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August 1, 2014

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

Attention: **Ms. Cheryl Blundon**
Director Corporate Services & Board Secretary

Dear Ms. Blundon:

Re: The Board's Investigation and Hearing into Supply Issues and Power Outages on the Island Interconnection System

In accordance with the Board's Interim Report dated May 15, 2014, wherein the Board required the filing of reports on today's date with respect to the above noted matter, please find enclosed the original plus 12 copies of Hydro's:

- Alarms, Event Recording Devices, and Digital Relays
- Air Blast Circuit Breakers

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Tracey L. Pennell
Legal Counsel

TLP/cp

cc: Gerard Hayes – Newfoundland Power
Paul Coxworthy – Stewart McKelvey Stirling Scales
Sheryl Nisenbaum – Praxair Canada Inc.
Thomas Johnson – Consumer Advocate
Thomas O' Reilly – Cox & Palmer
Danny Dumaresque

ecc: Roberta Frampton Benefiel – Grand Riverkeeper Labrador

Investigation and Hearing into Supply Issues and Power Outages on the Island Interconnected System

REPORT TO THE BOARD OF COMMISSIONERS OF PUBLIC UTILITIES RELATED TO AIR BLAST CIRCUIT BREAKERS

Newfoundland and Labrador Hydro

August 1, 2014

newfoundland labrador hydro
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1 BACKGROUND AND INTRODUCTION

Newfoundland and Labrador Hydro's ("Hydro") internal review and investigation of the supply disruptions and power outages which occurred on the Island Interconnected System in January 2014 included an in-depth review of various aspects of transmission availability. This included a root cause analysis of the performance of various transmission system components, including 230 kV air blast circuit breakers both in Sunnyside and in other locations.

The Integrated Action Plan (IAP) developed by Hydro following its internal review contains several actions which are concerned with addressing the reliable operation of air blast circuit breakers. In its Report to the Newfoundland and Labrador Board of Commissioners of Public Utilities ("Board") on June 16, 2014, Hydro outlined its plans and schedules related to several of these actions, including its plans for exercising all critical circuit breakers in 2014 and completing overdue testing and maintenance on these breakers.

On May 15, 2014 the Board issued its Interim Report in the matter of an investigation and hearing into supply issues and power outages on the Island Interconnected System ("Interim Report"). This Report is in response to a request by the Board that Hydro file by August 1, 2014 a report addressing other action items in Hydro's IAP related to air blast circuit breakers, and that it set out its schedule, resources required, and estimated costs in relation to the following:

a) An acceleration of the preventative maintenance cycle for air blast circuit breakers;
b) An acceleration of the replacement of air blast circuit breakers; and
c) Changes to internal procedures and documents addressing: (i) the application of the protective coating to air blast circuit breakers; (ii) false indications of the open/close state; and (iii) stating a specific pass/fail criterion for the timing test of air blast circuit breakers on the preventative maintenance check sheet.

2 PREVENTATIVE MAINTENANCE CYCLE

A key priority action identified by Hydro in its internal review report was to review its preventative maintenance (PM) program for air blast circuit breakers, including the length of the PM cycle. This review has been completed and Hydro accepts the recommendation by Liberty Consulting that the maintenance frequency be shortened from six years to four years.

This section of the report outlines the new standard as well as the implementation schedule and estimated cost.

2.1 Preventative Maintenance Standard

Prior to the events of January 2014, Hydro's preventative maintenance (PM) standard for air blast circuit breakers (ABCB) was to complete the maintenance program on a six year cycle. Considering the age of these assets and the issues experienced with air blast circuit breakers during these events, Hydro has reduced the PM frequency from six years to four years. Hydro has reviewed this in conjunction with its accelerated breaker replacement plan and will implement a new four year maintenance cycle for ABCBs starting in 2015.

2.2 Implementation Schedule

The implementation schedule for the change in frequency from six years to four years is outlined in the table presented in Appendix A.

2.3 Resources and Costs

As outlined in Table 2.1 below, over the period 2015 to 2020 there will be a requirement for an additional 11 PMs on ABCBs that would not otherwise have been performed in that period. This analysis takes into account that some breakers will be replaced on an accelerated schedule as discussed in the next Section of this Report.

To complete the necessary work for the additional PMs in 2015, Hydro plans to use a hybrid crew of both an external contract resource and internal resources. All remaining additional PMs beyond 2015 will be completed using internal resources only. The cost estimates for each year are outlined in Table 2.1.

Table 2. 1
Changing the ABCB PM Frequency From 6 Years to 4 Years

	2015	2016	2017	2018	2019	2020	Total
4 Year Frequency	12	4	3	6	0	0	25
6 Year Frequency	7	3	1	2	1	0	14
Additional PM's Using a 4 Year Frequency	5	1	2	4	-1	0	11
Estimated Cost For Additional PMs Using a 4 Year Frequency	**$75,000**	**$10,200**	**$20,400**	**$40,800**	**($10,200)**	**$0**	**$136,200**

3 BREAKER REPLACEMENT

Hydro has had an ongoing program to replace and refurbish circuit breakers, which includes the replacement and refurbishment of ABCBs. Hydro's internal investigation and review of the system events in January 2014 resulted in a recommendation that its breaker replacement program be reviewed and revised to accelerate the replacement of its ABCBs. To assist with this review, Hydro engaged AMEC Americas Limited to review its ABCB program and to develop an accelerated replacement program with consideration given to asset criticality; breaker age; previous date of overhaul; and outage availability.

3.1 Accelerated Replacement Program and Schedule

Hydro has worked with AMEC in developing an accelerated ABCB replacement program which contemplates the replacement of all air blast circuit breakers by 2020. Hydro's original plan contemplated the replacement of all remaining air blast breakers by 2031. Details of the overall program and schedule are outlined in the AMEC report which is attached in Appendix B.

3.2 Costs and Resources

A draft capital budget proposal (CBP) related to the accelerated replacement of ABCBs over the period 2016-2020 indicates an estimated cost of $ 24.5 million. This amount does not reflect the replacement cost of ABCBs which are covered by Hydro's 2015 CBP for Circuit Breaker Upgrades, to be submitted to the Board for approval as a part of the 2015 Capital Budget Submission. The 2015 submission currently has an allowance for approximately $ 9 million for air blast circuit breaker purchases and/or replacements. The total estimated cost from 2015 to 2020 for the accelerated ABCB replacement program is estimated to be approximately $33.5 million.

This program of accelerated breaker replacements will be done under a contract partnership agreement[1] with an Original Equipment Manufacturer to cover the removal of ABCBs and the supply and installation of the new SF_6 type breakers.

[1] Contract with breaker manufacturer to supply and install breakers over a defined period greater than one year.

4 INTERNAL PROCEDURES AND TESTS

Hydro's internal review and investigation of the system disruptions which occurred in January 2014 included a root cause analysis of the failure of air blast circuit breakers in Sunnyside and in other locations. The Root cause Analysis Team (RCAT) recommended changes related to various aspects of breaker performance and maintenance, including changes intended to address: (i) the application of the protective coating to air-blast circuit breakers; (ii) false indications of the open/close state; (iii) and stating a specific pass/fail criteria for the timing test on the PM check sheet for ABCBs.

This section of the report addresses changes to internal procedures and documents, and provides information relating to schedule, cost and resources for these changes.

4.1 Updates and Changes to Internal Procedures

4.1.1 Application of the protective coating to air-blast breakers

To address the concern regarding the potential for moisture contamination entering an air blast circuit breaker during the application of the protective coating, Hydro has updated work methods SWM-00317 (Insulating Column - Air Blast Breaker - Replace) and SWM-000318 (Interrupter Head - Air Blast Breaker – Replace). See Appendix C for copies of the updated work methods.

At the beginning of 2014 the only breakers which required the application of a protective coating were the breakers associated with Holyrood Unit 2 -- B2B11 and B2L42. Since breaker B2B11 is planned for replacement in 2014, only B2L42 will require the protective coating being added. The plan is to have previously coated parts that were installed on breaker B1L17 earlier in 2014 transferred to breaker B2L42, as breaker B1L17 will be replaced by November 2014. The work required to transfer these parts is currently ongoing and is expected to be completed by August 4, 2014. Further to this, all air blast breakers at Holyrood are planned to be replaced by the end of 2016 and as a result this will eliminate the risk of moisture getting inside an air blast circuit breaker during a protective coating application.[2] The new breakers being installed will be SF_6 type and not air blast.

4.1.2 False indications of the open/close state

Hydro's root cause investigation of breaker failures in January 2014 recommended that the following clause be added to Hydro's Terminals Engineering Standard TS09-001 entitled "Outdoor Power Circuit Breaker": *"the breaker shall not give false indication of the open/close state of any of its phases under any failure mode*". This was considered and the following has been added in section 3.7.3 of the Terminals Engineering Standard TS09-001: *"The circuit breaker shall not give false indication of the "CLOSE/OPEN" state of any of its phases under any failure mode"*.

See Appendix D for a copy of the updated standard. This updated standard will be applied in all future breaker purchases.

4.1.3 Specific pass/fail criteria for the timing test of the air-blast circuit breaker

A further recommendation of Hydro's RCAT was that its PM check sheets for air blast circuit breakers be revised to include the Original Equipment Manufacturer's (OEM) specific pass/fail criteria for timing tests. See Appendix E showing a copy of the latest check sheets for both DCF/DCVF and DLF type air blast circuit breakers with the timing criteria included.

4.2 Implementation Schedule, Cost and Resources

All changes identified in Section 4.1 above were completed in May and June, 2014. All work was done by internal resources and did not involve any significant extra cost.

[2] Hydro has only applied protective coating on breakers at Holyrood Terminal Station due to salt contamination from the ocean spray.

APPENDIX A

Implementation Schedule for Change in PM Frequency for Air Blast Circuit Breakers

ADJUSTED SCHEDULE FOR ABCB MAINTENANCE BASED ON A 4 YEAR PM CYCLE - NL HYDRO(July/2014)

REF	LOCATION	NLH ID	TYPE	MODEL	OPER VOLT (kV)	REPLACEMENT YEAR	PLANNED COMPLETED DATE (6 YEAR FREQUENCY)	NEW SCHEDULED DATE (4 YEAR FREQUENCY)	RESET FREQUENCY (Y / N)	COMMENTS (RESET TO 4 YEAR CYCLE STARTING IN 2015)
1	HRD TS	B2B11	Air Blast	DLF 245 nc2	230	2014	-	-	N	TO BE REPLACED IN 2014, PM WILL NOT BE RESET TO 4 YEARS.
2	HRD TS	B1B11	Air Blast	DLF 245 nc2	230	2014	-	-	N	TO BE REPLACED IN 2014, PM WILL NOT BE RESET TO 4 YEARS.
3	HRD TS	B1L17	Air Blast	DLF 245 nc2	230	2014	-	-	N	TO BE REPLACED IN 2014, PM WILL NOT BE RESET TO 4 YEARS.
4	SSD TS	B2T1	Air Blast	DCF 170 mc4	138	2014	-	-	N	TO BE REPLACED IN 2014, PM WILL NOT BE RESET TO 4 YEARS.
5	SSD TS	B1L03	Air Blast	DCVF 245 mc6	230	2014	-	-	N	TO BE REPLACED IN 2014, PM WILL NOT BE RESET TO 4 YEARS.
6	HWD TS	B1L01	Air Blast	DLF 245 nc2	230	2015	NOV. 2015	NOV. 2015	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
7	BDE TS1	B1T2	Air Blast	DCVF 245 mc6	230	2015	JUN. 2017	JUN. 2015	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
8	BDE TS1	B2T4	Air Blast	DCVF 245 mc6	230	2015	MAY. 2019	MAY. 2017	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
9	OPD TS	B1L18	Air Blast	DCVF 245 mc6	230	2015	JAN. 2015	JAN. 2015	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
10	HRD TS	B2L42	Air Blast	DLF 245 nc2	230	2015	JUL. 2014	JUL. 2018	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
11	BDE TS1	B2T3	Air Blast	DCVF 245 mc6	230	2015	APR. 2017	APR. 2015	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
12	HRD TS	B3L18	Air Blast	DLF 245 nc2	230	2015	SEPT. 2019	SEPT. 2017	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
13	HRD TS	B3B13	Air Blast	DLF 245 nc2	230	2015	SEPT. 2019	SEPT. 2017	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
14	SSD TS	B1L02	Air Blast	DCVF 245 mc6	230	2015	JUN. 2014	JUN. 2018	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
15	OPD TS	B1L36	Air Blast	DCVF 245 mc6	230	2015	MAY. 2015	MAY. 2015	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS
16	BDE TS1	B1B2	Air Blast	DCVF 245 mc6	230	2015	JUL. 2014	JUL. 2018	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
17	SSD TS	L06L07	Air Blast	DCVF 245 mc6	230	2015	JUN. 2020	JUN. 2018	N	TO BE REPLACED IN 2015, PM WILL NOT BE RESET TO 4 YEARS.
18	BDE TS1	B3T6	Air Blast	DCVF 245 mc6	230	2016	JUN. 2014	JUN. 2018	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
19	BDE TS1	B3T5	Air Blast	DCVF 245 mc6	230	2016	JUN. 2014	JUN. 2018	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
20	HRD TS	B12L42	Air Blast	DLF 245 nc2	230	2016	JUL. 2014	JUL. 2018	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
21	HRD TS	B12L17	Air Blast	DLF 245 nc2	230	2016	JUL. 2019	JUL. 2017	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
22	BDE TS1	B1T1	Air Blast	DCVF 245 mc6	230	2016	AUG. 2014	AUG. 2018	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
23	SSD TS	L02L07	Air Blast	DCVF 245 mc6	230	2016	JUL. 2014	JUL. 2018	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
24	BDE TS1	B4B5	Air Blast	DCVF 245 mc6	230	2016	OCT. 2016	OCT. 2015	Y	TO BE REPLACED IN 2016, PM WILL BE RESET TO 4 YEARS.
25	BBK TS	B1L11	Air Blast	DLF 245 nc2	230	2016	JUL. 2018	JUL. 2016	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
26	BBK TS	B1L09	Air Blast	DLF 245 nc2	230	2016	MAY. 2020	MAY. 2018	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
27	BBK TS	L09L33	Air Blast	DLF 245 nc2	230	2016	JUN. 2018	JUN. 2016	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
28	BBK TS	L11L33	Air Blast	DLF 245 nc2	230	2016	JUN. 2018	JUN. 2016	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.

ADJUSTED SCHEDULE FOR ABCB MAINTENANCE BASED ON A 4 YEAR PM CYCLE - NL HYDRO(July/2014)

REF	LOCATION	NLH ID	TYPE	MODEL	OPER VOLT (kV)	REPLACEMENT YEAR	PLANNED COMPLETED DATE (6 YEAR FREQUENCY)	NEW SCHEDULED DATE (4 YEAR FREQUENCY)	RESET FREQUENCY (Y / N)	COMMENTS (RESET TO 4 YEAR CYCLE STARTING IN 2015)
29	HRD TS	B12B15	Air Blast	DLF 245 nc2	230	2016	JUL. 2014	JUL. 2018	N	TO BE REPLACED IN 2016, PM WILL NOT BE RESET TO 4 YEARS.
30	MDR TS	B5L11	Air Blast	DCVF 245 mc6	230	2017	NOV. 2019	NOV. 2017	N	TO BE REPLACED IN 2017, PM WILL NOT BE RESET TO 4 YEARS.
31	BDE TS1	B6B10	Air Blast	DCVF 245 mc6	230	2017	JUN. 2014	JUN. 2018	N	TO BE REPLACED IN 2017, PM WILL NOT BE RESET TO 4 YEARS.
32	BDE TS1	B2B3	Air Blast	DCVF 245 mc6	230	2017	JUN. 2014	JUN. 2018	N	TO BE REPLACED IN 2017, PM WILL NOT BE RESET TO 4 YEARS.
33	MDR TS	B1L28	Air Blast	DCVF 245 mc6	230	2017	JUN. 2020	JUN. 2018	N	TO BE REPLACED IN 2017, PM WILL NOT BE RESET TO 4 YEARS.
34	BDE TS1	B3B4	Air Blast	DCVF 245 mc6	230	2017	JUN. 2014	JUN. 2018	N	TO BE REPLACED IN 2017, PM WILL NOT BE RESET TO 4 YEARS.
35	WAV TS	B1L37	Air Blast	DCVF 245 mc6	230	2018	JUN. 2014	JUN. 2018	N	TO BE REPLACED IN 2018, PM WILL NOT BE RESET TO 4 YEARS.
36	BDE TS1	B5B6	Air Blast	DCVF 245 mc6	230	2018	JUN. 2014	JUN. 2018	N	TO BE REPLACED IN 2018, PM WILL NOT BE RESET TO 4 YEARS.
37	WAV TS	B1L17	Air Blast	DCVF 245 mc6	230	2018	JUN. 2015	JUN. 2015	N	TO BE REPLACED IN 2018, PM WILL NOT BE RESET TO 4 YEARS, BUT PM WILL BE COMPLETED IN 2015
38	STB TS	B2L04	Air Blast	DCVF 245 mc6	230	2018	SEPT. 2017	SEPT. 2015	Y	TO BE REPLACED IN 2018, PM WILL BE RESET TO 4 YEARS.
39	STB TS	L05L31	Air Blast	DCF 245 mc6	230	2018	MAY. 2015	MAY. 2015	N	TO BE REPLACED IN 2018, PM WILL NOT BE RESET TO 4 YEARS.
40	SSD TS	B3T4	Air Blast	DCF 170 mc4	138	2018	AUG. 2018	AUG. 2016	Y	TO BE REPLACED IN 2018, PM WILL BE RESET TO 4 YEARS.
41	STB TS	B3L130	Air Blast	DCF 170 mc4	138	2018	SEPT. 2018	SEPT. 2016	Y	TO BE REPLACED IN 2018, PM WILL BE RESET TO 4 YEARS.
42	STB TS	B3T2	Air Blast	DCF 170 mc4	138	2018	MAY. 2018	MAY. 2016	Y	TO BE REPLACED IN 2018, PM WILL BE RESET TO 4 YEARS.
43	BDE TS1	B1B10	Air Blast	DCVF 245 mc6	230	2018	JUL. 2014	JUL. 2018	N	TO BE REPLACED IN 2018, PM WILL NOT BE RESET TO 4 YEARS.
44	SSD TS	B2L12	Air Blast	DCF 170 mc4	138	2018	AUG. 2014	AUG. 2018	N	TO BE REPLACED IN 2018, PM WILL NOT BE RESET TO 4 YEARS.
45	SSD TS	L19L100	Air Blast	DCF 170 mc4	138	2018	JUN. 2020	JUN. 2018	N	TO BE REPLACED IN 2018, PM WILL NOT BE RESET TO 4 YEARS.
46	WAV TS	B1L08	Air Blast	DCVF 245 mc6	230	2019	JUL. 2018	JUL. 2016	Y	TO BE REPLACED IN 2019, PM WILL BE RESET TO 4 YEARS.
47	STB TS	B1L31	Air Blast	DCVF 245 mc6	230	2019	OCT. 2015	OCT. 2015	N	TO BE REPLACED IN 2019, PM WILL NOT BE RESET TO 4 YEARS.
48	STB TS	L05L35	Air Blast	DCVF 245 mc6	230	2019	AUG. 2015	AUG. 2015	N	TO BE REPLACED IN 2019, PM WILL NOT BE RESET TO 4 YEARS.
49	STB TS	B1L32	Air Blast	DCVF 245 mc6	230	2019	DEC. 2015	DEC. 2015	N	TO BE REPLACED IN 2019, PM WILL NOT BE RESET TO 4 YEARS.
50	WAV TS	L03L17	Air Blast	DCVF 245 mc6	230	2019	JUN. 2015	JUN. 2015	N	TO BE REPLACED IN 2019, PM WILL NOT BE RESET TO 4 YEARS.
51	SSD TS	L109T4	Air Blast	DCF 170 mc4	138	2019	JUL. 2016	JUN. 2015	Y	TO BE REPLACED IN 2019, PM WILL BE RESET TO 4 YEARS.
52	STB TS	B1L35	Air Blast	DCF 245 mc6	230	2019	OCT. 2016	OCT. 2015	Y	TO BE REPLACED IN 2019, PM WILL BE RESET TO 4 YEARS.
53	SSD TS	L100L109	Air Blast	DCF 170 mc4	138	2019	JUN. 2020	JUN. 2018	Y	TO BE REPLACED IN 2019, PM WILL BE RESET TO 4 YEARS.
54	BUC TS	L05L33	Air Blast	DLF 245 nc2	230	2019	OCT. 2019	OCT. 2017	Y	TO BE REPLACED IN 2019, PM WILL BE RESET TO 4 YEARS.
55	BUC TS	B1L05	Air Blast	DLF 245 nc2	230	2019	OCT. 2014	OCT. 2018	Y	TO BE REPLACED IN 2019, PM WILL BE RESET TO 4 YEARS.

ADJUSTED SCHEDULE FOR ABCB MAINTENANCE BASED ON A 4 YEAR PM CYCLE - NL HYDRO(July/2014)

REF	LOCATION	NLH ID	TYPE	MODEL	OPER VOLT (kV)	REPLACEMENT YEAR	PLANNED COMPLETED DATE (6 YEAR FREQUENCY)	NEW SCHEDULED DATE (4 YEAR FREQUENCY)	RESET FREQUENCY (Y / N)	COMMENTS (RESET TO 4 YEAR CYCLE STARTING IN 2015)
56	WAV TS	L01L03	Air Blast	DCVF 245 mc6	230	2020	JUL. 2014	JUL. 2018	Y	TO BE REPLACED IN 2020, PM WILL BE RESET TO 4 YEARS.
57	STB TS	B3L133	Air Blast	DCF 170 mc4	138	2020	AUG. 2015	AUG. 2015	Y	TO BE REPLACED IN 2020, PM WILL BE RESET TO 4 YEARS.
58	STB TS	B3T1	Air Blast	DCF 170 mc4	138	2020	JUN. 2018	JUN. 2017	Y	TO BE REPLACED IN 2020, PM WILL BE RESET TO 4 YEARS.
59	STB TS	B3L22	Air Blast	DCF 170 mc4	138	2020	MAY. 2020	MAY. 2018	Y	TO BE REPLACED IN 2020, PM WILL BE RESET TO 4 YEARS.
60	BUC TS	L28L32	Air Blast	DLF 245 nc2	230	2020	SEPT. 2014	SEPT. 2018	Y	TO BE REPLACED IN 2020, PM WILL BE RESET TO 4 YEARS.
61	BUC TS	B1L28	Air Blast	DLF 245 nc2	230	2020	NOV. 2014	NOV. 2018	Y	TO BE REPLACED IN 2020, PM WILL BE RESET TO 4 YEARS.
62	WAV TS	B1B3	Air Blast	DLF 245 nc4	230	2020	JUN. 2016	JUN. 2015	Y	TO BE REPLACED IN 2020, PM WILL BE RESET TO 4 YEARS.
63	STB TS	B3L10	Air Blast	DLF 145 nc2	138	2020	SEPT. 2019	SEPT. 2017	Y	TO BE REPLACED IN 2020, PM WILL BE RESET TO 4 YEARS.

APPENDIX B

Accelerated Replacement Program for Air Blast Circuit Breakers

NEWFOUNDLAND AND LABRADOR HYDRO

Accelerated Air Blast Circuit Breaker Replacement Program

July 30, 2014

Prepared/Authored by: Brian Scott

Brian Scott

Electrical Engineering Specialist

AMEC Americas limited

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1) Executive Summary

Newfoundland and Labrador Hydro (Hydro) has an on-going program to replace circuit breakers at the end of the asset's useful life. This includes replacing all 63 air blast circuit breakers with SF6 circuit breakers by 2031. Although historically the performance of air blast circuit breakers has been reasonable, Hydro has experienced two significant outage incidents in the last two years in which the failure of air blast circuit breakers was a significant contributing factor. As a consequence Hydro now plans to initiate a program to carry out the replacement on an accelerated schedule. This document provides a strategic plan for accomplishing this.

The accelerated air blast circuit breaker replacement program is designed to be implemented in two three-year phases with the first installation of breakers in 2015. A partnership arrangement would be established between Hydro and an external contractor for each phase for the supply and installation of breakers. Breakers purchased under the current replacement program would be installed in 2014 but beginning in 2015 the existing program would be merged into the accelerated program.

The overall program scheduled to be completed by 2020 provides a significant reduction in the time required to replace all air blast circuit breakers while maintaining safety, ensuring reliability and maximizing the use of available resources.

2) Introduction

Hydro plans to initiate a program to replace all air blast circuit breakers on an accelerated schedule. There are a total of 63 air blast circuit breakers on the Hydro system. Although historically the performance of these breakers has been reasonable, Hydro has experienced two significant outage incidents in the last two years in which the failure of air blast circuit breakers was a significant contributing factor.

During the next few years there are a number of activities already in progress which will result in the replacement of a number of these breakers. The activities include the LCP program at Holyrood, Bay D'Espoir and Hardwoods, the NL/NS link at Bottom Brook, breaker replacement associated with the transformer repairs at Sunnyside and the program currently underway to replace breakers at end-of-life. The accelerated replacement program will be carried out in addition to these other programs but must consider the overall impact of all activities on the system and resources. Close coordination with these other programs is required.

3) Background

In July 2012 Hydro submitted an *Upgrade Circuit Breaker* plan to the Board of Commissioners of Public Utilities (PUB) as part of its 2013 capital plan. The plan contained two components. One was to refurbish and replace aging air blast and SF6 circuit breakers to ensure system reliability. The other was to comply with legislation to remove PCB contaminated bushings on oil circuit breakers by replacing the oil circuit breakers with new SF6 circuit breakers.

No changes are anticipated for either the oil circuit breaker replacement program or the SF6 refurbishment and replacement program

The July 2012 plan for air blast circuit breakers had been to overhaul these breakers at about 40 years of service and replace them at the useful end of the asset life between 50 and 55 years of service. Replacement breakers would be SF6 type breakers and the replacement program would be completed by 2031. This meant that four to five overhauls would be completed per year and about three replacements per year. The report indicated that the experience in Newfoundland and from other utilities was that overhauls were effective in maintaining the reliability of air blast circuit breakers and extending their lifecycle.

In January 2013 and January 2014 Hydro experienced major system outages. In both incidents air blast circuit breakers failed to operate properly. During the PUB investigation into the January 2014 power outages its consultant, the Liberty Consulting Group, made a number of recommendations regarding air blast circuit breakers. These recommendations included exercising breakers, catching up on overdue maintenance, reducing the preventive maintenance cycle from 6 years to 4 years and periodically operating breakers from protection. Furthermore, the PUB in its May 15th Interim Report has requested that Hydro file a report on August 1st on the acceleration of the replacement of air blast circuit breakers.

This Accelerated Air Blast Breaker Replacement program has been independently developed for Hydro to address the recent experience with the decreased reliability of air blast circuit breakers and the recommendations of the Liberty Consulting Group. Factors considered in the development of the program include the criticality of the circuit breaker to system reliability, the age of the breaker and time since its last overhaul, the optimal use of resources through selection of the number work sites and avoiding delays in removal of air systems. Data for the development of the program was obtained from Hydro's Breaker 20 Year Plan dated Mar 26, 2014 and revisions to it up to July 3, 2014.

4) Program Goal and Scope

The overall program goal is to replace all air blast circuit breakers on an accelerated schedule in order to eliminate reliability issues associated with failure of air blast circuit breakers. This requires a balanced approach that replaces the breakers on a timely basis but maintains reliability of the power system during the work required to replace them. A six (6) year project schedule has been chosen that would begin in 2015. A partnership arrangement would be established between Hydro and an external contractor. Initially, Hydro would prepare and issue tender documents, evaluate bids and award the contract. The external contractor would supply and install the breakers. During the contract execution, Hydro would disconnect existing breaker, review and approve drawings including protection and control, provide outage coordination and on-site supervision, and oversee commissioning.

The scope of the contract would include:

- Removal of existing breaker and foundation
- Construction of a new foundation for the circuit breaker structure
- Supply and installation of new breaker
- Installation of new protection equipment and control cables
- Commissioning of new breaker

The accelerated air blast circuit breaker replacement program is designed to be implemented in two three-year phases. For each phase, a multi-year contract (3 years) will be issued for supply and installation of breakers. The contract will contain specific numbers of breakers to be supplied and installed each year. The contract should also contain an option to supply and install additional breakers on an incremental basis by year that allows for flexibility to adapt to changing system conditions. By breaking the contract into two phases Hydro can ensure a competitive and competent supplier is used throughout while still benefitting from the economies resulting from large orders and dealing with one (either through a successful re-bid or a contract extension) or two suppliers.

5) Schedule

Due to the time required to procure circuit breakers it is not practical to implement an accelerated breaker replacement plan in the field prior to 2015. In 2014 the procurement process would be put in place that incorporates and replaces the existing Upgrade Circuit Breaker project to have the necessary breakers and services available in 2015. Current activities will ensure that a number of air blast circuit breakers get replaced in 2014. This also enables time to properly analyze the requirements, prepare a plan and put in place a contract for the accelerated replacement of circuit breakers beginning in 2015.

The plan requires that a tender be prepared and issued in the fall of 2014 for the first phase of the program to secure a contractor for the years 2015-2017. Breakers required for installation in 2015 need to be delivered in the spring of 2015. Installation would then take place during the construction season of April – October. Subsequent years 2016 and 2017 would follow a similar schedule. Preparation for Phase 2 would take place during the summer/fall of 2017. At that time either the existing contract could be extended for an additional 3 years or a new contract awarded in time to continue the replacement program without interruption.

It is important that a thorough review of the specific breakers to be replaced be conducted on an annual basis. This review should include all affected departments including system operations (ECC), regional operations and maintenance, engineering, plant operations as required and protection and control. The first review should take place in the fall to finalize the list for the following year. A preliminary schedule and resource requirements should be looked at. With this if there are resource issues then there is still time to address them. Three months prior to the beginning of the construction season the outage schedule needs to be finalized. During the construction season final scheduling and approval of outages would be done in accordance with Hydro procedures.

6) Risk

The accelerated air blast circuit breaker replacement program contains significant but manageable risks. During the years 2015 and 2016 there are 12 air blast circuit breakers being replaced each year. This is in addition to oil circuit breaker replacements (5 and 4 respectively), overhauls and preventive maintenance. This represents a significant risk to schedule and resource availability. However, in both 2015 and 2016 there are other breaker replacement programs already active such as LCP that would mitigate the risk somewhat. Coordination of the work by Hydro and the contractor / partner is critical to the success of this program.

7) General

The overall plan for accelerated circuit breaker replacement needs to meet the following criteria:

- ***Safety*** of personnel and equipment must be a priority at all times. Hence any plan that incorporates external resources needs to ensure that all safety requirements of Hydro are met or exceeded.
- ***Reliability*** of power system is continuously maintained. Although the outages incurred to install new breakers will impact the ability of the power system to respond to disturbances the overall plan should not create undue risks. It is imperative that the plan be coordinated with system operations.
- The replacement of the circuit breakers should consider ***effective use of resources*** including technical capabilities and capacity of available labour, equipment and materials as well as be ***economic***.
- ***Timely***. Accelerating the replacement of circuit breakers will reduce the potential for further outages caused by failures of air blast circuit breakers.

A number of factors were used to select and prioritize the breaker replacements. These included the criticality of the breaker to system reliability, the age of the breaker and time since its last overhaul, optimizing use of resources through selection of the number work sites and avoiding delays in removal of air systems. Locations where the breakers were critical to system reliability or where breakers with known problems existed were given the highest priority. For continuity and efficient use of resources, the number of work locations was constrained and once a Terminal Station was started replacements continued at that location until completed. This also ensured that the air systems could be removed on a timely basis. Coordination with other on-going breaker replacement programs was an important consideration due to the impact on both resources and reliability of the system. The age and the time of the last overhaul were used to guide the replacement when other more critical factors had been satisfied.

During **Phase 1** of the accelerated program from 2015 – 2017 a total of 18 air blast circuit breakers will be replaced. These are in addition to those being done under other programs currently in progress. By the end of 2017 a total of 34 breakers (all 230 kV) at 7 locations will have been replaced. This will also enable the associated air systems at 5 of these locations to be de-commissioned. At Sunnyside, the portion of the air system used to supply the 230 kV breakers can also be de-commissioned. The air systems which are an integral component required for the reliable operation of air blast circuit breakers require a significant amount of maintenance

In the years 2014 – 2016 other programs are in place that will result in replacement of air blast circuit breakers. The LCP program will result in ten (10) 230 kV breaker replacements at Holyrood and Bay D'Espoir. Two breakers (1 – 230 kV, 1 – 138 kV) are scheduled to be replaced in 2014 at Sunnyside in conjunction with the transformer T1 replacement. The NL/NS link requires that all four (4) 230 kV breakers at Bottom Brook be replaced in 2016.These are to be replaced by Emera and at this time are treated separately from the accelerated breaker program. In addition, the Upgrade Circuit Breakers project has air blast circuit breakers scheduled for replacement in 2015 and 2016 but these breakers have been included in the accelerated program beginning in 2015. For efficiency, consideration should also be given to incorporating the Emera work within the accelerated program.

During **Phase 2** of the accelerated program from 2018 – 2020 the remaining 29 air blast circuit breakers will be replaced (18 – 230 kV, 11 – 138 kV) at five locations. The air systems at these locations will also be de-commissioned. All 138 kV breaker replacements are scheduled to occur during Phase 2 because the 138 kV system is less critical to the overall reliability of the electrical grid and resultant outages tend to be more localized. Moreover, from a project perspective the initial procurement need not address 138 kV breakers.

The following table provides a summary of the complete air blast breaker replacement programs. A more detailed description of the replacement program by location is included in Section 9 and Appendix 1 contains a complete list of all breakers to be replaced.

Air Blast Circuit Breaker Replacement

		Phase 1			Phase 2			
Description	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Accelerated Program		9	4	5	11	10	8	47
LCP	3	3	4					10
NL/NS Link			4					4
Other	2							2
Total	5	12	12	5	11	10	8	63

8) Circuit Breaker Planned Maintenance and Overhauls

On June 2, 2014 Hydro filed a report with the PUB on work required on air blast circuit breakers. In it Hydro identified that 40 breaker Preventive Maintenance (PMs) were due to be completed by the end of 2015. The schedule would be to complete 23 in 2014 (14 planned, nine overdue) and 17 in 2015 (eight planned, nine overdue). In 2016 and beyond the PMs would return to nine or ten per year and decrease over time.

The PM program for air blast circuit breakers has not been reviewed as part of this study. It is anticipated, however, that all overdue work will still be completed by the end of 2015 and the number of scheduled PMs for air blast circuit breakers should decrease rapidly between 2016 and 2019 with no PMs required in 2020. Although the PM program for air blast breakers will decrease and then end by 2019, the PM program for SF6 breakers will correspondingly increase as new SF6 breakers are added.

Hydro also had plans for overhauls of existing breakers at about 40 years. The current plan is to complete overhauls in 2014 and 2015. Beyond 2015 the circuit breaker replacement program would eliminate the need for overhauls of air blast circuit breakers.

This overhaul program for air blast breaker was briefly reviewed to determine if any opportunities existed for eliminating some overhauls by advancing the schedule for breaker replacement. It was noted that Hydro had advanced a couple of breakers, one at Bay D'Espoir (B1B10) and another at Sunnyside (L100L109). Given the aggressive schedule for breaker replacement and the desire to replace the most critical breakers first, no further opportunities were identified. Moreover, completion of the overhauls in 2014 and 2015 will be beneficial to the accelerated breaker replacement program by providing some added flexibility in the scheduling of breakers in the latter years of the program.

Air blast circuit breakers that have been scheduled for an overhaul have been identified in the detailed description of the breaker replacement program by location contained in Section 9.

Appendix 1 also includes the date of the last overhaul for all breakers in the replacement program.

It is recommended that Hydro retain some breakers and/or breaker parts from those recently removed from service to be used as spares until the completion of the breaker replacement program. The inventory kept should be comparable to what is used for a breaker overhaul since maintenance personnel are familiar with the overhaul procedure.

9) Breaker Replacement Program by Location

There are currently 63 air blast circuit breakers at 10 locations still in service. A plan for each site follows. Programs that are already in place such as the LCP program are included to provide a complete picture of the activity level by year and location. Consideration has been given to reliability, efficient use of resources, and a balancing of the effort by year. A specific breaker replacement schedule is included. However, there is flexibility in the overall schedule that would allow for some swapping of breaker replacements while still achieving the same overall results.

a) Holyrood

Holyrood contains nine (9) 230 kV air blast circuit breakers. All of these breakers will be replaced between 2014 and 2016 as part of the LCP program. This program will be operated separately from the accelerated program but the numbers will be tracked. No changes to this program are anticipated.

Breaker replacement schedule[1]:
2014 – B2B11, B1B11, B1L17[2]
2015 – B2L42[3], B3L18, B3B13
2016 – B12L42, B12L17, B12B15

Notes

1. All breakers replaced as part of the LCP program.
2. Breaker failed in Jan 2014
3. Breaker scheduled for overhaul in 2014

b) Bay D'Espoir

Bay D'Espoir Terminal Station contains thirteen (13) 230 kV air blast circuit breakers. This generating station is critical to the reliability of the integrated island electrical system. During phase 1 eleven (11) of the breakers will be replaced.

There are 6 generator unit breakers that need to be replaced. These breakers are operated frequently as the hydro units are brought on and off line. The concern with these breakers is not with failure to having them exercised but rather with wear and tear due to the number of operations. Hydro has identified these breakers as the most critical to the system driven by the fact they are generator breakers without an alternate route to get power to the grid. Due to on-going work at other locations such as Sunnyside, Holyrood and Oxen Pond and the challenge of attempting to schedule outages for all generator breakers in one year, these breakers have been scheduled to be replaced in 2015 and 2016. This will also mitigate risks associated with having the hydro plant available for energy, peak demand and reserve.

From a risk perspective, if a generator breaker fails before it is replaced then the consequence is the loss of that generator until it can be repaired or replaced. For a hydro unit the risk is primarily loss of capacity and/or reserve in times when total supply is limited such as during peak load conditions. To mitigate this it is recommended that a plan be developed to rapidly deal with the failure of one of these breakers. This could include keeping a spare breaker or key parts set aside specifically for these locations. It is also recommended that a PM be performed in 2015 on the three breakers that are not scheduled for replacement until 2016.

The remaining seven breakers are part of the ring bus. The outage required to remove any one breaker will not impact the output of the plant or the delivery of energy to the system via the connecting transmission lines. However, the system will be at risk and tripping of any of the transmission lines at Bay D'Espoir may result in the loss of additional transmission lines or unit generation. Each outage will need to be carefully planned and the generation levels at Bay D'Espoir may need to be adjusted to ensure the overall system reliability is maintained. Given the complications and risks associated with replacing these breakers, the number of breakers scheduled in any one year has been limited to three. The result is that the outages for these breakers are spread over the four years to minimize system related reliability risks. One of the breakers B4B5 will be replaced in 2016 as part of the LCP program.

From a risk perspective, if a ring breaker fails before it is replaced then the consequence is that other breakers will operate to isolate the failed breaker. The most common failure mode occurs when a breaker is commanded to operate such as for a fault but fails to do so. The impact on the system is less predictable because of the numerous potential configurations and load levels but could be severe.

The air system will be de-commissioned in 2018 at the end of the breaker replacements.

Breaker replacement schedule:
2015 – B1T2, B2T3, B2T4, B1B2
2016 – B1T1, B3T5, B3T6, B4B5[1]
2017 – B3B4, B6B10, B2B3
2018 – B5B6, B1B10[2]

Notes:
1. Breaker to be replaced as part of LCP program
2. Breaker scheduled for overhaul in 2014. Advanced from 2016.

c) Sunnyside

Sunnyside Terminal Station contains four (4) 230 kV and six (6) 138 kV air blast circuit breakers. Sunnyside occupies a critical location in the Newfoundland electrical grid connecting the large generation supply of Bay D'Espoir to the major load area of the Avalon peninsula. Therefore, maintaining the integrity of the 230 kV ring bus at Sunnyside is crucial to the reliability of the grid. In the major outage of January 2014, tie transformer T1 failed and the 230 kV air blast circuit breaker B1L03 failed to operate. Work will be carried out in 2014 to replace the tie transformer, 138 kV breaker B2T1 which was damaged during the transformer fire and breaker B1L03.

During Phase 1 the remaining 230 kV breakers are scheduled to be replaced over a two year period. This will ensure that this critical location will be upgraded with new equipment by the end of 2016.

During Phase 2, the remaining air blast circuit breakers, all at 138 kV, will be replaced.

Breaker replacement schedule:
2014 – B1L03[1], B2T1[2]
2015 – B1L02, L06L07[3]
2016 – L02L07
2017
2018 – B3T4, B2L12[3], L19L100[3]
2019 – L109T4[4], L100L109[5]

Notes

1. Breaker failed to operate Jan 2014. New breaker purchased for Hardwoods moved to Sunnyside
2. Breaker damaged during transformer fire.
3. Breaker scheduled for overhaul in 2014
4. Breaker scheduled for overhaul in 2015
5. Breaker scheduled for overhaul in 2014. Advanced to 2014 due to condition assessment.

d) Hardwoods

One (1) 230 kV air blast circuit breaker remains in service at Hardwoods Terminal Station. Early replacement will allow for the air system to be de-commissioned. It was scheduled for replacement in 2014 but has been swapped with a breaker at Sunnyside. It has been re-scheduled to 2015.

Breaker replacement schedule:
2015 – B1L01[1]

Notes:

1. Purchased in 2013, scheduled for installation in 2014 but moved to Sunnyside.

e) Oxen Pond

Oxen Pond Terminal Station contains two (2) 230 kV air blast circuit breakers. To coordinate with transformer upgrade / tie breaker design one breaker will be installed in 2014 and placed in service in 2015. The other breaker will be scheduled for 2016 to complete the station and enable the air system to be de-commissioned.

Breaker replacement schedule:
2014/15 – B1L18[1]
2015 – B1L36

Notes:

1. Breaker to be installed in 2014 but commissioned in 2015. Therefore it is not included in accelerated replacement program.

f) Bottom Brook

All four (4) 230 kV breakers at Bottom Brook Terminal Station are air blast circuit breakers. These breakers are scheduled for replacement by Emera in 2016 for the NL/NS link. The breakers are configured in a ring bus arrangement and Bottom Brook supplies the southwestern part of NL. The removal from service of each breaker will need to be carefully planned. Although treated separately, the replacement of breakers at Bottom Brook will need to be coordinated with the accelerated breaker replacement program. Hydro should explore the possibility of managing this work under the accelerated program. When complete the air system can be de-commissioned.

Breaker replacement schedule[1]:
2016 – B1B11, B1L09, L09L33, L11L33

Notes:

1. All breakers to be replaced by Emera as part of NL/NS link

g) Massey Drive

Massey Drive Terminal Station contains two (2) 230 kV air blast circuit breakers. They are scheduled for replacement in 2017. This schedule needs to be reviewed prior to initiating the work to replace the breakers at Bottom Brook. If transmission line TL211 can be removed from service then one breaker at Massey Drive and two at Bottom brook can be replaced simultaneously under the same outage.

Breaker replacement schedule:
2017 – B1L28, B5L11

h) Stony Brook

Stony Brook Terminal station contains six (6) 230 kV air blast breakers and six (6) 138 kV air blast breakers. The replacement program is included in Phase 2. Four breakers are scheduled per year with a mixture of 230 kV and 138 kV breakers each year. Most of the 138 kV breakers will require a line or transformer outage for the duration of the replacement work. Work on this station has been delayed until Phase 2 because all 230 kV breakers have been overhauled since 2008 and should be reliable. Some of the 138 kV breakers are scheduled for an overhaul in the next couple of years. Due to the large number of breakers to be replaced and the requirement for outages for the 138 kV work, the scheduling of this work will require extra discussion and be carefully planned to ensure reliability and to minimize outage times. The air system can be de-commissioned in 2020.

Breaker replacement schedule:
2018 – B2L04, L05L31, B3L130, B3T2
2019 – B1L31, L05L35, B1L32, B1L35
2020 – B3L22[1], B3L133[2], B3T1[2], B3L10[2]

Notes:

1. Breaker scheduled for overhaul in 2014
2. Breaker scheduled for overhaul in 2015

i) Western Avalon

Western Avalon contains six (6) 230 kV air blast circuit breakers. These are all scheduled for replacement in Phase 2.The primary reason is that all six breakers will have been overhauled between 2005 and 2014. Two breakers per year are scheduled for replacement. This assumes that all breakers continue to perform well regardless of model. If issues arise with a particular model (e.g. B1L03 is an older model type DCVF), then adjustments may need to be made in the schedule. This can be done during the annual review process.

Breaker replacement schedule:
2018 – B1L17, B1L37
2019 – B1L08, L03L17
2020 – L01L03[1], B1B3[2]

Notes:

1. Breaker scheduled for overhaul in 2014
2. Breaker scheduled for overhaul in 2015

j) Buchans

Buchans Terminal station contains four (4) 230 kV breakers. These breakers are scheduled for replacement over a two year period in 2019 – 2020 at the end of Phase 2. With overhauls recently completed or scheduled for the current year the reliability of the station should be good. Hence, the installation of replacement breakers can be delayed. The breakers are configured in a ring bus configuration that enables the removal of one breaker at a time without causing any outages. The air system can be de-commissioned in 2020.

Breaker replacement schedule:
2019 – L05L33, B1L05[1]
2020 – L28L32[1], B1L28[1]

Notes:

1. Breaker scheduled for overhaul in 2014

10) Conclusions and Recommendations

This report provides a plan for the implementation of an accelerated air blast circuit breaker program. During the current year, 2014, previously scheduled work to replace breakers, undertake breaker overhauls and perform preventive maintenance will occur. In addition preparation work for the accelerated program should begin in 2014 with tender preparation, selection of a partner/contractor and ordering the first set of breakers. Installation of the air blast circuit breakers would then take place over a 6-year period between 2015 and 2020. At the end of 2020 all 63 air blast circuit breakers that were on the Hydro system at the beginning of 2014 would be replaced.

This report includes a discussion of the many factors affecting the replacement of the air blast circuit breakers and provides a summary by year and location of each breaker to be replaced. Some of the key recommendations contained in the report are repeated below.

R1. Implement the accelerated air blast circuit breaker replacement program in two phases. The actual implementation may be done through separate contracts or a single contract with extension. This will minimize spares as well as ensure efficiencies in the implementation.

R2. Coordinate the accelerated air blast circuit breaker replacement programs with other breaker replacement programs including LCP and NL/NS link.

R3. Review the plan annually to ensure the specific breakers selected are the most appropriate for replacement and to address any scheduling and resource issues.

R4. Maintain a set of spares from recently replaced breakers to have available in case of premature failure of a still-in-service air blast circuit breaker.

Appendix 1

Accelerated Air Blast Breaker Replacement Program

Location	NLH ID	Year Built	Oper Volt (kV)	Overhaul Year	Replacement Year	Age at Replacement	Criticality
HRD TS	B1B11	1974	230	-	2014	40	B
HRD TS	B1L17	1973	230	2014	2014	41	B
HRD TS	B2B11	1974	230	-	2014	40	B
SSD TS	B1L03	1966	230	2002	2014	48	B
SSD TS	B2T1	1969	138	-	2014	45	C
BDE TS1	B1B2	1966	230	2004	2015	49	B
BDE TS1	B1T2	1966	230	1999	2015	49	A
BDE TS1	B2T3	1966	230	2000	2015	49	A
BDE TS1	B2T4	1968	230	2000	2015	47	A
HRD TS	B2L42	1973	230	2014	2015	42	B
HRD TS	B3B13	1978	230	-	2015	37	B
HRD TS	B3L18	1978	230	-	2015	37	B
HWD TS	B1L01	1972	230	NA	2015	43	B
OPD TS	B1L18	1969	230	2008	2015	46	B
OPD TS	B1L36	1969	230	2008	2015	46	B
SSD TS	B1L02	1966	230	2003	2015	49	B
SSD TS	L06L07	1968	230	2014	2015	47	B
BBK TS	B1L09	1971	230	-	2016	45	C
BBK TS	B1L11	1971	230	-	2016	45	C

BBK TS	L09L33	1973	230	-	2016	43	C
BBK TS	L11L33	1978	230	-	2016	38	C
BDE TS1	B1T1	1966	230	2002	2016	50	A
BDE TS1	B3T5	1969	230	2000	2016	47	A
BDE TS1	B3T6	1966	230	2001	2016	50	A
BDE TS1	B4B5	1964	230	2003	2016	52	B
HRD TS	B12B15	1978	230	-	2016	38	B
HRD TS	B12L17	1973	230	-	2016	43	B
HRD TS	B12L42	1978	230	-	2016	38	B
SSD TS	L02L07	1966	230	2002	2016	50	B
BDE TS1	B2B3	1968	230	2006	2017	49	B
BDE TS1	B3B4	1972	230	2005	2017	45	B
BDE TS1	B6B10	1968	230	2005	2017	49	B
MDR TS	B1L28	1966	230	2007	2017	51	C
MDR TS	B5L11	1967	230	2006	2017	50	C
BDE TS1	B1B10	1975	230	2014	2018	43	B
BDE TS1	B5B6	1968	230	2007	2018	50	B
SSD TS	B2L12	1966	138	2014	2018	52	D
SSD TS	B3T4	1966	138	2012	2018	52	C
SSD TS	L19L100	1966	138	2014	2018	52	D
STB TS	B2L04	1966	230	2011	2018	52	C
STB TS	B3L130	1968	138	2012	2018	50	D
STB TS	B3T2	1969	138	2012	2018	49	C
STB TS	L05L31	1969	230	2008	2018	49	C

WAV TS	B1L17	1969	230	2009	2018	49	B
WAV TS	B1L37	1968	230	2005	2018	50	B
BUC TS	B1L05	1973	230	2014	2019	46	C
BUC TS	L05L33	1973	230	2013	2019	46	C
SSD TS	L100L109	1968	138	2014	2019	51	D
SSD TS	L109T4	1968	138	2015	2019	51	C
STB TS	B1L31	1966	230	2008	2019	53	C
STB TS	B1L32	1968	230	2009	2019	51	C
STB TS	B1L35	1966	230	2010	2019	53	C
STB TS	L05L35	1966	230	2009	2019	53	C
WAV TS	B1L08	1968	230	2010	2019	51	B
WAV TS	L03L17	1969	230	2009	2019	50	B
BUC TS	B1L28	1975	230	2014	2020	45	C
BUC TS	L28L32	1972	230	2014	2020	48	C
STB TS	B3L10	1977	138	2015	2020	43	D
STB TS	B3L133	1969	138	2015	2020	51	D
STB TS	B3L22	1967	138	2014	2020	53	D
STB TS	B3T1	1969	138	2015	2020	51	C
WAV TS	B1B3	1977	230	2015	2020	43	B
WAV TS	L01L03	1969	230	2014	2020	51	B

APPENDIX C

Updated Work Methods for Maintenance on Air Blast Circuit Breakers
(Insulating Column, Interrupter Head)

Document is valid for 14 days from 07/31/2014

Standard Work Method - Approved

Work Method Number:	SWM-000318	Revision Number:	1
Created By:	Nalcor Administrator/NLHydro	Creation Date:	01/13/2010

Organizational Structure: Newfoundland & Labrador Hydro - Regulated Operations - Transmission & Rural Ops - Transmission & Rural Ops

Task Area: Stations - Breaker - Air Blast Circuit Breaker

Work Method Title: Interrupter Head (Air Blast Circuit Breaker) - Replace

Work Method Type: Procedure

1.0 Purpose:

This method to be used as a procedure for replacing the interrupter head on an Air Blast Circuit Breaker.

Following this procedure is very important when replacing interrupter head on Air Blast Breaker. Errors may result in personal injury and/or equipment damage.

2.0 Safety Summary

2.1 Safety Credo

- Take Ownership
- Get Involved
- Reach Out
- Speak Up

I always follow safety requirements and best practices.

I always take time to complete my work safely.

I always take action when I see unsafe acts or conditions.

2.2 Tailboard Safety Talk

A Tailboard Safety Talk is a vital part of job planning for hazard recognition and risk control. Tailboards must be conducted at the job site, prior to the start of all work.

2.3 Step Back 5 X 5

The Step Back 5 X 5 is a vital part of job performance for hazard recognition and risk control. Step Back 5 X 5 must be conducted during the ongoing progression of work, as situations change and/or as personnel (crew or team members) change.

3.0 Employees Involved

3.1 As part of the Internal Responsibility System (IRS), there shall be a person identified as being in charge of the work being performed. The Worker in Charge is a person designated to direct the work at one or more work sites. A worker in charge maybe a manager, foreman, supervisor, worker tradesman or other person designated by the employer. The safe performance of this work requires:

Identification of a Leadhand, at minimum

3.2 Prior to starting work, the Worker in Charge shall:

- Identify any new worker(s) in the crew and coach individually for hazard recognition, evaluation and control.
- Review the correct work method(s).
- Complete a tailboard identifying all hazards.
- Ensure that all workers are trained and have the proper PPE.

- Ensure all workers are aware of the controls in place to mitigate the hazards identified.

4.0 Employee Protection and Training Considerations

4.1 PPE

The PPE to consider to perform this work safely includes:
FR Clothing/Arc Flash Protection, Gloves - Leather Work Gloves, Head Protection - Hard Hat, High Visiblity Clothing, Safety Boots - Resistive, Safety Glasses

4.2 Skills Training:

The skill training to consider to perform this work safely includes:
Aerial Device Operation, Boom Truck Operation Training, Fall Protection Training, First Aid Training, High Voltage Switching, Rigging Training, VHF Radio Operation, Work Protection Code Training

4.3 Rules & Regulations:

The rules and regulations to consider to perform this work safely includes:
Minimum Approach Distances, Work Protection Code

4.4 Safety & Health:

The safety and health issues to consider to perform this work safely includes:
First Aid

4.5 Special Permits:

The permits to consider to perform this work safely includes:
Not Applicable

5.0 Risk Assessment Information

Please ensure you have reviewed/completed the TBRA document before performing this work method.

6.0 References

6.1 CorporateFallProtectionProgram

6.2 CorporateSafety&HealthHandbook

6.2.1 Section 4.10 Tailboard Meetings
6.2.2 Section 5.0 Personal Protective Equipment
6.2.3 Section 6.0 Tools and Equipment
6.2.4 Section 7.0 Electrical Safety
6.2.5 Section 7.11 Temporary Grounds
6.2.6 Section 8.0 Work on Overhead Structures
6.2.7 Section 10.0 Vehicles and Transportation

6.4 EnvironmentalEmergencyResponsePlan

6.5 Environmental Standard Operating Procedures

6.5.1 TRO-ENV-SOP-11 Handling&DisposalofPCBContainingEquipment

6.6 Manufacturer's Manual

6.7 National Standard of Canada: CAN/ULC-S801-10

6.7.1 Section 4.5 Personal Protective Equipment
6.7.2 Section 10.3 Hazardous Energy Control In The Electric Utility Industry

6.8 OccupationalHealth&SafetyRegulations

6.8.1 Section 140 Fall Protection Systems

6.9 WorkProtectionCodeBook

7.0 Recommended Tools And Equipment

7.1 Radial Boom Truck

7.2 Aerial Device

7.3 Grip-all Stick

7.4 High Voltage Tester

7.5 Portable Grounds

7.6 Extension Ladder

7.7 Metric Tools

7.8 "O" Ring

7.9 Tarps to cover hole during interrupter head removal.

8.0 Work Method Procedure

8.1 Establish work protection.

8.2 Test for no voltage.

8.3 Apply portable grounds to both sides of work area, using live line techniques (rubber gloves or insulated stick).

8.4 Position vehicles for lifting. Ground any aerial device used during the job. Use live line techniques when connecting portable grounds (rubber gloves or insulated stick).

8.5 Ensure breaker is closed, remove DC and AC controls from breaker.

8.6 Close air inlet valve.

8.7 Open air drain valve.

8.8 Drain breaker of air pressure.

8.9 Check boom angle versus weight capacity chart on boom. Inspect slings to ensure they are in good condition and to verify it will support the weight of the interrupter head.

8.10 Prior to removing interrupter, ensure precipitation is not excessive that could introduce moisture into the receiver tanks. If excessive, then do not proceed to remove interrupter head until weather conditions permit.

8.11 Remove interrupter head to be replaced using proper rigging techniques.

8.12 Once interrupter head is removed and in a safe place, install cover ontop of receiver tank to prevent moisture from entering the tank. This should be in place as soon as the interrupter head is removed.

8.13 Once new interrupter is ready to install, remove protective cover. Ensure that precipitation is not excessive while removing the cover.

8.14 Install replacement interrupter head (complete with new "O" Ring).

8.15 Close air drain valve.

8.16 Open air inlet valve and check the system to ensure no leaks.

8.17 Restore DC and AC controls to breaker (if applicable).

8.18 Complete applicable testing.

8.19 Remove portable grounds, using live line techniques (rubber gloves or insulated stick).

8.20 Surrender work protection.

8.21 Perform necessary clean-up and removal of all vehicles, equipment and tools.

9.0 Approvals & Verification

Reviewers:	Gary Broderick/NLHydro, John Baker/NLHydro, Patrick O'Grady/NLHydro, Tony Walker/NLHydro	Owners:	Harold Kean/NLHydro, Rodney Champion/NLHydro, Wade Hillier/NLHydro
Primary Reviewer:	Gary Broderick/NLHydro John Baker/NLHydro Patrick O'Grady/NLHydro Tony Walker/NLHydro	Primary Owner:	Harold Kean/NLHydro Rodney Champion/NLHydro Wade Hillier/NLHydro
Submitted By:	Lisa Ledrew/NLHydro	Submitted Date:	06/10/2010
Reviewed By:	Gary Broderick/NLHydro	Reviewed Date:	07/31/2014
Verified By:	Blaine O Piercey/NLHydro	Verified Date:	07/31/2014
Approved By:	Rodney Champion/NLHydro	Approved Date:	07/31/2014

- Verified by Gary Broderick/NLHydro, John Baker/NLHydro, Keith Saunders/NLHydro, Tony Walker/NLHydro on 6/14/2010 2:11:50 PM with the following reasons: Verification transferred from previous work method in TRO Work Methods Database.
- Verified for Keith Saunders/NLHydro by John Baker/NLHydro on 9/23/2010 11:20:56 AM with the following reasons: Verification transferred from previous work method in TRO Work Methods Database
- Not Verified by Lisa Ledrew/NLHydro on 5/30/2014 1:46:43 PM with the following reasons: To make changes
- Verified for Blaine O Piercey/NLHydro by Gary Broderick/NLHydro on 7/31/2014 3:44:19 PM with the following reasons: Verified June 24th, 2014

- Not Approved by Hughie Ireland/NLHydro, Tom Sheppard/NLHydro, Wade Hillier/NLHydro on 6/30/2010 9:29:41 AM with the following reasons: Please update method to include establishing test condition after installation of head is completed. Also consider whether steps to establish work protection need to be included after you state establish work protection.
- Not Approved by Hughie Ireland/NLHydro, Tom Sheppard/NLHydro, Wade Hillier/NLHydro on 10/27/2010 9:11:57 AM with the following reasons: Step 8.9 is referring to a current transformer not a breaker interupting head. Please correct.
- Approved by Rodney Champion/NLHydro on 7/31/2014 3:53:07 PM with the following reasons: Approval to work method based on changes required to minimize risk of moisture entering the breaker receiver tanks during the work.

Work Method History:

- Work Method created by Lisa Ledrew on 5/30/2014 1:55:53 PM
- Work Method reviewed by Gary Broderick on 7/31/2014 3:43:25 PM

Task Based Risk Assessment Worksheet - Approved

Interrupter Head (Air Blast Circuit Breaker) - Replace

TBRA-000318

Organizational Structure: Newfoundland & Labrador Hydro - Regulated Operations - Transmission & Rural Ops - Transmission & Rural Ops
Task Area: Stations - Breaker - Air Blast Circuit Breaker
Task Description: Interrupter Head (Air Blast Circuit Breaker) - Replace
Revision Number: 1

		HAZARD			INITIAL RISK			CONTROLS	RESIDUAL RISK		
Step #	Area/Task Step Description	Hazard Description	Hazard Effect	Population at Risk	Hazard Severity	Probability	Risk Rating	All Required Controls	Hazard Severity	Probability	Risk Rating
1	Possibile leaks containing PCB oil. (DLF Type Breaker)	Spills or contact.	Carcenogenic.	Workers.	5	2	10	Test if leaking. Wear PPE. Treat as containing PCB, if not leaking.	1	1	1
2	Establish work protection.	Inexperience or lack of training.	Death or serious injury from inadequate work protection.	Workers.	5	3	15	Use experienced worker trained in work protection code.	2	1	2
3	Working on breaker.	Working near energized electrical equipment.	Electrocution causing death or serious injury.	Worker.	5	4	20	Work protection (isolate & de-energize). Obtain minimum approach distance.	1	1	1
4	Working on breaker.	Working on pressurized equipment.	Death or serious injury from explosion.	Workers.	5	3	15	Establish work protection (drain air and isolate air supply).	1	1	1
5	Working on breaker.	Fall from height.	Death or serious injury.	Workers.	5	2	10	Fall protection. Inspect fall arrest equipment before use and be trained in proper use of fall arrest.	2	1	2
6	Operating aerial device.	Poor control from inexperinced operator, lack of training, & condition of equipment.	Death or serious injury.	Workers.	5	4	20	Use trained operator familiar with equipment. Perform pre-use check on equipment.	1	1	1
7	Lifting breaker components.	Drop breaker parts.	Death or serious injury.	Workers.	5	2	10	Use radial boom truck. Use experinced, trained operator. Use signal man during lifting. Make sure workers wear hard hats and keep clear during lift. Conduct pre-use inspection before lift.	1	1	1

Approvals & Verification

Reviewed By: Keith Saunders/NLHydro — Reviewed Date: 01/13/2011
Approved By: Rodney Champion/NLHydro — Approved Date: 07/31/2014

Approval History:
- Approved by Rodney Champion/NLHydro on 7/31/2014 3:55:36 PM with the following reasons:

TBRA History:

Team Lead Signature: ______________________ Approver Signature: ______________________ Date: ______________

Legend:

Area/fask Description:	Separate the task into individualsteps and rec:ord in sequence.
Hazard Description:	Describe allhazards idernified.NOTE:Additionalhaurds may be aused by interactionwith otherwork.
Hazard Effect:	Describe the effects of ea<:h identified ruu n::l.
Population at Risk:	Name all types of personnelat risk. Include people outside the work crew who maybe affec:ted.
Hazard Se11erity:	From matrUeidentify severitywithcornrols in place for each haurd.
Probability:	From matrUeidentify likelihoodof occurrance withcontrols in place for each haurd.
Risk Rating:	Classify risk rating from matrix for each haurd.
All RequiredControls:	Describe fullyallcornrolsput in place for each haurd.

Hazard Assessment/TBRA Worksheet

		Hazard Severity				
		Negligibleinjury,no absence tomwork	2 Minor injury requiring first aid treatment	3 Injury leading to a medical treatment incident	4 Involving a lost time injury	Fmliry
Probability	1 A freak occurrence of factors would be required for an incident to result.	1	2	3	4	5
	2 A rare combination of factors would be required for an incident to result.	2	4	6	8	10
	3 Could happen when additional factors are present but otherwise unlikelyto occur.	3	6	9	12	15
	4 Not certain to happen but an additional factor may result in an incident.	4	8	12	16	20
	5 Almost ine\rilablethat an incident would r	5	10	15	20	25

Task Based Risk Assessment (TBRA) Worksheet

TBRA - 000318

Organizational Structure: Newfoundland & Labrador Hydro - Regulated Operations - Transmission & Rural Ops - Transmission & Rural Ops
Task Area: Stations - Breaker - Air Blast Circuit Breaker
Task Description: Interrupter Head (Air Blast Circuit Breaker) - Replace

		HAZARD			INITIAL RISK			CONTROLS	RESIDUAL RISK		
Step #	Area/Task Step Description	Hazard Description	Hazard Effect	Population at Risk	Hazard Severity	Probability	Risk Rating	All Required Controls	Hazard Severity	Probability	Risk Rating

Team Lead Signature: ______________________ Approver Signature: ______________________ Date: ______________

Document is valid for 14 days from 07/31/2014

Standard Work Method - Approved

Work Method Number:	SWM-000317	Revision Number:	2
Created By:	Keith Saunders/NLHydro	Creation Date:	05/30/2014 12:00:00 AM

Organizational Structure: Newfoundland & Labrador Hydro - Regulated Operations - Transmission & Rural Ops - Transmission & Rural Ops
Task Area: Stations - Breaker - Air Blast Circuit Breaker

Work Method Title: Insulating Column (Air Blast Circuit Breaker) - Replace
Work Method Type: Procedure

1.0 Purpose:

This method is to be used as a procedure for replacing an insulating column on an air blast breaker.

The function of an insulating column on an air blast breaker is to carry air to; and support the interrupter head.

Following this procedure when replacing an insulating column is very important. Errors may result in personal injury and/or equipment damage.

2.0 Safety Summary

2.1 Safety Credo

- Take Ownership
- Get Involved
- Reach Out
- Speak Up

I always follow safety requirements and best practices.

I always take time to complete my work safely.

I always take action when I see unsafe acts or conditions.

2.2 Tailboard Safety Talk

A Tailboard Safety Talk is a vital part of job planning for hazard recognition and risk control. Tailboards must be conducted at the job site, prior to the start of all work.

2.3 Step Back 5 X 5

The Step Back 5 X 5 is a vital part of job performance for hazard recognition and risk control. Step Back 5 X 5 must be conducted during the ongoing progression of work, as situations change and/or as personnel (crew or team members) change.

3.0 Employees Involved

3.1 As part of the Internal Responsibility System (IRS), there shall be a person identified as being in charge of the work being performed. The Worker in Charge is a person designated to direct the work at one or more work sites. A worker in charge maybe a manager, foreman, supervisor, worker tradesman or other person designated by the employer. The safe performance of this work requires:

Identification of a Leadhand, at minimum

3.2 Prior to starting work, the Worker in Charge shall:

- Identify any new worker(s) in the crew and coach individually for hazard recognition, evaluation and control.
- Review the correct work method(s).

- Complete a tailboard identifying all hazards.
- Ensure that all workers are trained and have the proper PPE.
- Ensure all workers are aware of the controls in place to mitigate the hazards identified.

4.0 Employee Protection and Training Considerations

4.1 PPE

The PPE to consider to perform this work safely includes:
Fall Protection, FR Clothing/Arc Flash Protection, Gloves - Leather Work Gloves, Head Protection - Hard Hat, High Visiblity Clothing, Safety Boots - Resistive, Safety Glasses

4.2 Skills Training:

The skill training to consider to perform this work safely includes:
Aerial Device Operation, Boom Truck Operation Training, First Aid Training, High Voltage Switching, Rigging Training, VHF Radio Operation, Work Protection Code Training

4.3 Rules & Regulations:

The rules and regulations to consider to perform this work safely includes:
Minimum Approach Distances, Work Protection Code

4.4 Safety & Health:

The safety and health issues to consider to perform this work safely includes:
First Aid

4.5 Special Permits:

The permits to consider to perform this work safely includes:
Not Applicable

5.0 Risk Assessment Information

Please ensure you have reviewed/completed the TBRA document before performing this work method.

6.0 References

6.1 CorporateFallProtectionProgram

6.2 CorporateSafety&HealthHandbook

6.2.1 Section 4.10 Tailboard Meetings
6.2.2 Section 5.0 Personal Protective Equipment
6.2.3 Section 6.0 Tools and Equipment
6.2.4 Section 7.0 Electrical Safety
6.2.5 Section 7.11 Temporary Grounds
6.2.6 Section 8.0 Work on Overhead Structures
6.2.7 Section 10.0 Vehicles and Transportation

6.4 EnvironmentalEmergencyResponsePlan

6.5 Environmental Standard Operating Procedures

6.5.1 TRO-ENV-SOP-11 Handling&DisposalofPCBContainingEquipment

6.6 Manufacturer's Manual

6.7 National Standard of Canada: CAN/ULC-S801-10

6.7.1 Section 4.5 Personal Protective Equipment
6.7.2 Section 10.3 Hazardous Energy Control In The Electric Utility Industry

6.8 OccupationalHealth&SafetyRegulations

6.8.1 Section 140 Fall Protection Systems

6.9 WorkProtectionCodeBook

7.0 Recommended Tools And Equipment

7.1 Radial Boom Truck

7.2 Aerial Device

7.3 Metric Tool Box

7.4 Grip-All Stick

7.5 Portable Grounds

7.6 High Voltage Tester

7.7 5 kV Insulation Tester (If required)

7.8 Extension Ladder

7.9 Lifting Slings

7.10 Motion Analyzer (If required)

7.11 Tarps to cover holes, while interrupters are removed.

8.0 Work Method Procedure

8.1 Establish work protection.

8.2 Test for no voltage.

8.3 Apply portable grounds to both sides of work area, using live line techniques (rubber gloves or insulated stick).

8.4 Ground any aerial device used during the job. Use live line techniques when connecting portable grounds (rubber gloves or insulated stick).

8.5 Close breaker. Breaker will fall close with no air.

8.6 Remove DC and AC controls from breaker.

8.7 Close air inlet valve.

8.8 Open air drain valve.

8.9 Drain breaker of air pressure.

8.10 Prior to removing interrupter ensure precipitation is not excessive that could introduce moisture into the receiver tanks. If excessive, then do not proceed.

8.11 Remove interrupter head from the column.

8.12 Once interrupter head is removed and there will be a substantial amount of time to remove the column, then cover the top of column to prevent moisture from entering the receiver tank.

8.13 Remove column.

8.14 Once column is removed and there will be a substantial amount of time between removal and installation, cover the receiver tank hole with cover to prevent moisture from entering receiver tank.

8.15 Once column and/or interrupter are ready to be replaced, remove the cover (only if there is no excessive precipitation).

8.16 Install replacement column.

8.17 Re-install interrupter on the new column.

8.18 Torque all bolts to manufacturer's specifications.

8.19 Close air drain valve.

8.20 Open air inlet valve, check to ensure no leaks.

8.21 Restore AC and DC controls (If applicable).

8.22 Operate breaker to test for air leaks.

Note: No air in heads unless breaker open.

8.23 Complete timing testing on breaker.

8.24 Remove portable grounds, using live line techniques (rubber gloves or insulated stick).

8.25 Surrender work protection.

8.26 Perform necessary clean-up and removal of all vehicles, equipment and tools.

9.0 Approvals & Verification

Reviewers:	Gary Broderick/NLHydro, John Baker/NLHydro, Patrick O'Grady/NLHydro, Tony Walker/NLHydro	Owners:	Harold Kean/NLHydro, Rodney Champion/NLHydro, Wade Hillier/NLHydro
Primary Reviewer:	Gary Broderick/NLHydro John Baker/NLHydro Patrick O'Grady/NLHydro Tony Walker/NLHydro	Primary Owner:	Harold Kean/NLHydro Rodney Champion/NLHydro Wade Hillier/NLHydro
Reviewed By:	Gary Broderick/NLHydro	Reviewed Date:	07/31/2014
Verified By:	Blaine O Piercey/NLHydro	Verified Date:	07/31/2014
Approved By:	Rodney Champion/NLHydro	Approved Date:	07/31/2014

- Verified for Blaine O Piercey/NLHydro by Gary Broderick/NLHydro on 7/31/2014 3:42:34 PM with the following reasons: Verified June 24th, 2014

- Approved by Rodney Champion/NLHydro on 7/31/2014 3:50:38 PM with the following reasons: Approval to work method based on changes required to minimize risk of moisture entering the breaker receiver tanks during the work.

Work Method History:

- Work Method created by Keith Saunders on 5/30/2014 2:03:42 PM
- Work Method reviewed by Gary Broderick on 7/31/2014 3:41:29 PM

Task Based Risk Assessment Worksheet - Approved

Insulating Column (Air Blast Circuit Breaker) - Replace
TBRA-000317

newfoundland labrador hydro
a nalcor energy company

Organizational Structure: Newfoundland & Labrador Hydro - Regulated Operations - Transmission & Rural Ops - Transmission & Rural Ops
Task Area: Stations - Breaker - Air Blast Circuit Breaker
Task Description: Insulating Column (Air Blast Circuit Breaker) - Replace
Revision Number: 1

		HAZARD			INITIAL RISK			CONTROLS	RESIDUAL RISK		
Step #	Area/Task Step Description	Hazard Description	Hazard Effect	Population at Risk	Hazard Severity	Probability	Risk Rating	All Required Controls	Hazard Severity	Probability	Risk Rating
1	Possibile leaks containing PCB oil. (DLF Type Breaker)	Spills or contact.	Carcenogenic.	Workers.	5	2	10	Test if leaking. Wear PPE. Treat as containing PCB, if not leaking.	1	1	1
2	Establish work protection.	Inexperience or lack of training.	Death or serious injury from inadequate work protection.	Workers.	5	3	15	Use experienced worker trained in work protection code.	2	1	2
3	Working on breaker.	Working near energized electrical equipment.	Electrocution causing death or serious injury.	Worker.	5	4	20	Work protection (isolate & de-energize). Observe minimum approach distance.	1	1	1
4	Working on breaker.	Working on pressurized equipment.	Death or serious injury from explosion.	Workers.	5	3	15	Establish work protection (drain air and isolate air supply).	1	1	1
5	Working on breaker.	Fall from height.	Death or serious injury.	Workers.	5	2	10	Use fall protection. Inspect fall arrest equipment before use and be trained in proper use of fall arrest.	2	1	2
6	Operating aerial device.	Poor control from inexperinced operator, lack of training, & condition of equipment.	Death or serious injury.	Workers.	5	4	20	Use trained operator familiar with equipment. Perform pre-use check on equipment.	1	1	1
7	Lifting breaker components.	Drop breaker parts.	Death or serious injury.	Workers.	5	2	10	Use radial boom truck. Use experinced, trained operator. Use signal man during lifting. Make sure workers wear hard hats and keep clear during lift. Conduct pre-use inspection before lift.	1	1	1

Approvals & Verification

Reviewed By: Keith Saunders/NLHydro — Reviewed Date: 01/13/2011
Approved By: Rodney Champion/NLHydro — Approved Date: 07/31/2014

Approval History:
- Approved by Rodney Champion/NLHydro on 7/31/2014 3:57:38 PM with the following reasons:

TBRA History:

Team Lead Signature: ____________________ Approver Signature: ____________________ Date: ____________

Legend:

Area/fask Description: Separate the task into individualsteps and rec:ord in sequence.
Hazard Description: Describe allhazards idernified.NOTE:Additionalhaurds may be aused by interaction with otherwork.
Hazard Effect: Describe the effects of ea<:h identified ruu n::l.
Population at Risk: Name all types of personnelat risk. Include people outside the work crew who maybe affec:ted.
Hazard Se11erity: From matrUeidentify severitywithcornrols in place for each haurd.
Probability: From matrUeidentify likelihood of occurrance withcontrols in place for each haurd.
Risk Rating: Classify risk rating from matrix for each haurd.
All RequiredControls: Describe fullyallcornrolsput in place for each haurd.

Hazard Assessment/TBRA Worksheet

		Hazard Severity				
		Negligibleinjury,no absence tomwork	2 Minor injury requiring first aid treatment	3 Injury leading to a medical treatment incident	4 Involving a lost time injury	Fmliry
Probability	1 A freak occurrence of factors would be required for an incident to result.	1	2	3	4	5
	2 A rare combination of factors would be required for an incident to result.	2	4	6	8	10
	3 Could happen when additional factors are present but otherwise unlikely to occur.	3	6	9	12	15
	4 Not certain to happen but an additional factor may result in an incident.	4	8	12	16	20
	5 Almost ine\rilablethat an incident would r	5	10	15	20	25

Task Based Risk Assessment (TBRA) Worksheet

TBRA - 000317

Organizational Structure: Newfoundland & Labrador Hydro - Regulated Operations - Transmission & Rural Ops - Transmission & Rural Ops
Task Area: Stations - Breaker - Air Blast Circuit Breaker
Task Description: Insulating Column (Air Blast Circuit Breaker) - Replace

		HAZARD			INITIAL RISK			CONTROLS	RESIDUAL RISK		
Step #	Area/Task Step Description	Hazard Description	Hazard Effect	Population at Risk	Hazard Severity	Probability	Risk Rating	All Required Controls	Hazard Severity	Probability	Risk Rating

Team Lead Signature: ______________________ Approver Signature: ______________________ Date: ______________

APPENDIX D

Terminals Engineering Standard TS09-001 – “Outdoor Power Circuit Breaker”

TERMINALS ENGINEERING STANDARD

OUTDOOR POWER CIRCUIT BREAKERS

STANDARD TS09-001

SPECIFICATION NO. 20XX-XXXXX

Approved for Release **Date**

Table of Contents

APPENDICES

1.0 General Requirements

1.1 This standard covers the design, manufacture, testing, supply and delivery of each circuit breaker (hereinafter called “Equipment”) complete with all auxiliary components, spare parts and special tools as described in this standard.

1.2 For circuit breakers rated 245 kV and below, equipment shall be designed to operate in an ambient temperature range of -35^{o}C to +40^{o}C unless otherwise specified in Appendix A.

1.3 For 800 kV class circuit breakers, equipment shall be designed to operate in an ambient temperature range of -50^{o}C to +40^{o}C.

1.4 Equipment shall be designed to withstand winds up to 160 km/h and 25 mm of ice in a marine high humidity corrosive environment.

1.5 Vendor shall have service personnel and facilities in Canada or United States for repair of supplied Equipment.

1.6 Equipment shall be a standard proven design reflecting contemporary practice and not incorporating any new designs, components or component arrangements which may be considered prototype. Equipment must have a proven service record under the service conditions equal to those stated in this standard. If required by Purchaser, Tenderer must submit with its Tender a list of other units in service in similar operating requirements as those specified in this standard.

1.7 Four-(4) weeks after receiving order, Vendor shall furnish two-(2) copies of the following documents for Purchaser’s review and acceptance:

(a) all documents certifying that the design work is complete and conforms with the terms of the purchase order,
(b) detailed technical literature,
(c) any other information and Drawings in sufficient detail to enable Purchaser to finalize the general arrangement, mounting details, buswork and schematics for the Equipment.

1.8 Following the documentation review, Purchaser shall return one-(1) copy of the documents stamped "Reviewed", or "Reviewed as Noted".

Upon receipt of Drawings and data stamped "Reviewed as Noted", Vendor shall modify the Drawings and data and any other Drawings and data affected by such modification and resubmit them to Purchaser for review. Modification and resubmission shall continue until such time as the Drawings and data are stamped "Reviewed".

1.9 No later than thirty-(30) days before scheduled shipment of the Equipment, Vendor shall furnish to the Purchaser, one-(1) complete set of all Drawings and data either electronically or on an electronic media. All Drawing files shall be compatible with .dwg extension using the latest version of AutoCAD.

1.10 Vendor shall furnish four-(4) copies of the operation and maintenance manuals two-(2) weeks prior to shipment of the Equipment. The complete operation and maintenance manuals shall include test reports, device data sheets including bushings, all Drawings, spare parts lists, MSDS sheets, CT curves, torque values and all other relevant information. An electronic copy, on electronic media, shall be included with each manual. Electronic documents shall be arranged through the use of hyperlinks to navigate between the table of contents and the body of the text.

1.11 One-(1) operation and maintenance manual shall be included with the Equipment at the time of shipment.

1.12 Purchaser shall be advised of any and all factory test failures which occur. A written report shall be supplied indicating the corrective action(s) taken.

1.13 Vendor shall be responsible for delivery of Goods to the F.O.B. Point. Vendor shall note that documentation shall be delivered to the address (es) stated on the requisition.

1.14 If Vendor fails to deliver the Goods on the delivery date stated in the Purchase Order, and such delay is not occasioned by Force Majeure, Vendor shall discount its Purchase Price, exclusive of taxes, stated therein by the sum of two percent (2%) per week for each of the first three-(3) calendar weeks of late delivery and one percent (1%) per calendar week for each subsequent week of the late delivery to a maximum of ten percent (10%) of the Purchase Price. Vendor hereby confirms and agrees that the aforesaid late delivery charges are reflective of the actual costs and damages to be sustained by Purchaser should a delay occur and Vendor hereby waives any right to dispute or challenge the amount of these charges and shall not take issue with or challenge such amounts in any legal proceedings that may be commenced concerning this Purchase Order / Contract.

2.0 Codes and Standards

Equipment shall be designed, manufactured, tested, and supplied in accordance with the latest edition of all applicable codes and standards as listed. The list of standards may not be exhaustive, and does not modify the legal obligations of the Vendor who is asked to comply with any further standard, regulation and legislation which may be relevant.

The editions indicated were valid at the time of calling the Tender. Vendor shall bear in mind that standards are subject to revision; their most recent edition shall always be applied.

In case of any conflict between codes, between standards, or between codes and standards, such conflict shall be brought to the attention of Purchaser for clarification and determination.

62271-1	High-Voltage Switchgear and control gear - Part 1 : Common Specifications
60137	Insulated Bushings for Alternating Voltages above 1000 Volts
62271-100	High-Voltage Switchgear and control gear - Part 100: Alternating current circuit breakers
C37.010	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
C37.011	Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers
C37.012	Application Guide for Capacitance Current Switching for AC High-Voltage Circuit Breakers
C37.04	IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
C37.06	AC High-Voltage Circuit Breakers Rated on Symmetrical Current Basis Preferred Ratings and Related Required Capabilities for Voltages Above 1000V
C37.081	IEEE Guide for Synthetic Fault Testing of AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
C37.09	IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
C37.11	Standard Requirements for Electrical Control for AC High-Voltage

	Circuit Breakers Rated on a Symmetrical Current Basis.
C37.12	Specification Guide for AC High-Voltage Circuit Breakers Based on a Symmetrical Current Basis
C37.90.1	IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
C37.100	Standard Definitions for Power Switchgear
C37.99	IEEE Guide for the Protection of Shunt Capacitor Banks
ISO 9001	Quality Control Program
EEMAC Y1-2	Performance Specification for Finishing Systems for Outdoor Electrical Equipment.
C22.2 NO. 127-09	Equipment and Lead Wires
CSA-C60044-1:07	Instrument Transformers Part 1: Current Transformers
NEMA CC-1	Electrical Power Connection for Substations
NEMA SG 6	Power Switching Equipment

Additional Standards applicable to 800 kV Class Breakers

IEC 60600-1	Alloys for Gas-Filled High-Voltage
IEC 61000-4-2	High Voltage Test Techniques – Part 1
	Electromagnetic compatibility (EMC) - Part 4-2: Testing and
IEC 61462	measurement techniques - Electrostatic discharge immunity test
IEC 62155	Composite hollow insulators
	Hollow pressurized and unpressurized ceramic and glass insulators
	for use in electrical equipment with rated voltages greater than
IEC 62271-1	1,000 V
	High Voltage Switchgear and Control Gear – Part 1: Common
IEC 62271-100	Specifications
	High Voltage Switchgear and Control Gear – Part 100: Alternating-current circuit-breakers
IEC 62271-101	High Voltage Switchgear and Control Gear – Part 101: Synthetic testing
IEC 62271-102	High Voltage Switchgear and Control Gear – Part 102: Alternating current disconnectors and earthing switches
IEC 62271-110	High Voltage Switchgear and Control Gear – Part 110: Inductive Load Switching

3.0 Technical Requirements

3.1 General

3.1.1 Each circuit breaker shall be supplied complete with a steel structure suitable for mounting on a concrete foundation. Each circuit breaker structure shall be double cross-braced on each side to prevent vibration and shall be supported using only concrete pads and anchor bolts. The steel structure shall include a hot-dipped galvanized steel platform complete with mounting steps to allow maintenance personnel to perform maintenance work within the circuit breaker control cabinet. Vendor shall ensure the minimum heights between live parts and circuit breaker base as listed in the Appendix A "Technical Requirements" shall be maintained.

3.1.2 The steel structure shall have two-(2) 2-hole NEMA drilled stainless steel faced terminal pads located on diagonally opposite corners of the structure. These holes shall be located 400 mm above the base of the structure for the purpose of grounding.

3.1.3 The circuit breaker shall be electrically, mechanically, (if applicable) trip free with anti-pumping circuits.

3.1.4 All pressure gauges, density meters and the circuit breaker position indicator shall be readily visible from ground level without opening doors, covers, or shields. All pressure gauges and density meters shall have a red-yellow-green colour scheme as well as graduated markings showing a numerical scale for the complete range of the device. Each phase shall be gauged individually for all voltage classes of Equipment and be temperature corrected. The Standard of Acceptance shall be: Wika Model 233.52.100 (GDM) with auxiliary contacts and Gas Density Transmitter or approved equal.

3.1.5 Circuit breaker nameplate must be made of stainless steel, with all breaker specifications engraved and blackened.

3.1.6 All moving parts shall be guarded. During operation, the circuit breaker shall be equipped with an over pressure device positioned so as not to impose danger to personnel or nearby equipment.

3.1.7 Circuit breaker that are manufactured with a spring operating mechanism design, shall be able to undergo one- (1) trip - close - trip cycle and restoration of full energy within 10 seconds after trip cycle operation. For 800 kV Class circuit breakers refer to Section 4.0 for operating sequence requirements.

3.1.8 For SF6 type, Vendor shall fit the circuit breaker with a 1/2 inch NPT male fitting, Type DILO #DN8, accessible from the ground level. Vendor shall supply two-(2) metres of flexible hose with 1/2 inch female swivel connectors Type DILO #DN8 at each end for filling circuit breaker with SF6 gas. Vendor shall supply one-(1) gas regulator with each circuit breaker.

3.2 Low Voltage Wiring

3.2.1 All wiring shall be Type SIS 41 strand wire, 90°C, 600 volts with colour black insulation AWM Style 1015 as per Section 2.0 Codes and Standards. The minimum wire size shall be #14 AWG.

Current transformer leads shall be #8 AWG as a minimum. All wires shall be terminated with ring tongue, non-split, nylon insulated compression type connectors.

3.2.2 All wiring for auxiliary components shall be #12 AWG, Type SIS 41 strand wire, 90°C, 600 volts with colour black insulation AWM Style 1015 as per Section 2.0 Codes and Standards.

3.2.3 Vendor shall provide white marking tags at both ends of all wiring to clearly identify all wiring terminations as shown on Drawings.

3.2.4 All wiring shall be terminal to terminal. Splices or tee-connectors are not acceptable. No more than two wires shall be connected to any one terminal.

3.2.5 Vendor shall arrange all wiring in a neat and quality manner. All wiring shall be placed in a wire duct system that is covered and securely fastened to the rear panel of the cabinet.

3.2.6 All terminal blocks for C.T. wiring shall be sliding disconnect link type, fire self-extinguishing. Standard of Acceptance shall be States Multi-Amp, Type NT-ZWM or approved equal.

3.2.7 All other terminal blocks shall be DIN rail mounted, mechanically bolted with a feed through connection, sliding link, minimum voltage level 600V and wire range 22 – 10 AWG. Standard of Acceptance shall be Phoenix OTTA6-T P/P or approved equal. A minimum of twelve-(12) spare terminals shall be supplied for Purchaser's future use.

3.2.8 Vendor shall arrange the circuit breaker with a separate phase cabinet for all CT secondary components. The CT cabinet shall be adjacent and connected to the control cabinet. All CT secondary wiring shall be terminated within the control cabinet.

3.2.9 Vendor shall maintain a minimum spacing of 100 mm (4") between the outside edges of all terminal blocks and from all four sides of the cabinet. All terminal blocks and relays shall be mounted on a back panel located at the rear of the control cabinet. The sides of the cabinet shall be left unused. Vendor shall make all internal connections on inside of terminal blocks only. The outside of the terminal blocks shall be left for Purchaser's use and clearly indicated on manufacturer's Drawings "For Customer Use". The bottom of the cabinet shall be left clear to facilitate entry and termination of Purchaser's cables. All equipment and terminal blocks shall be located so that they shall not interfere with the wiring and termination of cables.

3.2.10 All control cables running on the exterior of the circuit breaker shall be in rigid hot-dip galvanized conduit with matching end terminals at points of entrance cabinets and field devices.

3.3 Insulating Medium

3.3.1 Circuit breakers shall be supplied with a gas quantity to fully field test each circuit breaker and completely fill the circuit breaker to its operating density.

3.3.2 Circuit breakers rated 245 kV and below shall be designed to operate under the stated environmental conditions using pure SF6 gas. Heaters shall not be accepted.

3.3.3 Each phase of the circuit breaker shall have a separate gas system isolated from the other two phases. Each phase shall have its own three-way valve, density gauge and fill point.

3.3.4 Vendor shall supply one-(1) three-way ball valve as part of the gas system to enable the Purchaser to test and verify alarm and lockout points. The three-way valve shall have a center-off orientation.

3.4 Control Cabinet and Spring Mechanism Cabinet

3.4.1 The control cabinet shall be a stainless steel NEMA-4X enclosure.

3.4.2 The control cabinet doors shall use a three point latch mechanism, complete with padlocking facilities suitable for a 10 mm shank.

3.4.3 A drip shield shall be provided over the control cabinet doors.

3.4.4 The control cabinet shall be equipped with the following accessories:

(a) one-(1) 120 VAC, 900 lumen light source, switched by the opening of the cabinet door;

(b) one-(1) 125VAC, 20A, ground fault interrupter (GFI) duplex receptacle;

(c) one-(1) anti-condensation heater thermostatically controlled to maintain a cabinet temperature of approximately 10^{o}C in an ambient of -30^{o}C (or for 800kV Class circuit breakers, in the minimum ambient temperature as defined in Appendix B). The anti-condensation heater shall be mounted so as not to impede or obstruct the free access of wiring and cabling and allow for the entry of Purchaser's cabling through the bottom of the control cabinet.

(d) one-(1) ground bus to individually ground each set of current transformer leads and all other circuits requiring ground points.

(e) one-(1) stainless steel nameplate containing the gas type and filling chart information. The nameplate shall be fastened to the inside of a cabinet door.

3.5 Bushings and H.V. Terminals

3.5.1 All bushings shall be porcelain. Bushing creepage shall be as stated in Appendix A "Technical Requirements".

3.5.2 The terminals shall be 4-hole NEMA drilled and be compatible for bolting to a flat 4-hole NEMA drilled aluminum jumper terminal. The terminal shall be capable of withstanding a horizontal pull of 1300 N. For 800 kV circuit breaker terminal requirements refer to section 4.0.

3.6 Gas Monitoring System

3.6.1 Circuit breaker shall be equipped with a gas monitoring system. The gas monitoring system shall contain a display for local readout mounted external to circuit breaker and control cabinets and be easily viewed from ground elevation and shall not require the cabinet to be opened. The gas monitoring system shall provide the following auxiliary alarm signal contacts as a minimum:

a) "low gas density" or alarm condition;

b) "lockout" condition;

If available, additional auxiliary contacts shall be used for the following:

a) "fill up";

b) "over pressure".

3.6.2 Vendor shall provide a means for Purchaser to remotely monitor each breaker. The remote system shall consist of an adequate number of auxiliary contacts complete with a gas density transmitter to monitor SF6 gas density and pressure readouts remotely. Vendor shall provide a system to provide the ambient temperature of the Equipment.

The gas density transmitter shall transmit a 4-20mA output and be operational to a -40°C ambient (or if ambient stated in Appendix B is lower than -40C, the ambient stated in Appendix B shall be used). The Standard of Acceptance: WIKA Field Case Design Model GD-10.

Purchaser will develop the communication network to transmit the data to a remote database system.

3.6.3 On-Line Condition Monitoring (Optional):

On-Line Condition Monitoring is to be included if indicated in Appendix A.

The On-line Condition Monitoring system for each breaker shall monitor, maintain historical records, trend and alarm the following:

a. SF6 gas density and leakage rate
b. Breaker contact wear
c. Breaker travel and operating time (open and close)
d. Primary contacts separation speed, buffering and over travel
e. Trip and close coils continuity, voltage, and absorbed current versus time
f. Auxiliary supply and heater integrity
g. Spring charging motor current and operating time

All field end sensors, including their wiring, mounting and connections shall be included.

The monitor shall include the required Windows based software to accomplish the following:

a. Set up
b. Records display, analysis
c. Communications
d. File management

Local Interface:

a. LCD display and keypad
b. Self monitoring status relay
c. Minimum of 4 configurable output relays
d. Self monitoring status LED
e. Minimum of 4 local LED indicators

Communication requirements:

a. One RS232 port for local communication with a laptop
b. One isolated RS485 port with DNP-3,protocol

3.7 Control Cabinet Accessories

3.7.1 The close and trip circuits of the circuit breaker shall be separately fused, have a ganged knife switch for each circuit and be lockable. Fusing shall be type HRCI-R, 250 V, fast acting type.

3.7.2 Vendor shall supply a mechanical indicator for close and open positions of the circuit breaker. The "CLOSE/OPEN" indicator shall be visible from ground elevation and not require the cabinet to be opened.

3.7.3 The circuit breaker shall not give false indication of the "CLOSE/OPEN" state of any of its phases under any failure mode.

3.7.4 Circuit breaker shall be equipped with the following manual controls;

(a) "TRIP-OFF-CLOSE" control switch with spring return to "OFF" from both positions,

(b) "LOCAL/REMOTE" selector switch,

3.7.5 All incoming supplies shall be protected with fusing. In addition, the incoming supplies shall have the ability to be isolated with a lockable disconnecting means suitable for visible isolation.

3.7.6 A minimum of six-(6) reversible "a" contacts and six-(6) reversible "b" contacts per phase shall be provided for breakers with three-(3) independent poles. All contacts shall be anti-corrosive.

3.7.7 For breakers with three-(3) interconnected poles, the breaker shall be supplied with six-(6) reversible "a" contacts and six-(6) reversible "b" contacts, per breaker. All contacts shall be anti-corrosive.

3.7.8 For the safety of maintenance personnel, a close and/or trip blocking device shall be provided for each circuit breaker. Key operated device is not acceptable. A warning sign indicating "DO NOT WORK ON BREAKER IN CLOSED POSITION WITHOUT MAINTENANCE TRIP BLOCKING DEVICE IN PLACE" shall be placed near the operating mechanism.

3.7.9 Motors shall have open drip proof enclosures, Class A insulation, with a 40^{o}C rise above ambient temperature.

3.7.10 Circuit breakers shall be supplied with two-(2) sets of trip coils per phase for 230 circuit breakers and two-(2) trip coils per breaker for 66 and 138 kV circuit breakers.

3.8 Spare Parts and Special Tools

3.8.1 Vendor shall supply pricing for a list of recommended spare parts and special tools. The spare parts list shall contain components the manufacture believes are critical to the operation of the circuit breaker. The spare parts list shall contain the following items, as a minimum:

a) one-(1) spring charge mechanism;
b) two-(2) trip coils; and
c) two-(2) close coils.

3.8.2 Vendor shall supply pricing for any special tooling that is required to install the spare parts or to complete regular maintenance activities.

3.8.3 The spare parts list and special tools are optional items for Purchaser.

3.9 Ratings

3.9.1 For each voltage class, Appendix A and Appendix B specifies the technical requirements for the Equipment. Vendor shall refer to the voltage class specified with the Tender.

3.9.2 Equipment of a higher capability than defined in Appendix A and Appendix B shall be stated in Tender and if accepted, the nameplate shall be stamped with the higher rating.

3.10 Bushing Current Transformers

3.10.1 The continuous current rating factor for all bushing type current transformers shall not be less than 1.5 times rated current.

3.10.2 The secondary ratings and required quantity of CT's shall be stated either in Appendix A and / or on the Purchase Order / Contract.

4.0 Additional Requirements for 800kV Class Circuit Breakers

4.1 The rated peak withstand current (I_p) as defined in IEC 62271-100 shall be 2.7 times the rated short-time withstand current (I_k).

4.2 The required operating sequence is:

O – 0.3 s – CO – 3min - CO

4.3 800 kV Class circuit breakers shall be designed to operate under the stated environmental conditions using an SF6/CF4 gas mixture. Heaters shall not be accepted.

4.4 800 kV Class circuit breakers terminals shall be 6-hole NEMA drilled and be compatible for bolting to a flat 6-hole NEMA drilled aluminum jumper terminal. The terminal shall be capable of withstanding a horizontal pull of 2000 N.

4.5 800 kV Class circuit breakers shall be supplied with two-(2) sets of trip coils per phase.

4.6 When closing resistors are specified as being required in Appendix A “Optional Requirements” they shall be designed and tested as described in IEC 62271-1 and 62271-100.

4.7 The circuit breaker shall be equipped with a desiccant in order to absorb the humidity in the gas. The type and quantity of desiccant shall be specified by the manufacturer. Also, the desiccant shall not absorb a significant quantity of gas nor reduce significantly the pressure for the specified minimum and maximum temperature range. The manufacturer shall guarantee at least a 20 years life span for the desiccant.

4.8 Voltage grading capacitors installed at the terminals of the circuit breakers

The grading capacitors shall be able to withstand a voltage of 2.0 * Ur, for 2 hours in phase opposition condition without damage or reduction of their life span and to withstand a voltage of 1.1 Ur for an indeterminate time.

The grading capacitors shall be designed to withstand the mechanical forces and the vibrations occurring during normal service conditions as those caused by circuit breaker operation, by the wind and by the presence of ice.

The circuit breakers equipped with only one interrupting unit per pole shall be supplied without a capacitor at the terminals of the interrupting chambers.

800 kV Circuit breakers having an interrupting capability of 50 kA can be supplied with capacitors mounted in parallel with the interrupting chambers, but their equivalent capacitance shall be limited as follows :

500 pF for the 800 kV circuit breakers.

4.9 800 kV circuit breakers shall be single-pole controlled.

4.10 When heating is essential to the proper operation of the low voltage material, monitoring of the heating circuit is required. It shall be assured in the following way :

.1 A loss of power supply voltage relay on each phase, download to the fuses of the heating circuit, signals the loss of AC voltage;

.2 An alarm thermostat, in each cabinet requiring heating, signals a temperature below the acceptable level for the guaranteed operation of the low voltage circuits;

4.11 Out-of-phase detection circuit

.1 The single-pole controlled circuit breaker shall have two out-of-phase detection circuits, one for circuit “A” and the other for circuit “B”. Both circuits shall be completely redundant.

.2 After an out-of-phase detection, each circuit shall order, after a time delay, a three-pole opening of the circuit breaker. Circuit “A” and “B” respectively activate the shunt tripping releases “A” and “B”, by the intermediary relays, of the opening circuits “A” and “B”.

.3 The time delay shall be adjustable between 0.1s and 3.0s in a continuous manner or with a maximum of 100 ms steps. The in-plant adjustment of the time delay shall be made at 1.0s.

.4 An alarm originating from each of the two out-of-phase detection circuits (52F/A and 52F/B) shall be supplied.

4.12 Pole discordance detection circuit

.1 When the poles of a single-pole controlled circuit breaker have more than one module, the apparatus shall have two pole discordance detection circuits; one for circuit “A” and the other for circuit “B”.

.2 The two circuits shall be completely redundant.

.3 The pole “A” discordance detection circuit shall be designed in such a manner that the shunt tripping releases of phases A, B and C shall be directly fed respectively by the pole discordance detection of phases A, B and C, after the time delay. The delay shall be adjusted in order to consider the maximum time during which the main contact (s) of the concerned phase, that stayed open, that can withstand the rated voltage of the circuit breaker.

.4 The duration of the opening command shall be, in a sure manner, longer than the rated opening duration of the apparatus. The opening command shall not be maintained in order to avoid the damage of the shunt tripping releases of the discordant pole.

.5 In pole discordance, no closing command of the circuit breaker shall be sent to the shunt closing releases of the three phases. This state shall be maintained until an unlocking of the pole discordance circuit is done by the action of a push button located in the main cabinet.

.6 The pole “B” discordance circuit shall be maintained in the same manner. The unlocking of the pole “B” discordance circuit shall be done by the same push button used for unlocking the pole “A” discordance circuit.

.7 The pole discordance of each of the three phases shall be indicated by an alarm. This alarm is supplied by the pole “A” and “B” discordance detection circuit; the alarm shall be maintained until the unlocking of the pole discordance detection circuit. An alarm from each of the two pole discordance detection circuits shall be given.

4.13 Functional Tests

.1 Functional Test shall be as prescribed in the IEC 62271 series of standards and IEC 60060-1.

.2 Vendor shall provide with Tender a copy of a test plan used to functional test the Equipment specified.

.3 Purchaser has the right to add additional testing to this plan to verify the operation the Equipment.

4.14 Type Tests

.1 Only the reports or certificates of type tests done in independent laboratories or in other laboratories but in the presence of a recognized authority by NALCOR are accepted. The manufacturer shall commit to do, without additional cost and in the presence of a NALCOR representative, all the tests not done or not in compliance to the present standard.

.2 Type Tests shall include all "Mandatory Type Tests" and "Type Tests Dependant Upon Application, Rating or Design" as applicable per IEC 62271-100 Table 11. (Refer to "Characteristics of Line to be Switched" in Appendix B for additional information on the breaker's "Application, Rating and Design" information).

.3 When a requirement for capacitor bank switching is identified in Appendix B, tests shall be performed as per BC2 "capacitor bank current test-duty 2" as defined in IEC 62271-100 paragraph 6.111.9.

.4 Vendor shall provide a listing of all type testing completed on this Equipment specified.

.5 Motors and charging energy control

a. Verify that the closing command of the circuit breaker is impossible when the stored energy in the stored energy system is insufficient to perform a CO operation.

b. Perform the start up of each motor with the control circuit.

c. Verify the start-up sequence of the stored energy motors and the complete time required to rebuild the energy reserve.

d. Simulate an excessive operating time of a motor and verify the power supply interruption of all of the motors and the lockout of the circuit. Verify the reset of the circuit with reset switch.

.6 Inversion of polarities

When energizing the secondary system with inversed polarity voltage, it shall be verified that no component is damaged, except for a fuse.

.7 Low temperature tests

Paragraph 6.101.3.3 of IEC 62271-100 is applicable with the following complements:

a. The tangent delta and capacitance measurements of the voltage grading capacitors shall be taken (if applicable) before and after the tests.

b. The pole or the portion of the pole tested shall include all the accessories installed on the complete circuit breaker on the network including: the desiccant installed in the interrupting chambers the current transformers, the main control cabinet and the secondary control cabinet.

c. It shall be verified that the desiccant does not absorb a significant quantity of gas and that it does not reduce its pressure for the tested temperature range.

d. 72 hours after the test, a visual verification of the oil leaks is performed on the voltage grading capacitors (if applicable)

.8 Impact noise measurement

a. The measurement of impact noise in proximity of the circuit breakers shall be done according to the prescriptions of ANSI/IEEE C37.082 standard, by using the method described for the type test.

b. The circuit breaker under test shall comprise its three poles and be installed according to the monitoring foreseen in the sub-station. The nominal distances for the measurement of 2 and 3 feet, prescribed in the standard, shall be replaced by 0.5 and 1.0m respectively. The impact noise shall be measured in dB peak linear. At each measuring point, the noise level shall be measured during at least two closings and two openings.

.9 Grading capacitors tests

a. Conditioning of the sample: The sample shall be submitted to an alternative voltage having amplitude at least equal to 1.1 times its rated voltage during 16 to 24 hours in a room where the ambient temperature is at least 10 °C.

b. Initial measurement of the capacitance: The sample shall be placed during at least 12 hours in a room where the air circulation is forced, the temperature of the air being chosen in the range of 60° C to 75° C. Within a five minute interval after taking it out of the oven, it is required to measure the capacitance as well as the losses of the capacitor at the rated voltage.

c. Overvoltage test: The sample shall be placed in a cold room at a temperature of - 50° C during at least 12 hours. Afterwards, it must be placed at ambient air between 15° C and 35° C. Within an interval of ten minutes after having taken the sample out of the cold room, the sample must be put under voltage at 1.1 times its rated voltage: then 30 seconds after the application of the voltage, an overvoltage of an amplitude equal to 2.0 times its nominal voltage must be applied without interruption of the voltage during 15 cycles ; finally, a voltage of 1.1 times the rated voltage must again be applied without interrupting the voltage.

Duration of 15 cycles must be applied and so on. The sample must be exposed daily to a total of 130 to 185 overvoltages for a duration of 15 cycles.

After one day of tests, the sample must again be placed in a cold room (- 50° C) during a period of at least 12 hours. The test must continue in accordance with the procedure previously described during three days and until the sample has been exposed to at least 500 overvoltages of 15 cycles duration. Afterwards, the sample must return to the cold room at - 50° C for at least 12 hours.

The test must be repeated on the fourth day with an overvoltage amplitude of 2.2 instead of 2.0 times the nominal voltage and with an overvoltage duration of six cycles instead of 15. This test must continue until a total number of 130 to 170 overvoltages of six cycles duration are applied. Afterwards, the sample does not return to the cold room.

d. Continuous voltage test: A continuous voltage equal to 3.25 times the rated voltage shall be applied between the terminals of the sample for 10 seconds.

e. Final measurement of the capacitance and losses: The test described in b) shall be repeated and no significant increase of the capacitance and of the losses shall be observed.

f. Acceptance criteria: No puncture of a packet, elements comprising the capacitor, is allowed. Moreover, all the capacitive elements must be examined in detail and no trace of burning must appear at the surface of the electrodes comprising the capacitor.

4.15 Routine Tests

.2 Mechanical operation tests:

Paragraph 7.101 of IEC 62271-100 is applicable with the following complements:

The mechanical operation tests shall be done by testing the two circuits (circuit A and circuit B) of the circuit breaker.

.3 Additional routine tests:

a. Bushing type current transformers shall subject to the routine tests described in CSA CAN3-C13-M83.

b. Composite insulators shall be subject to the routine tests prescribed by IEC /TR2 61462.

c. Porcelain insulators shall be subject to the routine tests prescribed by IEC 62155.

d. tanks shall be subject to the routine tests described in the applicable CSA standards (CAN /CSA-C50052-99 or CAN/CSA-C50064-99 or CAN/CSA-C50068-99 or CAN/CSA-C50069-99).

.4 Additional Information to be given with Tenders:

In addition to any information requests defined in this technical specification the Vendor is to provide technical particulars of the circuit breaker as described in Section 9.102 of IEC 62271-100.

5.0 Information to be Supplied with Tender

5.1 Tender shall include a complete set of typical manufacturer's Drawings showing details and general description of the Equipment being tendered. This information shall include, as a minimum: outline and dimensions; nameplate drawings; control schematics (where applicable).

Vendor shall complete Appendix C "Information to be Supplied with Tender by Vendor" and submit it with the Tender.

5.2 Service Personnel and Facilities

Tender shall state the location of nearest service and facilities in Canada or the United States.

5.3 Quality Assurance

Tender shall include a copy of the ISO Quality Assurance Program Certification for the facility where the design manufacturing of the equipment will be performed

5.4 Equipment Testing

5.4.1 Functional Tests

Vendor shall provide with Tender a copy of a test plan used to functional test the Equipment specified.

Purchaser has the right to add additional testing to this plan to verify the operation the Equipment.

5.4.2 Type Tests

Vendor shall provide a listing of all type testing completed on this Equipment specified.

5.4.3 Factory Acceptance Testing

Vendor shall notify the Purchaser two-(2) weeks prior to functional testing of the Equipment to provide the option of the Purchaser to witness testing at the manufacturer's facilities.

APPENDIX A
Technical Requirements

	Voltage Class					
Technical Requirements	UNIT	34.5 kV	72.5 kV	145 kV	245 kV	800 kV
Nominal System Voltage	kV	25	46/66/69	138	230	735
Maximum Continuous voltage	kV	27.5	72.5	152	253	765
Basic Impulse Level	kV	150	350	650	1050	2100
Frequency	Hz	60	60	60	60	60
Rated Continuous Current	A	600	2000	1200	2000	4000
Rated Voltage Range Factor K	-	1.0	1.0	1.0	1.0	1.0
Interrupting Rating (symmetrical rms)	kA	12.5	31.5	20	31.5	50
Short Time Current Rating (rms)	kA	12.5	55.5	35.2	55.5	See Appendix B
Short Time Current Rating (crest)	kA	31.5	93.6	59.4	93.6	
Rated Short Circuit Current at rated voltage (rms)	kA	12.5	20	20	31.5	50
Interrupting Rating at O-C-O Operation	kA	12.5	31.5	20	31.5	50
Maximum Interrupting Time	cycle	3	3	3	3	2.5
Duty Cycle	-	0-C-0	0-C-0	0-C-0	0-C-0	0-C-0
Minimum Height Between Live Parts and Breaker Base	mm	2500	3700	4000	4600	6000
Minimum Creepage *	mm/kV	25	25	25	25	25
Control Voltage	Vdc	125	125	125	125	125
Breaker Charging Mechanism	V	125 Vdc	125 Vdc	125 Vdc	125 Vdc	208 VAC
Auxiliary Power	Vac	120	120	120	120	120
Single Phase Reclosing Capability	-	No	No	No	Yes	Yes
Three-Phase Reclosing Capability	-	Yes	Yes	Yes	Yes	Yes
Minimum Ambient Temperature (takes precedence over clause 1.2)	C					See Appendix B

* In areas deemed to have a pollution level of IV (Very Heavy), according to IEC 60071-2, a minimum creepage distance of 31mm/kV should be used.

Bushing Current Transformers			
Bushing	Number per Bushing	Ampere Ratio	Relaying / Metering Accuracy *
1, 3, 5			
1, 3, 5			
2, 4, 6			
2, 4, 6			

* Relaying accuracy is interpreted to mean voltage at the knee of the saturation curve.

Optional Requirements		
Clause	Description	Required (Yes/No)
4.6	Closing Resistors	
3.6.3	On-Line Condition Monitoring	

APPENDIX B
Additional Technical Requirements for 800 kV Class Breakers

For 800kV class breakers the technical requirements of both Appendix A and Appendix B are applicable.

800 kV Voltage Class		
Technical Requirements	**Unit**	
Characteristics of Line to be Switched		
- Positive Sequence impedance	ohms/mile	
- Zero Sequence Impedance	ohms/mile	
- Surge Impedance	ohms	
- Shunt reactor compensation at each end (Three phase bank)	MVAR	
- Trapped Charge When Reclosing	%	
- Line Reactors to be switched	MVAR	
- Transformer Banks to be Switched	MVA	
- Short Circuit X/R ratio		
Minimum Ambient Temperature	C	- 50
Maximum Ambient Temperature	C	40
Seismic Zone		
System Ground Configuration		Effectively grounded neutral
Mechanical Endurance		IEC Class M2
Rated Line-Charging Capacitive Switching		IEC Class C2
Rated withstand voltage (Switching Impulse)		
- to earth (dry/wet)	kV	1425 / 1425
- across open terminals (dry/wet)	kV	1175 / 1175
Rated withstand voltage at power frequency (1 min.)		
- to earth (dry/wet)	kV	830 / NA
- across open terminals (dry/wet)	kV	1150 / NA
Peak short-circuit withstand current	kA (peak)	135
Rated short Circuit Duration	seconds	1

APPENDIX C
Information to be Supplied with Tender by Vendor

Circuit Breaker Manufacturer	
Circuit Breaker Model	
Arc Extinguishing Medium	
Type of Breaker Operating Mechanism	/Spring
Net weight of Complete Breaker	kg
Shipping Weight of Largest Component	kg
Type of Interrupting Chambers	
Number of Interrupting Units per Phase	
Interrupting Chamber Muting	
Rated Maximum Voltage (continuous)	kV
Nominal System Voltage	kV
Basic Impulse Level	kV
Minimum Voltage for Rated Interrupted Capacity	kV
Rated Frequency (60 Hz) Withstand Voltage	kV
Impulse (1.2 x 50 microsec) Withstand Voltage	kV
Frequency	H_z
Rated Continuous Current	A
Symmetrical 3 Phase Interrupting Capacity	kA
Asymmetrical 3 Phase Interrupting Capacity	kA
Rated Making Capacity	kA
Short Time Current Rating (4 seconds)	kA
Rated Nominal Interrupting Current at the Second Tripping on an O-C-O Operation	kA
Rated Short Circuit Current at Max. Voltage	kA
Transient Recovery for a 3-Phase ungrounded fault on the line side terminal at:	

100% interrupting capacity	V/m sec
50% interrupting capacity	V/m sec
25% interrupting capacity	V/m sec
10% interrupting capacity	V/m sec
Arcing Time at 100% Breaking Capacity	Cycles
Total Closing Time	Cycles
Rated Interrupting Time at Minimum Fault Interrupting Capacity	ms
Rated Interrupting Time from Energization of Trip Coil to Final Arc Extinction	ms
Minimum Permissible Dead Time for Duty Cycle (O-C-O)	ms
Maximum Interrupting Time	ms
Phase to Phase Clearance / Bushings	mm
Minimum Clearance between Live Parts to Ground	mm
Leakage Distance of Bushings	mm
Permissible Safe Cantilever Loading	N
Duty Cycle	
Closing Resistors (Optional refer to Appendix A):	
- insertion time	ms
- energy	Ω/ms/J
Capacitive Switching Duty	
Minimum Ambient Temperature	^{o}C
Maximum Ambient Temperature	^{o}C
Capacity for Line Charging / Line Dropping	km
Control Voltage Range	vdc
Power of Motor	W
Tripping Current Per Phase	A

Closing Current Per Phase	A
Single Phase Reclosing Capabilities	Yes/No
Three Phase Reclosing Capabilities	Yes/No
Number of auxiliary spare contacts available for Purchaser's use	N/C
Operating Pressure or Density of Gas	kPa
State Minimum Density of Gas required for each : Block Trip, Block Close, Block Reclose, Lock Out and Total Volume	kPa
Type and percentage of gasses present	%
Nominal SF_6 pressure, gauge value at 20^oC (where applicable)	%
Recommended gas pressure at 20^oC for	
(i) Recharge alarm	kPa
(ii) Breaker trip	kPa
(iii) Block closing	kPa
Switching Surge Withstand Voltage (Wet)	kV
Power Frequency Withstand Voltage (Wet)	kV
Power Frequency Withstand Voltage (Dry)	kV
Kilometric Fault Interrupting Capability	
Maximum time interval between operation of first & last pole	
Air or Gas usage per single breaker operation	
Maximum air or gas operating pressure	
Minimum air or gas operating pressure	
Temperature at which gas will liquefy at normal working gas density.	^oC
Minimum Gas Pressure to maintain Rated Basic Impulse	kPa
Maximum allowable amount of moisture in gas at normal working gas pressure to maintain Rated Basic Impulse Level	ppm
Annual gas leakage rate of total volume	%
Estimated weight of gas per breaker	kg

Type of pressure relief devices provided	
Pressure at which pressure relief devices will operate	
Type of gas insulation monitoring devices	
Type of gasket material	
Other available SF_6 gas fault sensors	
Source Side C.T. Secondary Ratios	
Source Side C.T. Accuracy	
Load Side C.T. Secondary Ratio	
Load Side C.T. Accuracy	
Gas Density Monitor – Manufacturer and Model No.	
Gas Density Transmitter – Manufacturer and Model No.	

APPENDIX E

PM Check Sheets for DCF/DCVF and DLF Type Air Blast Circuit Breakers

4 Year – 230 kV DLF AIR BLAST CIRCUIT BREAKER INSPECTION

System ID: ____________ Station:____________ Serial No.: ____________
Manufacturer: ____________ Type: ____________Nominal Voltage Class: ____________
Test Date: ___________ Test Completed By: ______________________ J.D.E.W/O #: ____________

WEATHER CONDITIONS: ______ dry ______ rain ______ humidity ______ temperature

BEFORE OPERATING: Pressure ____________ kPa Counter: ____________

ACCEPTABLE DUCTOR READINGS < 120 µOhm		
	% CURRENT	µOhm
A ph		
B ph		
C ph		

MEGGER TEST 5 KV (PHASE TO GROUND)	***** **NOTE: ENSURE THAT BREAKER IS CLOSED** *****	
A PH Mega Ω	B PH Mega Ω	C PH Mega Ω

Command Current Close _________ amps Trip __________ amps

CONTROL CIRCUIT RESISTANCE (Ohms): (test to be completed from the Control Cabinet Terminal Board)			
Trip Coil # 1:	A ph Ω	B ph Ω	C ph Ω
Trip Coil # 2:	A ph Ω	B ph Ω	C ph Ω
Close:	A ph Ω	B ph Ω	C ph Ω

HEATER AMPERAGE			
CABINET HEATER :			
CONTROL BLOCKS:	A:	B:	C:

PRESSURE SETTINGS (kPa)		
	Found	Left
Block Reclose		
Block Trip		
Aux Block Trip		
Block Close		
Low Pressure Alarm		

DEW POINT TEMPERATURE:_________ ^{0}C @ OPERATING PRESSURE:______ KPA

Note: Measure Dew Point at Breaker, if possible.

4 Year – 230 kV DLF AIR BLAST CIRCUIT BREAKER INSPECTION

System ID: ____________ Station:____________ Serial No.: ____________
Manufacturer: ____________ Type: ____________Nominal Voltage Class: ____________
Test Date: ___________ Test Completed By: ______________________ J.D.E.W/O #: ____________

NOTE: ONLY COMPLETE TIMING TABLE BELOW, IF TIMING TEST SET DOES NOT PROVIDE A PRINTED COPY. PLEASE ATTACH PRINTED COPY TO COMPLETED INSPECTION FORM.

TIMING TEST (milliseconds)		
Closing Time: 50 ms Opening Time: 28 ms (23 ms for 2 cycle breakers) C-O Time: 45 ms (34 ms for 2 cycle breakers) Difference in phase: 2 ms Difference between phases: 5 ms	Contacts	
	1	2
A Phase Close Time (ms)		
B Phase Close Time (ms)		
C Phase Close Time (ms)		
A Phase Trip Time (ms)		
B Phase Trip Time (ms)		
C Phase Trip Time (ms)		
A Phase Trip Free Time (ms)		
B Phase Trip Free Time (ms)		
C Phase Trip Free Time (ms)		
A Phase Disagreement on Trip Time (ms)		
B Phase Disagreement on Trip Time (ms)		
C Phase Disagreement on Trip Time (ms)		
A Phase Resistors Contacts ✓ Checked OK		
B Phase Resistors Contacts ✓ Checked OK		
C Phase Resistors Contacts ✓ Checked OK		

TIMING TEST (milliseconds)			
	A	B	C
3-PH Close			
3-PH Trip			
Trip Free (dwell)			
Disagreement On Trip			
Resistor Contacts			

4 Year – 230 kV DLF AIR BLAST CIRCUIT BREAKER INSPECTION

System ID: ____________ Station:____________ Serial No.: ____________
Manufacturer: ____________ Type: ____________Nominal Voltage Class: ____________
Test Date: ___________ Test Completed By: ______________________ J.D.E.W/O #: ____________

CHECKS COMPLETED:

_______ Check for Air Leaks
_______ Lubricate Control Blocks
_______ Check Primary Connections and Bushings
_______ 20 Minute Pressure Drop
______ Clean Air Intake Filters
______ Check Receiver Tanks on breaker for moisture by removing drain plugs

______ A ph Control Block Aux Contacts
______ B ph Control Block Aux Contacts
______ C ph Control Block Aux Contacts
______ Control Cabinet Aux Contacts
______ Clean Main Filters
______ Visually Inspect
______ Perform Timing Test

AFTER OPERATING: Pressure ______ kPa Counter: ____________

CHECKS COMPLETED:

Doble Test Performed: __Yes __ No

COMMENTS:
____
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____

SUPERVISOR: ________________________ DATE: ________________________

4 YEAR - AIR BLAST CIRCUIT BREAKER 230/138 KV DCF/DCVF INSPECTION

System ID: _____________ Station:_____________ Serial No.: _____________
Manufacturer: _____________ Type: _____________Nominal Voltage Class: ____________
Test Date: ___________ Test Completed By: _______________________ J.D.E.W/O #: _____________

WEATHER CONDITIONS:_______ dry _______ rain _______ humidity _______ temperature
BEFORE OPERATING: Pressure _____________ kPa: Counter: _____________

DUCTOR (RESISTANCE) READING ACCEPTABLE READING < 350 µOHM 230 kV <250µOHM 138 kV		
	% CURRENT	MICRO Ω
A ph		
B ph		
C ph		

MEGGER TEST 5 KV (PHASE TO GROUND) ******* NOTE: ENSURE THAT BREAKER IS CLOSED*******		
A PH Mega Ω	B PH Mega Ω	C PH Mega Ω

CONTROL CIRCUIT RESISTANCE (Ohms): **(Tests to be completed from Control Cabinet Terminal Board)**			
Trip Coil #1:	A Ph Ω	B Ph Ω	C Ph Ω
Close:	A Ph Ω	B Ph Ω	C Ph Ω
Trip Coil # 2: (if applicable)	Ω		

PRESSURE SETTINGS (kPa)		
	Found	Left
Block Reclose		
Block Trip		
Aux Block Trip		
Block Close		
Low Pressure Alarm		

DEW POINT TEMPERATURE:_________ ^{0}C @ OPERATING PRESSURE:______ kPa

Note: Measure Dew Point at Breaker, if possible.

HEATER : AMPS		CABINET HEATER:	
CONTROL BLOCKS:	A:	B:	C:

AFTER OPERATING: Pressure _________ kPa Counter: ________________

4 YEAR - AIR BLAST CIRCUIT BREAKER 230/138 KV DCF/DCVF INSPECTION

System ID: ____________ Station:____________ Serial No.: ____________
Manufacturer: ____________ Type: ____________Nominal Voltage Class: ____________
Test Date: __________ Test Completed By: ______________________ J.D.E.W/O #: ____________

NOTE: ONLY COMPLETE TIMING TABLE BELOW, IF TIMING TEST SET DOES NOT PROVIDE A PRINTED COPY. PLEASE ATTACH PRINTED COPY TO COMPLETED INSPECTION FORM.

TIMING TEST (milliseconds)							
230 kV @16 bars	170 kV @ 16 bars	Contacts					
Opening: 45-53 ms	Opening: 43-55 ms						
Closing: 105-125 ms	Closing: 84-116 ms						
C-O: 63-75 ms	C-O: 63-75 ms						
Delta Phase (O & C): 7 ms	Delta Phase(O & C): 7 ms						
		1	2	3	4	5	6
A Phase Close Time (ms)							
B Phase Close Time (ms)							
C Phase Close Time (ms)							
A Phase Trip Time (ms)							
B Phase Trip Time (ms)							
C Phase Trip Time (ms)							
A Phase Trip Free Time (ms)							
B Phase Trip Free Time (ms)							
C Phase Trip Free Time (ms)							
A Phase Disagreement on Trip Time (ms)							
B Phase Disagreement on Trip Time (ms)							
C Phase Disagreement on Trip Time (ms)							
A Phase Resistors Contacts ✓ Checked OK							
B Phase Resistors Contacts ✓ Checked OK							
C Phase Resistors Contacts ✓ Checked OK							

Command Current Close _________ amps Trip __________ amps

TIMING TEST (milliseconds)			
	A	B	C
3-PH Close			
3-PH Trip			
Trip Free (dwell)			
Disagreement On Trip			
Resistor Contacts			

4 YEAR - AIR BLAST CIRCUIT BREAKER 230/138 KV DCF/DCVF INSPECTION

System ID: ____________ Station:____________ Serial No.: ____________
Manufacturer: ____________ Type: ____________Nominal Voltage Class: ____________
Test Date: __________ Test Completed By: ______________________ J.D.E.W/O #: ____________

CHECKS COMPLETED:

_______ Air Leaks
_______ Lubricate Control Blocks
_______ Check Primary Connections and Bushings
_______ 20 Minute Pressure Drop
______ Clean Air Intake Filters
______ Check Receiver Tanks on breaker for moisture by removing drain plugs

______ A ph Control Block Aux Contact
______ B ph Control Block Aux Contact
______ C ph Control Block Aux Contact
______ Control Cabinet Aux Contacts
______ Clean Main Filters
______ Perform Timing Test

Doble Test Performed: __Yes __ No

COMMENTS:

____
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____

SUPERVISOR: ________________________ DATE: ________________________