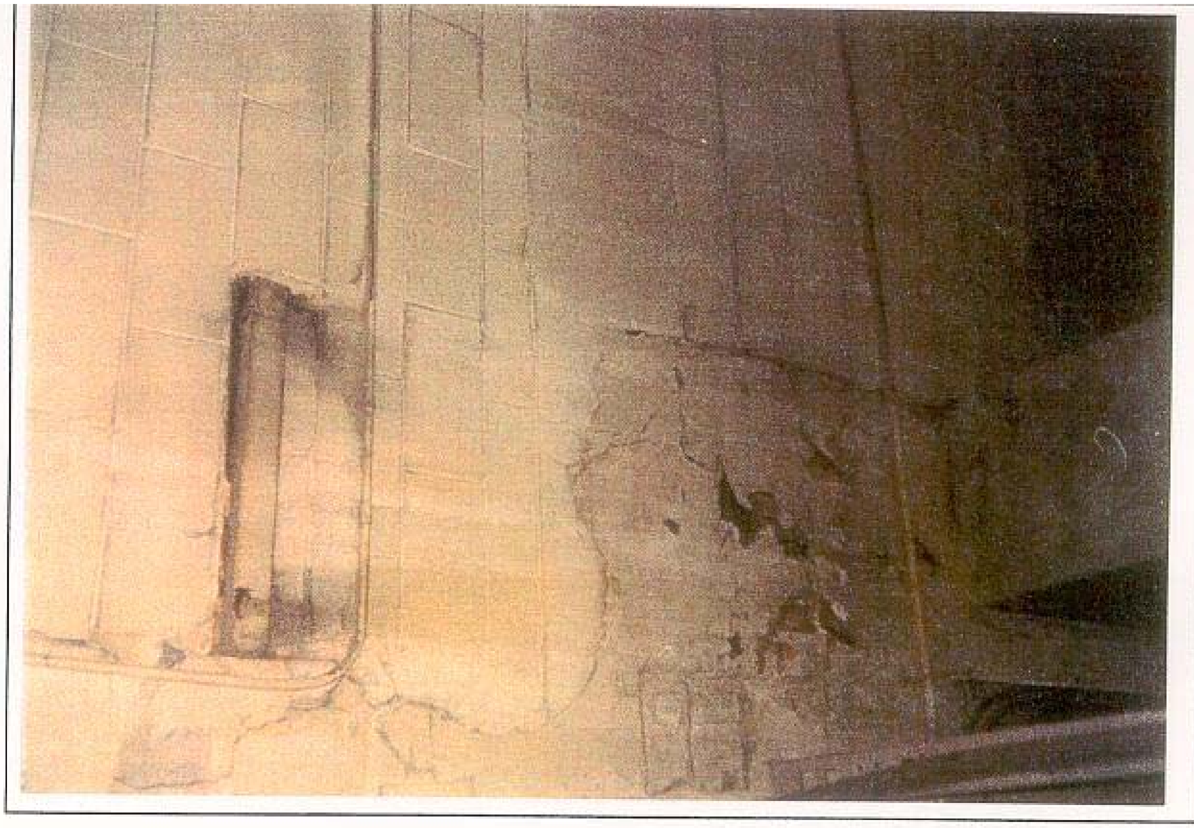

Photo 5: Type of structural deterioration in the building - August 19, 1998

Appendix C
Laboratory Analysis

Laboratory Report

Client: **ACRES Analytical Ltd.**
360 York Road - Units 1 & 2
Niagara-on-the-Lake, ONT L0S 1J0

Attention: Marie Tabaka
Project Ref # # GNGH & AIL
Purchase Order #
Project: **Bulk Sample Analysis**

Laboratory Project # ON808358
Project Manager: Paul Chopra
Start Date: 8/27/98
Report Date: 8/31/98
Analysis Type: **Bulk Asbestos Analysis by Polarized Light Microscopy**

Authorized Signature ____________________

☐ Daniel Miller, Senior Microscopist
☐ Paul S. Chopra, Laboratory Manager

Analysis Results Table

Client Sample	CLI Sample #	Sample Location / Description *Material Description(s)*	*Asbestos Content*	Analyst Comment *Non-Asbestos Content*	Analyst - Date
The following 3 samples were submitted by ACRES Analytical Ltd. on 8/27/98 and analyzed in accordance with PLM - EPA/600/R-93/116					
1	393187	*100% Black dust*	*No Asbestos Detected using PLM*	*54% Cellulose 46% Non-Fibrous Material*	JR 8/29/98
No asbestos detected in sample					
2	393188	*100% Black dust*	*No Asbestos Detected using PLM*	*20% Cellulose 80% Non-Fibrous Material*	JR 8/29/98
No asbestos detected in sample					
3	393189	*100% Black dust*	*No Asbestos Detected using PLM*	*10% Cellulose 90% Non-Fibrous Material*	JR 8/29/98
No asbestos detected in sample					

Analysis Results Table

Client Sample	CLI Sample #	Sample Location / Description	Analyst Comment	
	Material Description(s)	*Asbestos Content*	*Non-Asbestos Content*	Analyst - Date

Additional testing is recommended for any material which contains <1% asbestos or NOB (non-friable organically bound) bulk materials which are negative or <1% asbestos. Analysis by Polarized Light Microscopy (PLM) has a degree of uncertainty that is dependent on the sample matrix, non-asbestos minerals present, size of the asbestos present, the sample homogeneity and analyst variability. PLM coefficients of variance range from approx. 1.8, at the quantitation limit of 1%, to 0.1 at high fiber concentrations. All PLM analyses must be reviewed with these factors taken into consideration.

CHOPRA-LEE
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NIST NVLAP Lab # 1208-01
NYS DOH ELAP Lab # 10954