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July 5, 2017

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

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

Dear Ms. Blundon:

Re: The Board's Investigation and Hearing into Supply Issues and Power Outages on the Island Interconnected System – Availability of Requested Information from Hydro, July 5, 2017 Update

In our letter of May 26, 2017, Hydro indicated that certain updates and information would be provided on or before July 5, 2017. Please find our update below.

The current status of each item requested by the Board is noted in the table attached as Appendix "A".

MAY 3, 2017 INFORMATION REQUESTS – UPDATE

Item #	Description	Hydro Response
1	Current integrated transition work plan and schedule	Please see the attached Appendix "B".
3	Current schedule for completion of LIL and ML	The current schedule for completion of Labrador-Island Link (LIL) and the Labrador Transmission Assets (LTA) for power flow is as follows: • First Power Transfer – LIL (beginning of Q3, 2018); • Ready for Power Transmission (Low Load Testing Complete) Pole 1 (Q4, 2018); and • Dynamic Testing Complete Bi-Pole (Low Load) (end of Q1, 2019). NSP Maritime Link are working to make the Maritime Link (ML) available for the beginning of Q1, 2018.

Item #	Description	Hydro Response
5	Update on service support agreements and copies of any such agreements	With respect to the converter station equipment, Nalcor is in active contractual negotiation on the arrangements with the service arm of the original equipment manufacturer, GE Grid, based out of La Prairie, Quebec. This vendor will provide technical oversight and support and a number of other services for the converter stations at Muskrat Falls and Soldiers Pond, as well as the gas-insulated switchyards in Labrador, the synchronous condenser plant in Soldiers Pond, and the air-insulated switchyard at Soldiers Pond. Nalcor is looking at a five-year contract with a number of optional aspects to that commitment. In addition, Nalcor has engaged ATCO Electric, who has staff with significant experience in HVdc facilities and in particular with a system with similar controls as being supplied by GE Grid to Nalcor. They are assisting in the completions aspects to the HVdc equipment and Nalcor is planning to engage them in an operational contract to assist in a mentoring/job-shadowing role for a two-year term, aimed at developing the technical competencies of Nalcor's Power Supply organization in the operation of the HVdc and interrelated systems. Both the GE and ATCO Electric contracts are projected to be secured in Q4, 2017. With respect to the HVdc marine cable, a facility has been built to store securely the spare submarine cable inside the port authority marine base at Corner Brook. Cable repairs at the Strait of Belle Isle will require specialized service providers to uncover, retrieve, and repair or splice any faulted section of marine cable from the ocean floor. As previously described by Hydro, in the event a fault does occur, a fully redundant spare cable was installed as part of the basis of design, given that the timeline to execute a marine cable fault repair could be months depending on the time of year. Recognizing that, retainer arrangements with specialized service contractors will be negotiated to ensure that a thoughtful plan is documented and support groups can be quickly engaged to execute repairs as soon as practicable. It is anticipated that these arrangements will be secured in Q2, 2018, prior to cable energization.

Item #	Description	Hydro Response
7	Update on Emergency Restoration Plans and copies of any draft or final plans	With respect to the preparation of an Emergency Response Plan (ERP) for the overhead portion of LIL, Nalcor prepared and issued a Request for Proposals and received proposals from national and international consultants. EFLA Consulting Engineers was the successful proponent. The consultant's work has begun with a target date of November 2017 for a first draft of the ERP. The ERP will provide a detailed and logical plan for the safe, timely and adequate line restoration of the LIL. The plan shall consider operational utility norms, industry best practice throughout the world, with a focus on northern climates. The ERP shall carefully study the probable failures and classify the probable risk associated with each failure of the LIL, offering design solutions for interim connections to speed up recovery time, along with strategic longer-term repair methods for critical spares. This will help in classification of the required response to dispatch and define the requirements with respect to crew complements and equipment. Local contractor and equipment availability will also be studied and included in the results. The ERP will consider access to all sections of the LIL transmission system and identify the routes and equipment needed to access specific locations in the transmission system.
8	Update on arrangements for use of LIL and copies of any contracts regarding same	Subsequent to interconnection of the Island with Labrador via LIL and prior to completion of the commissioning of the Muskrat Falls Generating Station, Hydro expects to utilize recapture power and energy sourced from external markets to serve Island customers, thus reducing reliance on more costly thermal generation at Holyrood. The required commercial agreements have been identified and divided into two key areas, specifically (i) a power purchase agreement(s) for the purchase of recapture power for use on the Island and imports, and (ii) transmission related matters, specifically the provision of transmission service related to the transmission lines connecting the island portion of the Province to the hydroelectric facility at Churchill Falls. Transmission service agreements will be used by Hydro to utilize the new transmission lines upon the completion of all transmission interconnections as part of the implementation of an open access transmission regime. Hydro will have all firm transmission rights related to the new transmission facilities. These agreements will apply for the period prior to and after the completion of Muskrat Falls Generating Station. No further commercial agreements for transmission service will be required to be executed. As at the date of this submission, these commercial arrangements have not been finalized.

Item #	Description	Hydro Response
11	Update on Emergency Power / Reserve Sharing arrangements	As a part of the Interconnection Operators Agreement (IOA) executed between Hydro and Nova Scotia Power (NSPI), there are provisions whereby both parties agree to formalize arrangements to share operating reserves and to provide emergency and security energy to one another. These arrangements will be detailed in the schedules contemplated in the IOA. Both NSPI and Hydro have been working towards finalizing the contents of the schedules and mature drafts have been exchanged. The intent is to finalize the schedules prior to energization of the ML. A copy of the Amended and Restated IOA (July 31, 2014) is attached as Appendix "C". This version of the IOA supersedes the version filed by Hydro as part of PUB-NLH-220 (Revision 1, July 28-14).
14	Update on agreements regarding Recall Power supply over LIL, including amounts available for the Labrador Interconnected system and IIS with relevant time frame	Subsequent to interconnection of the Island with Labrador via LIL and prior to completion of the commissioning of the Muskrat Falls Generating Station, Hydro expects to utilize recapture power and energy sourced from external markets to serve Island customers, thus reducing reliance on more costly thermal generation at Holyrood. The required commercial agreements have been identified and divided into two key areas, specifically (i) a power purchase agreement(s) for the purchase of recapture power for use on the Island and imports, and (ii) transmission related matters, specifically the provision of transmission service related to the transmission lines connecting the island portion of the Province to the facility at Churchill Falls. Transmission service agreements will be used by Hydro to utilize the new transmission lines upon the completion of all transmission interconnections as part of the implementation of an open access transmission regime. Hydro will have all firm transmission rights related to the new transmission facilities. These agreements will apply for the period prior to and after the completion of Muskrat Falls Generating Station. No further commercial agreements for transmission service will be required to be executed. As at the date of this submission, these commercial arrangements have not been finalized. Based on existing Labrador supply and the current Labrador Interconnected System's demand forecast, 110 MW of firm capacity is available at Soldiers Pond to support winter peak (December to March). During periods of lower demand for the Labrador Interconnected System (typically during the shoulder and summer seasons), up to 214 MW of capacity is available to the Island Interconnected System at Soldiers Pond.

Item #	Description	Hydro Response
15	Update on technical requirements regarding use of Recall Power on the IIS, including addition of synchronous condenser	Please see the attached Appendix "D".
17	Update on planning criteria applicable post Muskrat Falls	The delayed in-service of the Lower Churchill Project assets and the subsequent separation of the generation and transmission aspects resulted in a shift of primary focus for Hydro to ensure its capability to provide reliable service to its customers in advance of interconnection.[1] Hydro continues to investigate the most appropriate planning criteria for the provincial electricity system following the in-service of the LIL, the ML, and the Muskrat Falls Generating Station. To assist in this assessment, Hydro is developing the following: • A new software model for generation planning developed in Plexos.[2] This software is capable of modelling Hydro's electrical system in greater detail. Further, the model will include representation of Hydro's bulk transmission system, ensuring the deliverability of Hydro's resources to meet customer requirements. • An evaluation of the impacts of compliance with North American reliability standards. Hydro is conducting this analysis for both deterministic (i.e., reserve margin) and probabilistic (i.e., Loss of Load Expectation) reliability assessments. • Estimates for the construction of: o an eighth unit at the Bay d'Espoir Generating Station; and o a gas turbine. • Commercial negotiations with market participants for supply over both the ML and the LIL. Once the above has been compiled and assessed, Hydro will make its recommendations on appropriate planning criteria to the Board in Q4 2018.

[1] To assess the near-term reliability of the system, Hydro analyzed its ability to meet higher than anticipated customer requirements in consideration of extreme operating scenarios by considering a concurrent P90 peak demand forecast and unavailability of multiple units at Holyrood. To ensure the robustness of the analysis, multiple demand forecast sensitivities and outage rates were considered, as well as varying outage rates for Hydro's gas turbines and hydraulic facilities. Additionally, Hydro conducted analysis across its thermal, hydraulic, and standby facilities to ensure it had good understanding of the most relevant risks facing these facilities and associated mitigation measures to address. The results of this analysis were provided most recently in Hydro's Near-term Generation Adequacy report, published May 15, 2017, and previously in Hydro's Energy Supply Risk Assessments, published May and November 2016. The Near-term Generation Adequacy report is published twice annually, and the next report will be filed at the Board on November 15, 2017, in advance of the winter peak demand period. Based on the most recent report findings, no additional generation is required in advance of interconnection to the North American grid, even if such interconnection is delayed through 2021.

Item #	Description	Hydro Response
18	Update on Power Supply over the ML including status of negotiations with potential suppliers	Use of the 300 MW firm capacity over the ML is not required until the post-Muskrat Falls period in 2020/2021, when Holyrood is removed from service as a prime generation source. Therefore, negotiations for this block will be completed closer to the requirement of the use of this firm transmission supply path, likely in 2019/2020. In the meantime, Nalcor Energy Marketing (NEM) approached NSPI and New Brunswick Power (NBP) in late 2016 and early 2017 to discuss potential opportunities for the near term supply of energy without firm capacity to the Island over the ML. Both NSPI and NBP indicated that opportunities will likely materialize to provide energy via the ML, but such arrangements were not identifiable for contract in advance. It is expected that these opportunities will materialize closer to the dates of anticipated delivery, based on what they will have available in excess of their actual requirements for their customers are at the time. The next steps will be to approach these parties to either develop terms that will govern such transactions as/when they materialize, including price, or prepare market solicitation packages to source this energy that can be used to displace Holyrood fuel. These activities are expected to occur early in Q3 2017 and conclude early in Q4 2017. These arrangements could serve as a proven framework for future negotiations related to electricity products such as sustained emergency supplies that may be required once Muskrat Falls is in production, Holyrood has been removed from service and there is high reliance on the LIL to provide firm transmission capacity from Muskrat Falls.

[2] Plexos is a power system simulation tool developed by Energy Exemplar. Hydro intends to develop and use Plexos for generation planning. Plexos is widely used in industry, and is currently in use by both NSPI and NBP.

Item #	Description	Hydro Response
22	Update on multi-year reliability compliance program and Provincial Reliability Framework	To date, the Government of Newfoundland and Labrador has not entered into a Memorandum of Understanding with the North American Electric Reliability Corporation (NERC) to mandate the compliance with the NERC standards, in whole or in part. However, Nalcor Energy and Hydro do recognize the value and importance of operating the system consistent with the reliability standards in place for the broader North American electric grid. In many ways, Hydro's reliability practices and procedures are similar to many of the NERC reliability standard requirements. Where there are differences, the divergence is often related to the isolated nature of the existing hydroelectric system within the island portion of the Province. These gaps have been identified and are known, and Nalcor is working towards closing these gaps. Nalcor and Hydro are targeting voluntary compliance with the NERC standards through phasing in different aspects of the standards over time. The focus in 2017 is to: • develop policies and procedures, compliant with NERC covering transactions between Hydro and NSP over the ML; • training of Energy Control Centre operators to handle relevant transactions between the two systems; • real time and next day secure system operations planning; and • cybersecurity enhancements at Bottom Brook, Soldiers Pond and the Energy Control Centre. In addition, a compliance program will be established during the development of these standards to ensure that the standards meet the compliance requirements, and a Manager of Reliability Standards and Commercial Compliance has been hired to oversee this compliance program. This first phase of adoption of NERC standards is underway, with a consultant on-board for development of the policies and procedures, and the compliance program and roadmap, with completion and commencement of implementation of this first phase by the end of 2017. (Please refer to Item 23 for additional details on this first phase of the NERC compliance plan.) With respect to open access, the Newfoundland and Labrador System Operator has been set up to act as an independent body to manage the open access requirements, and to ensure that transmission access is managed in an impartial way to deliver power across the grid. This group continues to develop and will be ready once the Island is ready to become interconnected with the North American grid.

Item #	Description	Hydro Response
23	Status of plan for compliance with NERC	Nalcor Energy, using consultants experienced in development of policies and procedures compliant with the NERC standards, is in the process of developing a reliability compliance program and the required policies and procedures aimed towards interconnection with the North American grid. This work includes development of: • a Reliability Governance and Compliance Program; • NERC compliance roadmap and requirements to maintain compliance to the Program; • NERC procedures, plans and programs directed towards interconnection with the North American grid; and • development of new operating instructions and procedures for operation of the new assists such as the ML, the LIL and LTA within the Energy Control Centre. (Specifically, the NERC standards and portions of the standards around disturbance control (BAL-002); operating personnel communications protocols (COM-001 and COM-002); system restoration coordination (EOP-006); facility ratings (FAC-008); interchange transactions and modifications for reliability (FAC-006, FAC-008 and FAC-010); reliability coordination analysis and real-time assessments (IRO-002, IRO-008 and IRO-010); operator training (PER-005 and PER-006); transmission operations planning (TOP-001 and TOP-002); as well as the Critical Infrastructure Protection standards (CIP-002 to CIP-010) are all part of this first phase of implementation.) This work has commenced with contracts established, with a target of policies and procedures in place by the end of 2017 for the above noted work. Once these policies and procedures are in place, Nalcor will continue to adopt additional NERC standards based on their priority and effect on the system into 2018.

Please advise if you have any questions with respect to the attached.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Geoffrey P. Young
Corporate Secretary & General Counsel
GPY/bds

cc: Gerard Hayes – Newfoundland Power
Paul Coxworthy – Stewart McKelvey Stirling Scales
Roberta Frampton Benefiel – Grand Riverkeeper Labrador
Dennis Browne, Q.C. – Consumer Advocate
Danny Dumaresque

ecc: Denis Fleming- Vale Newfoundland & Labrador Limited
Larry Bartlett – Teck Resources Ltd.

APPENDIX "A"

INFORMATION REQUESTED BY THE BOARD – MAY 3, 2017
Status Update – July 5, 2017

Legend
Green: Information delivered to the Board as requested
Orange: Update provided and information to close out the request will be post-July 5, 2017 (as noted)

Item #	Description	Reference	Status
1	Current integrated transition work plan and schedule	PUB-NLH-501, Liberty Report, page 79, Recommendation IV-6 and page 106, Recommendation VI-1	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.**
2	Current organizational structure for transition teams	PUB-NLH-500, Liberty Report, page 107, Recommendation VI-3 and VI-4	**RESPONSE PROVIDED TO THE BOARD, MAY 26, 2017.**
3	Current schedule for completion of LIL and ML		**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.**
4	Any change in design of the LIL from that described in Chapters III and IV of the Liberty Report, August 19, 2016 ("Liberty Report")		**RESPONSE PROVIDED TO THE BOARD, MAY 15, 2017.**
5	Update on service support agreements and copies of any such agreements	Liberty Report, page 27	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.**
6	Update on studies for HVdc converter station contractors' studies and copies of any completed study	Liberty Report, page 79, Recommendation IV-2	**HIGH POWER STUDY SCHEDULED FOR 2018.** *The scope and timing of this study may be subject to any response by Hydro to this recommendation and the Board's final determination on (i) Liberty's recommendations and (ii) the parties' submissions.*
7	Update on Emergency Restoration Plans and copies of any draft or final plans	PUB-NLH-503 and Liberty Report, page 107, Recommendation VI-11	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.**

Item #	Description	Reference	Status
8	Update on arrangements for use of LIL and copies of any contracts regarding same	NP-NLH-158	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.** **FURTHER INFORMATION TO BE FILED AS COMPLETED.**
9	Update on interaction studies between the IIS and the ML completed since Preliminary Interconnection Studies dated August 2014, including with the ML in and out of service	Liberty Report, page 34, Recommendations III-3 and PUB-NLH-524	**LOW POWER STUDY SCHEDULED FOR DELIVERY FALL 2017.** **HIGH POWER STUDY SCHEDULED FOR 2018.**
10	Update on study regarding additional reactive power	PUB-NLH-531	**HIGH POWER STUDY SCHEDULED FOR 2018.**
11	Update on Emergency Power / Reserve Sharing arrangements	PUB-NLH-502, PUB-NLH-593 and Liberty Report, page 71 and page 102-103	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.**
12	Update on Frequency Controller study for the ML	PUB-NLH-521	**STUDY SCHEDULED FOR DELIVERY FALL 2017.**
13	Systems Studies to determine reserve sharing between LIL and IIS generation	PUB-NLH-564, Liberty Report, page 71	**HIGH POWER STUDY SCHEDULED FOR 2018.**
14	Update on agreements regarding Recall Power supply over LIL, including amounts available for the Labrador Interconnected system and IIS with relevant time frame	PUB-NLH-280	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.**
15	Update on technical requirements regarding use of Recall Power on the IIS, including addition of synchronous condenser	PUB-NLH-630, Attachment 1	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.**
16	Updated Energy Supply Risk Assessment Post Muskrat Falls	Liberty Report, page 87, Recommendation V-3 and page 112, Recommendation V-3	**RESPONSE PROVIDED TO THE BOARD, MAY 15, 2017.** *The ultimate scope and timing of this study may be subject to any response by Hydro to this recommendation and the Board's final determination on (i) Liberty's recommendations and (ii) the parties' submissions.*

17	Update on planning criteria applicable post Muskrat Falls	PUB-NLH-539 and PUB-NLH 540	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.**
18	Update on Power Supply over the ML including status of negotiations with potential suppliers	NP-NLH-160, PUB-NLH-620 and Liberty Report, page 87, Recommendation V-1	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.**
19	Bay d'Espoir instabilities studies	PUB-NLH-511, PUB-NLH-564 and Liberty Report, page 79, Recommendation IV-4	**HIGH POWER STUDY SCHEDULED FOR 2018.**
20	Underfrequency Load Shedding scheme post Muskrat Falls	PUB-NLH-527, PUB-NLH-535, PUB-NLH-537 and Liberty Report, page 71	**HIGH POWER STUDY SCHEDULED FOR 2018.**
21	Operational Studies regarding IIS post Muskrat Falls	PUB-NLH-445, PUB-NLH-486 and PUB-NLH-563	**HIGH POWER STUDY SCHEDULED FOR 2018.**
22	Update on multi-year reliability compliance program and Provincial Reliability Framework	Liberty Report, Recommendations VI-15, page 106	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.** *The nature of the information provided may ultimately be subject to any response by Hydro to this recommendation and the Board's final determination on (i) Liberty's recommendations and (ii) the parties' submissions.*
23	Status of plan for compliance with NERC	Liberty Report, page 101-102 and Recommendation VI-14, page 106	**RESPONSE PROVIDED TO THE BOARD, JULY 5, 2017.** *The nature of the information provided may ultimately be subject to any response by Hydro to this recommendation and the Board's final determination on (i) Liberty's recommendations and (ii) the parties' submissions.*
24	Operating Guidelines for operation of IIS with LIL and with the ML in service and the ML out of service		**LOW POWER STUDY/GUIDELINES SCHEDULED FOR DELIVERY FALL 2017.** **HIGH POWER STUDY/GUIDELINES SCHEDULED FOR 2018.**

nalcor energy LOWER CHURCHILL PROJECT		LCP Integrated Project Schedule with TTO Integration Milestones	Finish Quarter	Status
LTA -Labrador Transmission Assets				
LCP Milestones				
TTO MILESTONES FOR LTA PREPAREDNESS				
	RFO	PCS Completions Database (Commissioning, Testing, As Built Drawing Records)	Q4 17	In Progress
	RFI	Enabling ECC Operations (Equipment Tagging, Single Line Diagrams, Point Lists)	Q4 17	In Progress
	RFI	Operational Studies, Operating Limits / Operating Instruction Inputs - low power	Q3 17	In Progress
	RFI	Grid Energization Procedures	Q3 17	In Progress
	RFCI	CF Commercial Arrangements	Q4 17	In Progress
	BTPO	O&M Onboarding & Training	Q4 17	In Progress
	BTPO	O&M Contractor Supports	Q4 17	In Progress
	BTPO	Asset Hierachies, Criticality Assessment, Maintenance Program (Top 5%)	Q4 17	In Progress
	BTPO	Finance (Budgets, Assets Records, Operational Structures & Setup)	Q1 18	In Progress
LITL - Labrador Island Link				
LCP Milestones				
TTO MILESTONES FOR LITL PREPAREDNESS				
	RFO	PCS Completions Database (Commissioning, Testing, As Built Drawing Records)	Q4 17	In Progress
	RFI	Enabling ECC Operations (Equipment Tagging, Single Line Diagrams, Point Lists)	Q3 17	In Progress
	RFI	Operational Studies, Operating Limits / Operating Instruction Inputs - low power	Q1 18	In Progress
	RFI	Grid Energization Procedures	Q1 18	In Progress
	RFI	Key NERC Reliability Standards (Assess, Define and Develop Voluntary Standards)	Q4 17	In Progress
	RFCI	Government Legislative Support	Q4 17	In Progress
	RFCI	Rates & Regulatory Preparation	Q3 17	In Progress
	RFCI	Transmission Regime & Open Access Agreements	Q3 17	In Progress
	BTPO	O&M Onboarding & Training	Q4 17	In Progress
	BTPO	O&M Contractor Supports	Q4 17	In Progress
	BTPO	Asset Hierachies, Criticality Assessment, Maintenance Program (Top 5%)	Q4 17	In Progress
	BTPO	Finance (Budgets, Assets Records, Operational Structures & Setup)	Q1 18	In Progress
	BTPO	Emergency Repair & Restoration (SOP, SOBI, OTL Response Strategy)	Q4 17	In Progress
	BTPO	Maintenance & Support Contracts (11)	Q4 17	In Progress
	BTPO	Inventory & Spares (Short & Long Term Strategy)	Q4 17	In Progress
ML - Maritime Link				
EMERA Milestones				
TTO MILESTONES FOR LITL PREPARDNESS				
	RFI	Equipment Tagging, Single Line Diagrams, Point Lists	Q2 17	In Progress
	RFI	Operational Studies, Operating Limits / Operating Instruction Inputs - low power	Q3 17	In Progress
	RFCI	Emera Agreements	Q3 17	In Progress

WBS L1	WBS L2	WBS L3	WBS L4	Baseline Dates: Baseline Start Date	Baseline Dates: Baseline End Date	Project Priority	people/ process/ system/ delivery
RFI SCOPE							
			Governance & Oversight	Q4 16	Q4 18		
RFI SYSTEM STUDIES - TRANSMISSION							
			GE Grid (Alstom) Studies Support & Review	Q1 15	Q2 17	P2	Delivery
			ABB Studies Support & Review	Q3 14	Q4 17	P2	Delivery
			Operational System Studies & Support of Operating Limits/Instructions	Q1 16	Q4 17	P3	Delivery
			Energization System Studies	Q2 17	Q4 17	P3	Delivery
RFI OTHER PREPAREDNESS - TRANSMISSION							
			NLH Equipment Tagging and Single Line Diagrams	Q1 15	Q2 17	P3	Delivery
			Support Delivery of Final Points Lists (ECC Control & Monitoring)	Q1 15	Q1 20	P3	Delivery
			Support Delivery of Grid Energization Procedures	Q4 16	Q3 17	P2	Delivery
			Support RTDS Testing and System Commissioning and Witnessing	Q1 17	Q2 18	P3	Delivery
RFI NERC - TRANSMISSION							
			Key NERC Reliability Standards (Assess, Define and Develop Voluntary Standards)	Q1 15	Q4 17	P4	Delivery
BTPO SCOPE							
			Governance & Oversight - Workstream Manager	Q1 16	Q2 20		
BTPO: PEOPLE SCOPE							
			Team Lead - People	Q1 16	Q2 20		
BTPO: PEOPLE - TRANSMISSION							
			CBA - Initial FY17 Collective Bargaining Agreement, Negotiations & Mtgs	Q4 16	Q1 17	P2	People
			Staffing Strategy and Recruitment				
			Strategy & Planning	Q1 16	Q4 19	P2	People
			BTPO - Secure Team Resourcing	Q1 16	Q3 17	P2	People
			LTA - Secure O&M Team Resourcing (Supervisor, Operator, Maintainer)	Q1 16	Q4 17	P2	People
			LIL - Secure O&M Team Resourcing (Supervisor, Operator, Maintainer)	Q1 16	Q4 17	P2	People
			Contractor (HVdc Expertise) - Secure O&M Supports	Q2 16	Q4 17	P2	People
			Training Assement, Schedule and Execution				
			LTA - Deliver O&M Training Requirements	Q1 17	Q4 19	P2	People
			LIL - Deliver O&M Training Requirements	Q1 17	Q4 19	P2	People
BTPO: ASSET MANAGEMENT SCOPE							
			Team Lead - Assets	Q2 16	Q2 20		
BTPO: ASSETS - TRANSMISSION							
HVac TERMINAL STATION ASSETS							
			Soldiers Pond TS (Hierachies, Criticality, TOP 5% Spares & Program)	Q2 16	Q4 17	P3	Processes
			Churchill Falls & Muskrat Falls TS (Hierachies, Criticality, TOP 5% Spares & Program)	Q2 16	Q4 17	P2	Processes
TRANSMISSION ASSETS							
			AC Transmission Labrador (Hierachies, Criticality, TOP 5% Spares & Program)	Q2 16	Q4 17	P3	Processes
			DC Subsea Transmission -Straight of Bell Isle (Hierachies, Criticality, TOP 5% Spares	Q2 16	Q4 17	P3	Processes
			DC Overland Transmission - Muskrat Falls to Soldiers Pond (Hierachies, Criticality, T	Q2 16	Q4 17	P3	Processes
			AC Transmission -TL267 (Hierachies, Criticality, TOP 5% Spares & Program)	Q2 16	Q4 17	P3	Processes
HVdc TRANSITION COMPOUND AND CONVERTER ASSETS							
			Transition Compounds (Hierachies, Criticality, TOP 5% Spares & Program)	Q2 16	Q4 17	P3	Processes
			Converter Stations - Muskrat Falls & Soldiers Pond (Hierachies, Criticality, TOP 5% S	Q2 16	Q4 17	P3	Processes
			DC Transmission Yards - Muskrat Falls & Soldiers Pond (Hierachies, Criticality, TOP 5	Q2 16	Q4 17	P3	Processes
OTHER ASSETS							
			Synchronous Condenser Plant at Soldiers Pond	Q2 16	Q4 17	P3	Processes

WBS L1	WBS L2	WBS L3	WBS L4	Baseline Start Date	Baseline End Date	Project Priority	people/ process/ system/ delivery
			Communication Equipment - Churchill Falls to ECC, A and B paths (Hierachies, Critic	Q2 16	Q4 17	P3	Processes
JDE DATA IMPORT & SETUP							
			JDE Data Migration & Linkage (TOP 5% BOM's, Drawings, Spares, Methods Linkages	Q3 17	Q1 18	P3	Systems
BTPO: FINANCE SCOPE							
Team Lead - Finance				Q2 16	Q2 20		
FINANCE - TRANSMISSION							
			LTCo (Budgets, Asset Records, Operational Structures & Setup)	Q2 16	Q1 18	P2	Process
			LILGPCo (Budgets, Asset Records, Operational Structures & Setup)	Q2 16	Q1 18	P3	Process
			MFCo (Budgets, Asset Records, Operational Structures & Setup)	Q2 16	Q1 18	P4	Process
BTPO: EMERGENCY RESPONSE AND RESTORATION SCOPE							
BTPO: EMERGENCY RESPONSE & RESTORATION - TRANSMISSION							
			Soldier's Pond (Risk Assessment & Response Strategy)	Q2 17	Q4 17	P3	Processes
			Overland Transmission (Risk Assessment & Response Strategy)	Q2 17	Q4 17	P3	Processes
			SOBI-Marine Cable (Risk Assessment & Response Strategy)	Q2 17	Q4 17	P3	Processes
BTPO: O&M CONTRACTS SCOPE							
BTPO: O&M CONTRACTS - TRANSMISSION							
			Operational & Maintenance Contracts (HVdc Expertise, NLH/CF Service Contracts)	Q4 16	Q4 17	P3	Systems
			Maintenance Support Contracts (Key Maintenance Contracts)	Q3 16	Q4 17	P3	Systems
BTPO: INVENTORY AND SPARES SCOPE							
BTPO: INVENTORY - TRANSMISSION							
			Interim Inventory & Spares Storage Arrangements	Q3 17	Q4 17	P3	Systems
			Long Term Inventory & Spares Storage Arrangements	Q3 17	Q4 17	P4	Systems
BTPO: WORK PROTECTION & SAFETY SCOPE							
			Work Protection & Safety	Q3 17	Q4 19	P2	Systems
RFCI SCOPE							
			RFCI Governance & Oversight	Q1 16	Q4 18	P4	Process
			Agreements (Commercial, Regulatory, Open Acess, Legislative)	Q4 13	Q2 18	P4	Process
			Commercial - Generation Production Optimization	Q2 15	Q4 17	P4	Process
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NEWFOUNDLAND AND LABRADOR HYDRO

and

NOVA SCOTIA POWER INCORPORATED

AMENDED AND RESTATED INTERCONNECTION OPERATORS AGREEMENT

July 31, 2014

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Schedules:

AMENDED AND RESTATED
INTERCONNECTION OPERATORS AGREEMENT

THIS AMENDED AND RESTATED INTERCONNECTION OPERATORS AGREEMENT is made effective the 31st day of July, 2014 (the "**A&R Effective Date**")

BETWEEN:

> **NEWFOUNDLAND AND LABRADOR HYDRO**, a body corporate existing pursuant to the *Hydro Corporation Act, 2007*, being Chapter H-7 of the *Statutes of Newfoundland and Labrador, 2007* ("**NLH**")

- and -

> **NOVA SCOTIA POWER INCORPORATED**, a company incorporated under the laws of the Province of Nova Scotia ("**NSPI**")

WHEREAS:

A. NLH is a fully-integrated, electric utility operating in NL in a regulated environment;

B. NSPI is a fully-integrated, electric utility operating in NS in a regulated environment;

C. NLH and NSPI wish to manage and optimize the operational aspects of the interconnection between their transmission systems via the Maritime Link by developing, administering and implementing practices and procedures and exchanging information relating to Reliability coordination and power system operation as necessary to allow for the safe and reliable integration of the Maritime Link Interconnection Facilities with the NL Transmission System and the NS Transmission System for the benefit of both Parties;

D. on July 31, 2012 NLH and NSPI entered into the original version of this Agreement (the "**Original IOA**");

E. contemporaneously with the execution and delivery of this Agreement, Nalcor and Emera are entering into an amended and restated Maritime Link Joint Development Agreement (the "**A&R ML-JDA**"); and

F. NLH and NSPI wish to amend and restate the Original IOA to update certain provisions and make other amendments for consistency with the A&R ML-JDA;

NOW THEREFORE this Agreement witnesses that in consideration of the mutual covenants and agreements hereinafter contained the Parties, intending to be legally bound, agree as follows:

ARTICLE 1
DEFINITIONS AND INTERPRETATION

1.1 Definitions

In this Agreement including the recitals and, subject to **Section 1.2(f)**, in the Schedules:

"**A&R Effective Date**" has the meaning set forth in the commencement of this Agreement;

"**A&R ML-JDA**" has the meaning set forth in the preamble to this Agreement;

"**Adequacy**" means the ability of the electric system to reliably supply electrical demand and energy requirements at all times, taking into account scheduled and unscheduled outages of system elements;

"**Affiliate**" means, with respect to any Person, any other Person who, directly or indirectly, Controls, is Controlled by, or is under common Control with, such Person; provided however that the NL Crown shall be deemed not to be an Affiliate of NLH or Nalcor;

"**Agreement**" means this Interconnection Operators Agreement, including all Schedules, as it may be modified, amended, supplemented or restated by written agreement between the Parties;

"**Applicable Law**" means, in relation to any Person, property, transaction or event, all applicable laws, statutes, rules, codes, regulations, treaties, official directives, policies and orders of, and the terms of all judgments, orders and decrees issued by, any Authorized Authority by which such Person is bound or having application to the property, transaction or event in question;

"**Authorized Authority**" means, in relation to any Person, property, transaction or event, any (a) federal, provincial, state, territorial, municipal or local governmental body (whether administrative, legislative, executive or otherwise), (b) agency, authority, commission, instrumentality, regulatory body, court or other entity exercising executive, legislative, judicial, taxing, regulatory or administrative powers or functions of or pertaining to government, (c) court, arbitrator, commission or body exercising judicial, quasi-judicial, administrative or similar functions, (d) private regulatory entity, self-regulatory organization or other similar Person, or (e) other body or entity created under the authority of or otherwise subject to the jurisdiction of any of the foregoing, including any stock or other securities exchange, in each case having jurisdiction over such Person, property, transaction or event;

"**Balancing Authority**" means the entity with the highest level of responsibility, pursuant to Reliability Standards, for integrating resource plans ahead of time, maintaining load-interchange generation balance within a Balancing Authority Area, and for supporting interconnection frequency in real time;

"**Balancing Authority Area**" means the metered extent, or footprint, containing a collection of generation, transmission and loads for which the Balancing Authority maintains load-resource balance;

"**Bulk Electric System**" means the electrical generation resources, transmission lines, interconnections with neighbouring systems and associated equipment, generally operated at voltages of 100 kV or higher. Radial transmission facilities serving only load with one transmission source are generally not included in this definition;

"**Bulk Power System**" means the interconnected electrical systems within north-eastern North America comprised of system elements on which faults or disturbances can have a significant adverse impact outside of a Local Area;

"**Business Day**" means any day that is not a Saturday, Sunday or legal holiday recognized in the City of St. John's, NL, or in Halifax Regional Municipality, NS;

"**Claims**" means any and all Losses, claims, actions, causes of action, demands, fees (including all legal and other professional fees and disbursements, court costs and experts' fees), levies, Taxes, judgments, fines, charges, deficiencies, interest, penalties and amounts paid in settlement, whether arising in equity, at common law, by statute, or under the law of contracts, torts (including negligence and strict liability without regard to fault) or property, of every kind or character;

"**Commercial Operation Date**" means the "Commercial Operation Date" of the Maritime Link as set forth in the Maritime Link Joint Development Agreement;

"**Confidential Information**" has the meaning given to such term in the Project NDA;

"**Control**" of a Person means the possession, direct or indirect, of the power to elect or appoint a majority of such Person's board of directors or similar governing body, or to direct or cause the direction of the management, business and/or policies of such Person, whether through ownership of Voting Shares, by contract or otherwise, and, without limiting the generality of the foregoing, a Person shall be deemed to "**Control**" any partnership of which, at the time, the Person is a general partner, in the case of a limited partnership, or is a partner who, under the partnership agreement, has authority to bind the partnership, in all other cases (and the terms "**Controlled by**" and "**under common Control with**" have correlative meanings);

"**Delivery Point**" means the point separating the NS Balancing Authority Area and the NL Balancing Authority Area and is the 345 kV side of the Maritime Link HVdc converter transformers at Woodbine*,* NS;

"**Dispute**" means any dispute, controversy or claim of any kind whatsoever arising out of or relating to this Agreement, including the interpretation of the terms hereof or any Applicable Law that affects this Agreement, or the transactions contemplated hereunder, or the breach, termination or validity thereof;

"**Effective Date**" means July 31, 2012;

"**Emera**" means Emera Inc., a company incorporated under the laws of NS and its successors;

"**Emergency**" means any abnormal system condition that requires automatic or manual action to prevent or limit loss of transmission facilities or generation supply that could adversely affect the

Reliability of, in the case of NL, the Bulk Electric System, and in the case of NS, the Bulk Power System;

"**Emergency Energy**" means energy supplied from Operating Reserve or electrical generation available for sale in NL or NS or available from another Balancing Authority Area that may be provided in cases of sudden and unforeseen outages of generating units, transmission lines or other equipment, or to meet other sudden and unforeseen circumstances such as forecast errors, or to provide sufficient Operating Reserve;

"**Energy and Capacity Agreement**" means the agreement dated July 31, 2012 between Nalcor and Emera relating to the sale and delivery of energy and capacity by Nalcor to Emera;

"**Excise Tax Act**" means the *Excise Tax Act* (Canada);

"**Force Majeure**" means an event, condition or circumstance (each, an "**event**") beyond the reasonable control of the Party claiming the Force Majeure, which, despite all commercially reasonable efforts, timely taken, of the Party claiming the Force Majeure to prevent its occurrence or mitigate its effects, causes a delay or disruption in the performance of any obligation (other than the obligation to pay monies due) imposed on such Party hereunder. Provided that the foregoing conditions are met, "**Force Majeure**" may include,

(a) an act of God, storm, fire, flood, iceberg, ice conditions, epidemic declared by an Authorized Authority having jurisdiction, geomagnetic activity, explosion, earthquake or lightning;

(b) a war, revolution, terrorism, insurrection, riot, blockade, sabotage, civil disturbance, vandalism or any other unlawful act against public order or authority;

(c) a strike, lockout or other industrial disturbance;

(d) an accident causing material physical damage to, or materially impairing the operation of, or access to, the Interconnection Facilities, the NL Transmission System or the NS Transmission System; and

(e) the inability to obtain or the revocation, failure to renew or other inability to maintain in force or the amendment of any order, permit, licence, certificate or authorization from any Authorized Authority, unless such inability or amendment is caused by a breach of the terms thereof or results from an agreement made by the Party seeking or holding such order, permit, licence, certificate or authorization,

provided that the following shall not be considered events of Force Majeure:

(i) lack of finances or changes in economic circumstances of a Party;

(ii) any delay in the settlement of any Dispute; and

(iii) if the event, condition or circumstance relied upon resulted from a breach of Good Utility Practice by the Party claiming Force Majeure;

"**Good Utility Practice**" means those project management, design, procurement, construction, operation, maintenance, repair, removal and disposal practices, methods and acts that are engaged in by a significant portion of the electric utility industry in Canada during the relevant time period, or any other practices, methods or acts that, in the exercise of reasonable judgment in light of the facts known at the time a decision is made, could have been expected to accomplish a desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be the optimum practice, method or act to the exclusion of others, but rather to be a spectrum of acceptable practices, methods or acts generally accepted in such electric utility industry for the project management, design, procurement, construction, operation, maintenance, repair, removal and disposal of electric utility facilities in Canada. Notwithstanding the foregoing references to the electric utility industry in Canada, in respect solely of Good Utility Practice regarding subsea HVdc transmission cables, the standards referenced shall be the internationally recognized standards for such practices, methods and acts generally accepted with respect to subsea HVdc transmission cables. Good Utility Practice shall not be determined after the fact in light of the results achieved by the practices, methods or acts undertaken but rather shall be determined based upon the consistency of the practices, methods or acts when undertaken with the standard set forth in the first two sentences of this definition at such time;

"**HST**" means all amounts exigible pursuant to Part IX of the Excise Tax Act, including, for greater certainty, the Taxes commonly referred to as the goods and services tax (GST) and the harmonized sales tax (HST);

"**Inadvertent Interchange**" means the difference between net actual interchange and net scheduled interchange at the Delivery Point;

"**Income Tax Act**" means the *Income Tax Act* (Canada);

"**Insolvency Event**" means, in relation to any Party, the occurrence of one or more of the following:

(a) an order is made, or an effective resolution passed, for the winding-up, liquidation or dissolution of such Party;

(b) such Party voluntarily institutes proceedings for its winding up, liquidation or dissolution, or to authorize or enter into an arrangement under the *Corporations Act* (Newfoundland and Labrador) or similar legislation in any other jurisdiction affecting any of its creditors, or takes action to become bankrupt, or consents to the filing of a bankruptcy application against it, or files an assignment, a proposal, a notice of intention to make a proposal, an application, or answer or consent seeking reorganization, readjustment, arrangement, composition, protection from creditors, or similar relief under any bankruptcy or insolvency law or any other similar Applicable Law, including the *Bankruptcy and Insolvency Act* (Canada) and the *Companies' Creditors Arrangement Act* (Canada), or consents to the filing of any such application for a bankruptcy order, or consents to the appointment of an interim receiver, receiver, monitor, liquidator, restructuring officer or trustee in bankruptcy of all or substantially all of the property of such Party or makes an assignment for the benefit of creditors, or admits in writing its inability to pay its debts generally as they come due or commits any other act of bankruptcy or insolvency, or suspends or threatens to suspend transaction of its usual business, or any action is taken by such Party in furtherance of any of the foregoing;

(c) a court having jurisdiction enters a judgment or order adjudging such Party a bankrupt or an insolvent person, or approving as properly filed an application or motion seeking an arrangement under the *Corporations Act* (Newfoundland and Labrador) or similar legislation in any other jurisdiction affecting any of its creditors or seeking reorganization, readjustment, arrangement, composition, protection from creditors, or similar relief under any bankruptcy or insolvency law or any other similar Applicable Law, or an order of a court having jurisdiction for the appointment of an interim receiver, receiver, monitor, liquidator, restructuring officer or trustee in bankruptcy of all or substantially all of the undertaking or property of such Party, or for the winding up, liquidation or dissolution of its affairs, is entered and such order is not contested and the effect thereof stayed, or any material part of the property of such Party is sequestered or attached and is not returned to the possession of such Party or released from such attachment within 30 days thereafter;

(d) any proceeding or application is commenced respecting such Party without its consent or acquiescence pursuant to any Applicable Law relating to bankruptcy, insolvency, reorganization of debts, winding up, liquidation or dissolution, and such proceeding or application (i) results in a bankruptcy order or the entry of an order for relief and a period of 30 days has elapsed since the issuance of such order without such order having been reversed or set aside or (ii) is not dismissed, discharged, stayed or restrained in each case within 30 days of the commencement of such proceeding or application; or

(e) such Party has ceased paying its current obligations in the ordinary course of business as they generally become due;

"**Interconnection Facilities**" means the facilities described in **Schedule B**;

"**Interconnection Operators Committee**" means the committee established pursuant to **Section 7.1**;

"**Interconnection Point**" means the point of interconnection of the NL Transmission System and the NS Transmission System located at the point on the Maritime Link that is the midpoint of the undersea portion of the Maritime Link cables;

"**Interconnection Reliability Operating Limit**" means a System Operating Limit that, if violated, could lead to instability, uncontrolled separation or cascading outages that adversely impact the Reliability of the Bulk Electric System, in the case of NL, or the Bulk Power System, in the case of NS;

"**Knowledge**" means in the case of either Party, as applicable, the actual knowledge of any of the executive officers of such Party and other facts or matters that such executive officers could reasonably be expected to discover or otherwise become aware of in the course of performing their ordinary responsibilities as executive officers of such Party;

"**Legal Proceedings**" means any actions, suits, investigations, proceedings, judgments, rulings or orders by or before any Authorized Authority;

"**Local Area**" means an electrically confined or radial portion of the system. The geographic size and number of system elements contained will vary based on system characteristics. A local area may be relatively large geographically with relatively few buses in a sparse system, or be relatively small geographically with a large number of buses in a densely networked system;

"**Losses**" means any and all losses (other than Transmission Losses), damages, costs, expenses, charges, fines, penalties and injuries of every kind and character;

"**ML Transmission Procedures**" means the rules and practices applicable to the administration of transmission service over the Maritime Link, subject to approval by the UARB, as developed by the Interconnection Operators Committee pursuant to **Section 7.2** in accordance with the outline attached as **Schedule D**;

"**Maritime Link**" means the transmission facilities to be constructed between the existing NL Transmission System and the existing NS Transmission System in accordance with the Maritime Link Joint Development Agreement;

"**Maritime Link Joint Development Agreement**" or "**ML-JDA**" means the agreement dated July 31, 2012 between Nalcor and Emera relating to the development of the Maritime Link;

"**Maritimes Area**" means the geographic area including the Provinces of New Brunswick, Nova Scotia, Prince Edward Island, and the northern part of the State of Maine radially connected to New Brunswick (currently referred to as the Northern Maine Market);

"**Marketing Personnel**" means a natural Person who, individually or on behalf of any other Person, sells or purchases for consumption or resale capacity, energy, energy derivatives and ancillary services in the wholesale power markets, and includes any natural Person who conducts such transactions on behalf of transmission service customers, power exchanges, transmission owners that are not also a System Operator, load serving entities, loads, holders of energy derivatives, generators and other power suppliers and their designated agents;

"**Metered Quantity**" means active power and reactive power, with associated time tagging and any other quantity that may be measured by a Party's Metering Equipment and that is reasonably required by either Party for Security reasons or revenue requirements;

"**Metering Equipment**" means the potential transformers, current transformers, meters, interconnecting wiring and recorders used to measure and record any Metered Quantity;

"**Mutual Benefits**" means the transient and steady-state support that the integrated generation and Transmission Systems in NL and NS inherently provide to each other by virtue of being interconnected. Mutual Benefits shall exclude energy products or services that are normally marketed or compensated through other wholesale trading markets or sales agreements;

"**MVAr**" means megavolt-ampere reactive;

"**MW**" means megawatt;

"**NB Reserve Sharing Agreement**" means the reserve sharing agreement between NSPI and the NBSO dated October 1, 2005;

"**NBSO**" means the New Brunswick System Operator established pursuant to the *Electricity Act* (New Brunswick) or any successor corporation or division of any corporation which may be established or authorized to carry out the functions of system operator of the Bulk Power System in New Brunswick;

"**NERC**" means the North American Electric Reliability Corporation or its successor organization;

"**NL**" means the Province of Newfoundland and Labrador;

"**NLSO**" means the system operations department of NLH responsible for the safe and reliable operation of the Bulk Electric System in NL, or a functionally separate division of NLH performing this function, or any successor as applicable;

"**NL Transmission System**" means, on and after the Commercial Operation Date, the transmission facilities located in NL operating at a voltage level of 230 kV or higher, together with, on and after the Commercial Operation Date, that portion of the Maritime Link on the NL side of the Interconnection Point;

"**NPCC**" means the Northeast Power Coordinating Council or its successor organization;

"**NS**" means the Province of Nova Scotia;

"**NSPSO**" means the Nova Scotia Power System Operator, a functionally separate division of NSPI responsible for the safe and reliable operation of the Bulk Power System in NS, or any successor;

"**NS Transmission System**" means, on and after the Commercial Operations Date, the 138kV, 230 kV and 345 kV transmission facilities located in NS, together with, on and after the Commercial Operation Date, that portion of the Maritime Link on the NS side of the Interconnection Point;

"**Nalcor**" means Nalcor Energy, a body corporate existing pursuant to the *Energy Corporation Act* (NL), and its successors;

"**New Taxes**" means:

(a) any Tax exigible pursuant to Applicable Law which comes into force after the Effective Date; and

(b) any change to a Tax exigible pursuant to Applicable Law which comes into force after the Effective Date;

"**Nominal Transfer Capability**" means the thermal capacity that the equipment in the Interconnection Facilities can withstand in the Interconnection Facilities' original configuration as specified in **Schedule B** without regard to external system impacts by the interconnected AC Transmission Systems or other Transmission Systems;

"**Notice**" means a communication required or contemplated to be given by either Party to the other under this Agreement, which communication shall be given in accordance with **Section 16.1**;

"**Operating Instructions**" means the operating procedures and steps used for the operation of the Interconnection Facilities as established from time to time by the Interconnection Operators Committee in accordance with **Section 7.4**;

"**Operating Reserve**" means that capability above firm system demand required to provide for regulation, load forecasting error, equipment forced and scheduled outages and local area protection. It consists of spinning and non-spinning reserve;

"**Operational Control**" means security monitoring, adjustment of generation and transmission resources, coordinating and approval of changes in transmission status for maintenance, determination of transmission status for Reliability, coordination with other Balancing Authorities, voltage reductions and load shedding;

"**Original IOA**" has the meaning set forth in the preamble to this Agreement;

"**PUB**" means the Board of Commissioners of Public Utilities established pursuant to the *Public Utilities Act* (NL), or any successor performing substantially the same functions;

"**Parties**" means the parties to this Agreement, and "**Party**" means one of them;

"**Payee**" has the meaning set forth in **Section 13.1**;

"**Payor**" has the meaning set forth in **Section 13.1**;

"**Person**" includes an individual, a partnership, a corporation, a company, a trust, a joint venture, an unincorporated organization, a union, a government or any department or agency thereof and the heirs, executors, administrators or other legal representatives of an individual;

"**Prime Rate**" means the variable rate of interest per annum expressed on the basis of a year of 365 or 366 days, as the case may be, established from time to time by The Bank of Nova Scotia, or any successor thereto, as its reference rate for the determination of interest rates that it will charge on commercial loans in Canadian dollars made in Canada;

"**Project NDA**" means the Restricted Use and Non-Disclosure Agreement dated June 20, 2011 between Nalcor and Emera;

"**Regular Business Hours**" means 8:30 a.m. through 4:30 p.m. local time on Business Days in St. John's, NL, when referring to the Regular Business Hours of NLH, and 9:00 a.m. through 5:00 p.m. local time on Business Days in Halifax Regional Municipality, NS, when referring to the Regular Business Hours of NSPI;

"**Regulatory Approval**" means any approval required by any Authorized Authority, including any regulatory, environmental, development, zoning, building, subdivision or occupancy permit, licence, approval or other authorization;

"**Reliability**" means the degree of performance of the electric power system that results in electricity being delivered within Reliability Standards and in the amount desired. Electric system Reliability can be addressed by considering two basic and functional aspects of the electric systems: Adequacy and Security;

"**Reliability Coordinator**" means, for a given region, the entity that is the highest level of authority that is responsible for the reliable operation of the Bulk Electric System, has the wide area view of the Bulk Electric System, and has the operating tools, processes and procedures, including authority to prevent or mitigate emergency operating situations in both next-day analysis and real-time operations;

"**Reliability Standards**" means the criteria, standards and requirements relating to Reliability established or authorized by a Standards Authority;

"**Reserve Responsibility**" means an amount of Operating Reserve measured in MW that a Balancing Authority must have available to recover from contingencies;

"**Sanction Agreement**" means the agreement dated December 17, 2012 between Nalcor and Emera;

"**Security**" means the ability of the electric system to withstand disturbances such as electric short circuits or unanticipated loss of system elements;

"**Security Energy**" means energy delivered by NLH to NSPI or by NSPI to NLH, used to bias the flow of energy in order to prevent cascading transmission outages following a single contingency event;

"**Security Limits**" means electricity system voltage, frequency, stability and thermal safe operating limits;

"**Standards Authority**" means:

(a) in respect of NSPI, NERC, NPCC and the UARB or any successor thereof, or any other agency with authority over NSPI regarding standards or criteria applicable to NSPI relating to the Reliability of the NS Transmission System; and

(b) in respect of NLH at the Effective Date, the Government of NL, the PUB or any other agency as may assume authority over NLH subsequent to the Effective Date regarding standards or criteria applicable to NLH relating to the Reliability of the NL Transmission System;

"**Supplemental Agreements**" means the supplemental agreements and documentation identified in **Schedule A**;

"**Supporting Material**" has the meaning set forth in **Section 13.1**;

"**System Operating Limit**" means the value (such as MW, MVAr, amperes, frequency or volts) that satisfies the most limiting of the prescribed operating criteria for a specified system configuration to ensure operation within acceptable Reliability criteria. System Operating Limits are based upon certain operating criteria. These include, but are not limited to:

(a) facility ratings (applicable pre-and post-contingency equipment or facility ratings);

(b) transient stability ratings (applicable pre-and post-contingency stability limits);

(c) voltage stability ratings (applicable pre-and post-contingency voltage stability); and

(d) system voltage limits (applicable pre-and post-contingency voltage limits);

"**Tariff Charges**" means any charges arising pursuant to a tariff or other schedule of fees in respect of electricity transmission services;

"**Tax**" or "**Taxes**" means any tax, fee, levy, rental, duty, charge, royalty or similar charge including, for greater certainty, any federal, state, provincial, municipal, local, aboriginal, foreign or any other assessment, governmental charge, imposition or tariff (other than Tariff Charges) wherever imposed, assessed or collected, and whether based on or measured by gross receipts, income, profits, sales, use and occupation or otherwise, and including any income tax, capital gains tax, payroll tax, fuel tax, capital tax, goods and services tax, harmonized sales tax, value added tax, sales tax, withholding tax, property tax, business tax, ad valorem tax, transfer tax, franchise tax or excise tax, together with all interest, penalties, fines or additions imposed, assessed or collected with respect to any such amounts;

"**Term**" has the meaning set forth in **Section 11.1**;

"**third party**" means any Person that does not Control, is not Controlled by and is not under common Control with the applicable Party;

"**Transmission Losses**" means losses of electrical energy normally incurred in the transmission of electrical energy;

"**Transmission System**" means a network for transmitting high voltage electricity, and includes any structures, equipment or other facilities used for that purpose;

"**UARB**" means the Utility and Review Board established by NS pursuant to the *Utility and Review Board Act* (NS), as it may be replaced or reconstituted from time to time; and

"**Voting Shares**" means shares issued by a corporation in its capital stock, or equivalent interests in any other Person, the holders of which are ordinarily, in the absence of contingencies, entitled to vote for the election of directors (or Persons performing similar functions) of such Person, even if such right to vote has been suspended by the happening of such contingency.

1.2 Construction of Agreement

(a) Interpretation Not Affected by Headings, etc. - The division of this Agreement into articles, sections and other subdivisions, the provision of a table of contents and the insertion of headings are for convenience of reference only and shall not affect the construction or interpretation of this Agreement. Unless otherwise indicated, all references to an "Article", "Section" or "Schedule" followed by a number and/or a letter refer to the specified article, section or schedule of this Agreement. The terms "this Agreement", "hereof", "herein", "hereby", "hereunder" and similar expressions refer to this Agreement and not to any particular Article or Section hereof. All references to a given agreement, instrument or other document, other than a Formal Agreement, shall be, unless otherwise stated herein, a reference to that agreement, instrument or other document as it stood on the Effective Date. All references to a Formal Agreement shall be a reference to that Formal Agreement as modified, amended, supplemented and restated from time to time.

(b) Singular/Plural; Derivatives - Whenever the singular or masculine or neuter is used in this Agreement, it shall be interpreted as meaning the plural or feminine or body politic or corporate, and vice versa, as the context requires. Where a term is defined herein, a capitalized derivative of such term has a corresponding meaning unless the context otherwise requires.

(c) "Including" - The word "including", when used in this Agreement, means "including without limitation".

(d) Trade Meanings - Terms and expressions that are not specifically defined in this Agreement, but which have generally accepted meanings in the custom, usage and literature of the electricity industry in Canada as of the date of this Agreement, shall have such generally accepted meanings when used in this Agreement, unless otherwise specified elsewhere in this Agreement.

(e) Statutory References - Any reference in this Agreement to a statute shall include, and shall be deemed to be, a reference to such statute and to the regulations made pursuant thereto, and all amendments made thereto (including changes to section numbers referenced herein) and in force from time to time, and to any statute or regulation that may be passed that has the effect of supplementing or replacing the statute so referred to or the regulations made pursuant thereto, and any reference to an order, ruling or decision shall be deemed to be a reference to such order, ruling or decision as the same may be varied, amended, modified, supplemented or replaced from time to time.

(f) Terms Defined in Schedules - Terms defined in a Schedule or part of a Schedule to this Agreement shall, unless otherwise specified in such Schedule or part of a Schedule or elsewhere in this Agreement, have the meaning ascribed thereto only in such Schedule or such part of such Schedule.

(g) Calculation of Time - Where, in this Agreement, a period of time is specified or calculated from or after a date or event, such period is to be calculated excluding such date or the date on which such event occurs, as the case may be, and including the date on which the period ends.

(h) Time Falling on Non-Business Day - Whenever the time for doing something under this Agreement falls on a day that is not a Business Day such action is to be taken on the first following Business Day.

(i) No Drafting Presumption - The Parties acknowledge that their respective legal advisors have reviewed and participated in settling the terms of this Agreement and agree that any rule of construction to the effect that any ambiguity is to be resolved against the drafting Party shall not apply to the interpretation of this Agreement.

(j) Approvals, etc. - Except where otherwise expressly provided herein, whenever an action referred to in this Agreement is to be "approved", "decided" or "determined" by a Party or requires a Party's "consent", then (i) such approval, decision, determination or consent by a Party must be in writing, and (ii) such Party shall be free to take such action having regard to that Party's own interests, in its sole and absolute discretion.

1.3 Conflicts between Parts of Agreement

If there is any conflict or inconsistency between a provision of the body of this Agreement and that of a Schedule or any document delivered pursuant to this Agreement, the provision of the body of this Agreement shall prevail.

1.4 Applicable Law and Submission to Jurisdiction

This Agreement shall be governed by and construed in accordance with the laws of NL and the Federal laws of Canada applicable therein, but excluding all choice-of-law provisions. Subject to **Article 12**, the Parties irrevocably consent and submit to the exclusive jurisdiction of the courts of NL with respect to all matters relating to this Agreement, subject to any right of appeal to the Supreme Court of Canada. Each Party waives any objection that it may now or hereafter have to the determination of venue of any proceeding in such courts relating to this Agreement or that it may now or hereafter have that such courts are an inconvenient forum.

1.5 Schedules

The following are the Schedules attached to and incorporated by reference in this Agreement, which are deemed to be part hereof:

Schedule A – Supplemental Agreements

A1 - Area Adequacy Reviews (Atlantic Provinces)

A2 - Operating Reserve Agreement

A3 - Emergency and Security Energy Transactions

A4 - Maritimes Link ACE Management and Inadvertent Energy

Schedule B – Description of Interconnection Facilities

Schedule C – Functional Operating Relationship

Schedule D – Outline of ML Transmission Procedures

1.6 <u>Inter-Relationship with Original IOA</u>

Effective as of the A&R Effective Date, this Agreement amends and restates the Original IOA in its entirety, it being understood and agreed that all liabilities and obligations under the Original IOA existing or arising with respect to occurrences prior to the A&R Effective Date will survive and continue to exist, and neither of the Parties is waiving any of its rights or remedies in respect thereof.

ARTICLE 2
PURPOSE AND SCOPE OF AGREEMENT

2.1 <u>Purpose and Scope of Agreement</u>

The purpose of this Agreement is to provide for the safety, Reliability and operability of the Interconnection Facilities in conjunction with the interconnected NS Transmission System and NL Transmission System and through coordinated scheduling of the Interconnection Facilities. The purpose of this Agreement is also to provide for emergency assistance and to provide for the procedures associated with Inadvertent Interchange accounting and interchange scheduling between the NS Transmission System and the NL Transmission System.

This Agreement establishes a framework for the following functions related to the Reliability and the optimization of interconnected operations between the Parties:

(a) coordinating the operation of the NS Transmission System, the NL Transmission System and the Interconnection Facilities;

(b) ensuring compliance with the requirements of their respective Standards Authorities;

(c) developing and issuing Operating Instructions and Security Limits for the Interconnection Facilities: (i) to ensure secure and reliable operation of the Interconnection Facilities; (ii) to comply with the requirements of Standards Authorities; and (iii) to the extent that interconnected operations may affect the Reliability of either system, to ensure secure and reliable operation of the NS Transmission System and the NL Transmission System;

(d) implementing the respective Reliability Standards applicable to each Party;

(e) conducting operating performance reviews of the Interconnection Facilities;

(f) providing assistance between the NL Transmission System and the NS Transmission System in an Emergency and in respect of system restoration;

(g) developing procedures to notify adjacent areas of new or modified facilities that are anticipated to have an impact on the Reliability or operability of either of the NL Transmission System or the NS Transmission System; and

(h) coordinating and administering matters relating to transmission service and transmission access as they relate to the Reliability and operability of the NS Transmission System or the NL Transmission System.

ARTICLE 3
MUTUAL BENEFITS

3.1 No Charge for Mutual Benefits of Interconnection

The NL Transmission System and the NS Transmission System, by virtue of being connected to each other, will share Mutual Benefits. NLH and NSPI shall not charge one another for Mutual Benefits.

3.2 Maintenance of Mutual Benefits

The Parties shall endeavour to coordinate the operation of the Interconnection Facilities to realize Mutual Benefits. The Parties recognize that circumstances beyond their control, such as operating configurations, contingencies, maintenance or actions by third parties, may result in a reduction of Mutual Benefits. Neither Party shall be obligated to provide compensation in any form to the other Party for any reduction of Mutual Benefits.

ARTICLE 4
INTERCONNECTED OPERATION

4.1 Operational Control

The Parties shall have Operational Control, for the purpose of system operations, over the portions of the Interconnection Facilities on their respective sides of the Interconnection Point. Notwithstanding the foregoing: (i) the Reliability Standards for the NS Transmission System shall apply to the Interconnection Facilities; and (ii) each owner of generation and transmission resources shall continue to be otherwise responsible for the operation and maintenance of its own facilities.

4.2 Adoption and Compliance with Reliability Standards

To the extent that the operation of the Interconnection Facilities may affect the Reliability of either system, the Parties shall adopt, enforce and comply with requirements and standards that will safeguard Reliability of the interconnected NS Transmission System and NL Transmission System. NSPI and NLH shall each comply at all times with their respective Reliability Standards.

4.3 Obligation to Remain Interconnected

The Parties shall, following the Commercial Operation Date, operate or direct the operation of their respective Transmission Systems so that they remain interconnected at the Nominal Transfer Capability, except:

(a) during the occurrence of an event of Force Majeure which renders a Party unable to remain interconnected;

(b) when the Interconnection Facilities are opened in accordance with the terms of an Operating Instruction or, if the Operating Instruction does not anticipate a particular circumstance, where there is an imminent risk of equipment failure, danger to personnel or the public, damage to the environment, or risk to Security or Reliability of a Transmission System, which cannot be avoided by Good Utility Practice; or

(c) during planned maintenance where notice has been given in accordance with outage procedures as implemented by the Interconnection Operators Committee.

4.4 <u>Notification of Circumstances</u>

In the event that the Interconnection Facilities are to be opened or if the Interconnection Facilities transfer capability is to be changed, the Party which plans to initiate the opening of, or the transfer capability change, shall provide the other Party with notification indicating the circumstances of the opening of the Interconnection Facilities and/or the change in its transfer capability, and the expected restoration time. These notifications shall be given in accordance with procedures implemented by the Interconnection Operators Committee. For greater certainty, all references herein to changes in transfer capability refer to operational adjustments made by a Party to address transient system conditions and shall not be taken as conferring either Party with a right to make permanent or long-term changes to the transfer capability of the Interconnection Facilities.

4.5 <u>Reliability Coordination and Reliability Assessment of Outages</u>

Both Parties agree to provide each other with appropriate updates on planned outage schedules and other activities that may impact on the transfer capability of the Interconnection Facilities. Such updates shall be provided no less frequently than semi-annually.

The Parties shall jointly determine the System Operating Limits and Interconnection Reliability Operating Limits for the Interconnection Facilities. Consistent with such System Operating Limits and Interconnection Reliability Operating Limits, the Parties shall interact with other Balancing Authority Areas and Reliability Coordinators to perform Reliability coordination and Reliability assessments of outages.

4.6 <u>Control and Monitoring</u>

Each Party shall provide or arrange for continuous control and monitoring of the portion of the Interconnection Facilities for which it is responsible, as specified in **Schedule B**.

4.7 <u>Control and Dispatch of Reactive Power</u>

The Parties will develop control and dispatch operating instructions and procedures for scheduling reactive power required at their respective terminals of the Maritime Link.

4.8 Real Power Transfers

For the purposes of the subject matter of this Agreement, real power will be considered to have transferred over the Interconnection Facilities at the Delivery Point. The NSPSO and NLSO shall both approve the scheduled real power transfers at the Delivery Point in compliance with standards and procedures established by the Interconnection Operators Committee. Such standards and procedures shall accord with the relevant standards adopted by NERC. The NSPSO will be responsible for setting the power flow for the Delivery Point in the Interconnection Facilities control system unless required otherwise by the procedures established by the Interconnection Operators Committee.

4.9 Inadvertent Interchange

The Parties will develop procedures for inadvertent energy management and accounting in accordance with the standards and procedures adopted by NERC.

4.10 Reserve Sharing

The Parties will share energy and reserves to improve Reliability to their respective customers while respecting each Party's obligations to comply with its respective Reliability Standards and NSPI's obligations to comply with its current obligations under the NB Reserve Sharing Agreement. The Parties shall establish the formal reserve sharing agreement as referenced at **Schedule A2** which shall form part of this Agreement.

4.11 Completion of Supplemental Agreements

The Parties shall complete the Supplemental Agreements associated with **Schedule A2** by no later than one year prior to the anticipated Commercial Operation Date.

ARTICLE 5
EMERGENCY ASSISTANCE

5.1 Emergency Assistance

To the extent practical in accordance with Good Utility Practice and all applicable Reliability Standards, each Party shall exercise due diligence to mitigate an Emergency occurring on its respective Transmission System that affects the Interconnection Facilities. Without limiting the foregoing, where appropriate, each Party shall strive to implement commercial transactions to assist in mitigating such Emergency as soon as possible.

5.2 Emergency Energy Transactions

Each Party shall, to the maximum extent it deems consistent with the safe and proper operation of its respective Transmission System, provide Emergency Energy to the other Party in accordance with the provisions of **Schedules A3** and **C9.0**.

ARTICLE 6
EXCHANGE OF INFORMATION AND CONFIDENTIALITY

6.1 Information

NSPI and NLH agree to exchange such information as may be required from time to time for the purpose of implementing this Agreement, including such information necessary for the Interconnection Operators Committee to perform its duties. Such information will be comprised of but not limited to the following:

(a) information required for developing Operating Instructions;

(b) Transmission System facility specifications and modeling data required to perform Security analysis;

(c) functional descriptions of Transmission System protective devices and communication facilities;

(d) ratings data, and associated ratings methodologies, for Interconnection Facilities;

(e) telemetry points, equipment alarms and status points required for real time monitoring of Security dispatch;

(f) data required for reconciling accounts for Inadvertent Interchange, and for Emergency Energy transactions;

(g) commercially valuable Transmission System information concerning such things as transfer capabilities, physical curtailments and interruptions, and ancillary services, provided however that this commercially valuable Transmission System information shall not be shared by the receiving Party with Marketing Personnel; and

(h) such other information as may be reasonably required for the Parties to maintain the reliable operation of their interconnected Transmission Systems and fulfill their obligations under this Agreement and to any Standards Authority exercising jurisdiction over such Party, provided, however, that this other information will be exchanged only if it can be done in accordance with applicable restrictions on the disclosure of information to any Marketing Personnel.

6.2 Incorporation of Project NDA

The Parties agree that the Project NDA is incorporated in this Agreement by reference and applies to all Confidential Information disclosed by either Party to the other under or in connection with this Agreement, the Party disclosing Confidential Information being a Disclosing Party as defined in the Project NDA, and the Party receiving Confidential Information being a Receiving Party as defined in the Project NDA.

6.3 <u>Disclosure of Agreement</u>

Each Party hereby agrees to the other Party making the body of this Agreement public at any time and from time to time after the Effective Date. Neither Party may make any Schedule public without the consent of the other Party, which consent shall not be unreasonably withheld.

ARTICLE 7
INTERCONNECTION OPERATORS COMMITTEE

7.1 <u>Interconnection Operators Committee Inauguration and Authorization</u>

The Parties formed an Interconnection Operators Committee under this Agreement. Each of the Parties appointed two representatives, a principal and an alternate, to serve as members of the Interconnection Operators Committee with the authority to act on their behalf with respect to actions or decisions taken by the Interconnection Operators Committee. A Party may, at any time upon providing prior Notice to the other Party, designate a replacement principal member or alternate member to the Interconnection Operators Committee.

7.2 <u>Interconnection Operators Committee Duties and Responsibilities</u>

The Interconnection Operators Committee shall administer the implementation of the provisions of this Agreement. The Interconnection Operators Committee shall develop and adopt policies, instructions and recommendations relating to the Parties' performance of their obligations under this Agreement, attempt to resolve Disputes between the Parties pursuant to **Article 12** and shall undertake any other actions specifically delegated to it pursuant to this Agreement.

Any recommendations made by the Interconnection Operators Committee regarding revisions to this Agreement or Supplemental Agreements contained in **Schedule A** shall be provided to each Party's appropriate corporate officers for approval.

Any recommendations made by the Interconnection Operators Committee regarding revisions to documents contained in **Schedule B** (Description of Facilities) or **Schedule C** (Operating Instructions) may be approved by the written mutual agreement of the Interconnection Operators Committee members from NLH and NSPI and signed by an Interconnection Operators Committee member from each party. Such approval shall not be unreasonably withheld. The Interconnection Operators Committee shall use commercially reasonable efforts to complete the documentation contemplated by **Schedules B** and **C** as soon as practicable and in any event by no later than 12 months prior to the anticipated Commercial Operation Date, and shall be empowered to amend and revise such documentation as required without the re-signing of this Agreement.

Subject to the preceding paragraph, the Interconnection Operators Committee shall undertake to jointly develop and authorize Operating Instructions to implement the intent of this Agreement in accordance with **Schedule C1.0** (Procedures for Development and Authorization of Operating Instructions). The Interconnection Operators Committee has the authority to strike subcommittees as required to initiate reviews or studies of various operational issues, such as the operating performance of the Interconnection Facilities.

The Interconnection Operators Committee shall complete and implement the ML Transmission Procedures contained in **Schedule D** by no later than 18 months prior to the anticipated Commercial Operation Date.

Should the terms and conditions contained in this Agreement be found to conflict with or fail to recognize the requirements of a Standards Authority exercising jurisdiction over either Party or other regulatory requirements, the Parties agree to attempt in good faith to negotiate amendments to this Agreement that allow the affected Party to comply with the requirements of its Standards Authority or other applicable regulatory requirements. For clarity, a Party shall not be required to amend this Agreement where the amendment would result in regulatory requirements applicable to the other Party being imposed upon such Party.

7.3 Limitations of Interconnection Operators Committee Authority

While each Party may incur expenses that may result from the Interconnection Operators Committee's administration of the implementation of this Agreement, the Interconnection Operators Committee has no authority to commit or otherwise contractually bind either Party to incur or pay any costs or expenditures.

7.4 Exercise of Interconnection Operators Committee Duties

The Interconnection Operators Committee shall strive to hold semi-annual meetings and in any event shall hold meetings no less frequently than once each calendar year. The matters to be addressed at all meetings shall be specified in an agenda, which shall contain items specified by either Party in advance of the meeting and sent to the representatives of the other Party. All decisions of the Interconnection Operators Committee must be unanimous and are binding upon both Parties. More specifically, the decisions may be unanimously affirmative or negative, however a lack of unanimity between the members of the Interconnection Operators Committee shall be interpreted as a negative decision. Furthermore, all decisions of the Interconnection Operators Committee shall be final and shall not be subject to dispute resolution in accordance with **Article** 12.

Special meetings may be called at any time if the Interconnection Operators Committee deems such meetings to be necessary or appropriate.

Subject to the limitations on its authority as described in this **Article 7**, the Interconnection Operators Committee has the responsibility and authority to take action on all aspects of this Agreement, including the following:

(a) preparing, amending, adding or cancelling **Schedules B** and **C** and the attached appendices or Operating Instructions;

(b) preparing and amending the ML Transmission Procedures;

(c) assessing non-compliance with this Agreement and, subject to **Article 12**, taking of appropriate action in respect thereof;

(d) documenting decisions related to the initial resolution of Disputes, or in cases of unresolved Disputes, the circumstances relevant to the Dispute in question as contemplated by the requirements of **Article 12**; and

(e) preparing documentation and retaining and distributing Interconnection Operators Committee meeting minutes and agendas.

7.5 <u>Compliance with Directives of the Interconnection Operators Committee</u>

Each Party shall direct the operation of the Interconnection Facilities over which it has been assigned operational responsibility pursuant to **Section 4.1** in accordance with its obligations under its respective tariffs, rules and standards and pursuant to applicable directions of the Interconnection Operators Committee that conform with the applicable tariffs, rules and standards. The Interconnection Operators Committee direction includes decisions and jointly-developed and approved Operating Instructions. If decisions of the Interconnection Operators Committee do not anticipate or provide for a particular circumstance, the Parties shall act in accordance with Good Utility Practice.

7.6 <u>Expenses</u>

Each of the Parties shall pay the expenses of its own members on the Interconnection Operators Committee. Any expenses jointly incurred by the Interconnection Operators Committee for activities pertaining to the Interconnection Operators Committee shall be shared equally by the Parties hereto or in such other proportion as may be agreed upon by the Interconnection Operators Committee.

The Interconnection Operators Committee has no authority to commit either Party to any expenditure that is beyond those expenses described herein.

ARTICLE 8
OPERATIONAL INFORMATION

8.1 <u>Obligation to Provide Operational Monitoring Facilities</u>

The Parties shall ensure that appropriate monitoring facilities are installed for the Interconnection Facilities as required to provide for electric power quantities or equipment loading to enable monitoring of Security Limits and Inadvertent Interchange that meet requirements of each applicable Standards Authority.

8.2 <u>Obligation to Provide Points of Operational Data</u>

The points of data for operating information are those points as may be agreed in writing by the Interconnection Operators Committee.

ARTICLE 9
INTERCONNECTION REVENUE METERING

9.1 Obligation to Provide Revenue Metering

The Parties shall ensure appropriate electric revenue metering devices, including back-up metering equipment, are installed on the Interconnection Facilities as required to measure electric power quantities for managing Inadvertent Interchange accounting.

9.2 Standards for Metering Equipment

Any Metering Equipment used to measure Metered Quantities for accounting purposes shall be designed, verified, sealed and maintained in accordance with the requirements of the *Electricity and Gas Inspection Act* (Canada) and the Party's respective metering standards or as otherwise agreed to by the Interconnection Operators Committee.

9.3 Meter Compensation to the Delivery Point

The metering compensation for Transmission Losses to the Delivery Point shall be determined by the Party's respective standards or otherwise agreed to by the Interconnection Operators Committee.

9.4 Meter Readings

Meters shall be read in accordance with the procedures established by the Interconnection Operators Committee from time to time.

9.5 Inspection and Testing

Any authorized representative of either of the Parties shall have access to the billing meters associated with the Maritime Link for the purpose of reading the same. The accuracy of the meters shall be verified at regular intervals and by tests as agreed to by the Interconnection Operators Committee, and at any other time upon reasonable Notice given by either of the Parties hereto to the other, and each of the Parties hereto shall be entitled to have a representative present at such verification.

The work of testing and adjusting any meter shall be performed by, and at the expense of, the party owning the meter, provided that such a test is not called for more often than the regular intervals established by the Interconnection Operators Committee. If either of the Parties hereto shall more frequently request the verification of the meter, and the verification of the meter proves it to be accurate within two percent, the additional verification shall be at the expense of the Party requesting it. In the event that inaccuracies of greater than two percent are discovered, retroactive billing adjustments, if any, shall be determined by the Interconnection Operators Committee.

9.6 **Meters Out of Service**

When billing meters are out of service for testing or repairs or because of failure or malfunction, electrical power and energy flow during the period of the outage or malfunction shall be determined from other meter readings, if available, or if not available, shall be estimated and agreed to in accordance with the methodology agreed to by the Interconnection Operators Committee. If the Interconnection Operators Committee is unable to agree on a settlement, the issue will be dealt with using the dispute resolution process of **Article 12**.

ARTICLE 10
LIABILITY

10.1 **Force Majeure**

If by reason of an event of Force Majeure, a Party is not reasonably able to fulfil an obligation, other than an obligation to pay or spend money, in accordance with the terms of this Agreement, then such Party shall:

(a) forthwith provide Notice to the other Party of such Force Majeure, or orally so notify such other Party (confirmed in writing), which Notice (and any written confirmation of an oral notice) shall provide reasonably full particulars of such Force Majeure;

(b) be relieved from fulfilling such obligation or obligations during the continuance of such Force Majeure but only to the extent of the inability to perform so caused, from and after the occurrence of such Force Majeure;

(c) employ all commercially reasonable means to reduce the consequences of such Force Majeure, including the expenditure of funds that it would not otherwise have been required to expend, if the amount of such expenditure is not commercially unreasonable in the circumstances existing at such time, and provided further that the foregoing shall not be construed as requiring a Party to accede to the demands of its opponents in any strike, lockout or other labour disturbance;

(d) as soon as reasonably possible after such Force Majeure, fulfil or resume fulfilling its obligations hereunder;

(e) provide the other Party with prompt Notice of the cessation or partial cessation of such Force Majeure; and

(f) not be responsible or liable to the other Party for any loss or damage that the other Party may suffer or incur as a result of such Force Majeure.

10.2 **Liability to Third Parties**

NLH shall indemnify and hold harmless NSPI from and against any and all Losses asserted against NSPI by a third party to the extent such Losses result from, arises out of or is related to NLH acts or omissions occurring in connection with, incidental to or arising from NLH's obligations under this Agreement, including any act or omission by an NLH employee or agent or an NLH directive or instruction to a third party.

NSPI shall indemnify and hold harmless NLH from and against any Losses asserted against NLH by a third party to the extent such Losses result from, arises out of or is related to NSPI acts or omissions occurring in connection with, incidental to or arising from NSPI's obligations under this Agreement, including any act or omission by an NSPI employee or agent or an NSPI directive or instruction to a third party.

10.3 <u>Liability Between Parties</u>

The Parties' duties and standard of care with respect to each other, and the benefits and rights conferred on each other shall be no greater than as expressly stated herein. Neither Party, its directors, officers, trustees, employees or agents, shall be liable to the other Party for any Losses, whether direct, indirect, incidental, punitive, special, exemplary or consequential, arising from the other Party's performance or non-performance under this Agreement, except to the extent that a Party is found liable for gross negligence or wilful misconduct, in which case the Party responsible shall be liable only for direct and ordinary damages and not for any incidental, consequential, punitive, special, exemplary or indirect damage. This **Section 10.3** shall survive any termination of this Agreement.

10.4 <u>Liability for Interruptions</u>

Neither Party shall be liable to the other Party for any Losses, whether direct, indirect, incidental, punitive, special, exemplary or consequential, resulting from an occurrence on the circuits or system that are under its Operational Control and which results in damage to or renders inoperative the circuits or system of the other Party, or the disconnection of the systems in an Emergency, or interrupts or diminishes service, or increases, decreases or in any way affects for whatever length of time the voltage or frequency of the energy delivered hereunder to the other Party. This **Section 10.4** shall survive any termination of this Agreement. For greater certainty, this **Section 10.4** shall not affect the liability of the Parties or their Affiliates pursuant to any other agreement.

ARTICLE 11
TERM AND TERMINATION

11.1 <u>Term</u>

The term of this Agreement (the "**Term**") commenced on the Effective Date and shall terminate in accordance with **Section 11.2**.

11.2 <u>Termination</u>

This Agreement, including the Supplemental Agreements, shall, subject to this **Section 11.2**, terminate upon the written agreement of the Parties to terminate.

Notwithstanding the foregoing, in no event shall this Agreement be subject to termination pursuant to this **Section 11.2** prior to the termination date of the Energy and Capacity Agreement.

ARTICLE 12
DISPUTE RESOLUTION

12.1 General

In the event of a Dispute that is not resolved by the Interconnection Operators Committee within seven days of the reference to the Interconnection Operators Committee of such Dispute, notwithstanding the provisions otherwise requiring unanimity of the Interconnection Operations Committee in **Section 7.4**, each Party shall, within 14 days' Notice by either Party to the other, designate a senior officer with authority and responsibility to resolve the Dispute and refer the Dispute to them. The senior officer designated by each Party shall have authority to make decisions on its behalf with respect to that Party's rights and obligations under this Agreement. The senior officers, once designated, shall promptly begin discussions in a good faith effort to agree upon a resolution of the Dispute. If the senior officers do not agree upon a resolution of the Dispute within 14 days of its referral to them, or do not within the same 14 day period agree to refer the matter to some individual or organization for alternate dispute resolution, then either Party shall have the right to pursue any and all remedies available to it at law or in equity. Neither the giving of notice of a Dispute, nor the dependency of any Dispute resolution process as described in this **Section 12.1** shall deprive a Party of its rights or relieve a Party of its obligations under this Agreement, extend any notice period described in this Agreement or extend any period in which a Party must act as described in this Agreement.

ARTICLE 13
INVOICING AND PAYMENT

13.1 Invoices

Unless otherwise provided in this Agreement with respect to specific payments, the calendar month is the standard period for invoicing amounts payable by a Party (the "**Payor**") to the other Party (the "**Payee**") hereunder. On or before the 15th day of each calendar month, the Payee shall provide an invoice to the Payor for all amounts in respect of the preceding month chargeable by the Payee to the Payor and, subject to **Section 13.8**, any amounts not previously invoiced to the Payor. The Payee shall provide with the invoice such supporting documents and information as the Payor may reasonably require to verify the accuracy of the fees, charges and third party charges invoiced (the "**Supporting Material**").

13.2 Disputed Amounts

Within 30 days after receipt of an invoice from the Payee, the Payor shall report in writing to the Payee any disputed amounts in the invoice, specifying the reasons therefor.

13.3 Time and Method of Payment

Within 30 days after its receipt of a properly prepared invoice, accompanied by acceptable Supporting Material, the Payor shall pay to the Payee the amount stated on the invoice less any amounts disputed pursuant to **Section 13.2** and any withholding required by Applicable Law. The Payor shall make payment by electronic funds transfer or other mutually agreed method to an account designated by the Payee.

13.4 Effect of Payment

Notwithstanding **Section 13.2**, payment of an invoice will not prejudice the right of the Payor to dispute the correctness of the invoice for a period of up to two years after the end of the calendar year in which the Payor received the invoice. Failure by the Payor to dispute charges will not be deemed to be acceptance of the charges or preclude the Payor from subsequently disputing an amount or conducting an audit of the charges within two years after the end of the calendar year in which the Payor received the invoice. Any charges not disputed in writing by the Payor within two years after the end of the calendar year in which the Payor received the invoice for such charges will conclusively be presumed to be true and correct.

13.5 Resolution of Objections

The Parties shall make good faith efforts to resolve any disputed amounts by mutual agreement within 60 days after the Payee's receipt of a notification of disputed amounts pursuant to **Section 13.2**. If the disputed amounts are not resolved within such period, or such extended period as may be agreed in writing by the Parties, the disputed amounts will constitute a Dispute and may be submitted by either Party for resolution pursuant to **Article 12**. Once the disputed amounts are resolved, the Payor shall pay any amount determined to be owing to the Payee within five Business Days after the Payor receives an invoice from the Payee for such amount.

13.6 Overpayments

Within 15 Business Days after a Payee's discovery or receipt of written evidence of an overpayment, the Payee shall refund the overpayment to the Payor.

13.7 Interest on Overdue Amounts

Any amount not paid by either Party when due, including any charge disputed by the Payor pursuant to **Section 13.2** and subsequently determined to be valid, which shall be considered to have been due on its original due date pursuant to **Section 13.3**, and any refund of an overpayment pursuant to **Section 13.6**, will bear interest at the Prime Rate plus three percent per annum, calculated daily not in advance, from the date upon which the payment became due to and including the date of payment, and interest accrued will be payable on demand.

13.8 Waiver of Unbilled Charges

If a Payee entitled to payment in respect of an amount paid by the Payee to a third party fails to invoice the Payor pursuant to this **Article 13** for such amount within six months after the date the Payee made payment to the third party, the right to such payment by the Payor is waived. Notwithstanding the foregoing, a Party may recover Taxes pursuant to a statutory right to recover such Taxes, including the right to recover HST pursuant to Section 224 of the Excise Tax Act.

ARTICLE 14
TAXES

14.1 Supplies and Payments Exclusive of Taxes

(a) Payment of Taxes - Each Party is separately responsible for, and shall in a timely manner discharge, its separate obligations in respect of the payment, withholding and remittance of all Taxes in accordance with Applicable Law.

(b) HST - Notwithstanding **Section 14.1(a)**, the Parties acknowledge and agree that:

(i) all amounts of consideration, or payments and other amounts due and payable to or recoverable by or from the other Party, under this Agreement are exclusive of any Taxes that may be exigible in respect of such payments or other amounts (including, for greater certainty, any applicable HST), and if any such Taxes shall be applicable, such Taxes shall be in addition to all such amounts and shall be paid, collected and remitted in accordance with Applicable Law;

(ii) if subsection 182(1) of the Excise Tax Act applies to any amount payable by one Party to the other Party, such amount shall first be increased by the percentage determined for "B" in the formula in paragraph 182(1)(a) of the Excise Tax Act, it being the intention of the Parties that such amount be grossed up by the amount of Taxes deemed to otherwise be included in such amount by paragraph 182(1)(a) of the Excise Tax Act;

(iii) if one Party is required to collect Taxes pursuant to this Agreement, it shall forthwith provide to the other Party such documentation required pursuant to **Section 14.3**; and

(iv) if one Party incurs an expense as agent for the other Party pursuant to this Agreement, that Party shall not claim an input tax credit in respect of any Taxes paid in respect of such expense, and shall obtain and provide all necessary documentation required by the other Party to claim, and shall cooperate with the other Party to assist it in claiming, such input tax credit.

(c) Changes in Taxes - Subject to **Section 14.1(b)**, any New Taxes shall be paid by the Party on whom such New Taxes are imposed by Applicable Law.

(d) Income Taxes - For greater certainty:

(i) NSPI and its Affiliates are solely responsible for the payment of income taxes and HST payable by NSPI and its Affiliates, as the case may be; and

(ii) NLH and its Affiliates are solely responsible for the payment of income taxes and HST payable by NLH and its Affiliates, as the case may be.

14.2 Determination of Value for Tax Compliance Purposes

(a) Subject to the right of final determination as provided under **Section 14.2(b)**, the Parties agree to co-operate in determining a value for any property or service supplied pursuant to this Agreement for non-cash consideration.

(b) If a Party supplying a property or service under this Agreement for non-cash consideration is required to collect Taxes in respect of such supply, or if a Party acquiring a property or service under this Agreement for non-cash consideration is required to self-assess for Taxes in respect of such property or service, that Party shall determine a value expressed in Canadian dollars for such property or service for purposes of calculating the Taxes collectable or self-assessable, as applicable.

14.3 Invoicing

All invoices issued pursuant to **Article 13** shall include all information prescribed by Applicable Law together with all other information required to permit the Party required to pay Taxes, if any, in respect of such supplies to claim input tax credits, refunds, rebates, remission or other recovery, as permitted under Applicable Law. Without limiting the foregoing, except as otherwise agreed to by the Parties in writing, all invoices issued pursuant to this Agreement shall include all of the following particulars:

(a) the HST registration number of the supplier;

(b) the subtotal of all HST taxable supplies;

(c) the applicable HST rate(s) and the amount of HST charged on such HST taxable supplies; and

(d) a subtotal of any amounts charged for any “exempt” or “zero-rated” supplies as defined in Part IX of the Excise Tax Act.

14.4 Payment and Offset

(a) Subject to **Section 14.4(b)**, Taxes collectable by one Party from the other Party pursuant to this Agreement will be payable in immediately available funds within 30 days of receipt of an invoice.

(b) A Party may offset amounts of Taxes owing to the other Party under this Agreement against Taxes or other amounts receivable from the other Party pursuant to this Agreement, subject to reporting and remittance of such offset Taxes in accordance with Applicable Law.

14.5 HST Registration Status and Residency

(a) NLH represents and warrants that it is registered for purposes of the HST and that its registration number is 121394928 RT 0001, and undertakes to advise NSPI of any change in its HST registration status or number.

(b) NSPI represents and warrants that it is registered for purposes of the HST and that its registration number is 11931 4938 RT 0001, and undertakes to advise NLH of any change in its HST registration status or number.

(c) NLH represents and warrants that it is not a non-resident of Canada for the purposes of the Income Tax Act, and undertakes to advise NSPI of any change in its residency status.

(d) NSPI represents and warrants that it is not a non-resident of Canada for the purposes of the Income Tax Act, and undertakes to advise NLH of any change in its residency status.

14.6 Cooperation to Minimize Taxes

Each Party shall use reasonable efforts to implement the provisions of and to administer this Agreement in accordance with the intent of the Parties to minimize all Taxes in accordance with Applicable Laws, so long as neither Party is materially adversely affected by such efforts. Each Party shall obtain all available exemptions from or recoveries of Taxes and shall employ all prudent mitigation strategies to minimize the amounts of Taxes required to be paid in accordance with Applicable Law in respect of this Agreement. If one Party obtains any rebate, refund or recovery in respect of any such Taxes, it shall immediately be paid to such other Party to the extent that such amounts were paid by such other Party (and not previously reimbursed).

14.7 Additional Tax Disclosure

Notwithstanding any other provision in this Agreement, unless otherwise agreed to by the Parties in writing, each of the Parties agrees to provide to the other Party, in writing, the following additional information for the purposes of assisting the other Party with the application of Taxes to the Parties in respect of this Agreement:

(a) whether a particular supply is, or is not, subject to HST or to any other Tax which a Party is required to pay to the supplier of such supply;

(b) whether the recipient of consideration or other form of payment under this Agreement is not resident in Canada for the purposes of the Income Tax Act, and, where such recipient is receiving such payment as agent for another Person, whether such other Person is not resident in Canada for the purposes of the Income Tax Act; and

(c) any other fact or circumstance within the knowledge of a Party which the other Party advises the Party, in writing, is relevant to a determination by the other Party of whether it is required to withhold and remit or otherwise pay a Tax to an Authorized Authority or other Tax authority in respect of such supply, consideration or payment.

In addition to the notification required under this Section, each Party undertakes to advise the other Party, in a timely manner, of any material changes to the matters described in **Sections 14.7(a)** through **14.7(c)**.

14.8 <u>Prohibited Tax Disclosure</u>

Except as required by Applicable Law, notwithstanding any other provision of this Agreement, each Party shall not make any statement, representation, filing, return or settlement regarding Taxes on behalf of the other Party to an Authorized Authority without the prior written consent of such other Party.

14.9 <u>Withholding Tax</u>

If required by the Applicable Laws of any country having jurisdiction, a Party shall have the right to withhold amounts, at the withholding rate specified by such Applicable Law, from any compensation payable pursuant to this Agreement by such Party, and any such amounts paid by such Party to an Authorized Authority pursuant to such Applicable Law shall, to the extent of such payment, be credited against and deducted from amounts otherwise owing to the other Party hereunder. Such Party shall note on each applicable invoice whether any portion of the supplies covered by such invoice was performed inside or outside of Canada for the purposes of Canadian income tax legislation or such other information requested or required by the other Party to properly assess withholding requirements. At the request of the other Party, the Party shall deliver to the other Party properly documented evidence of all amounts so withheld which were paid to the proper Authorized Authority for the account of the other Party.

14.10 <u>Tax Indemnity</u>

Each Party (in this Section referred to as the "First Party") shall indemnify and hold harmless the other Party from and against any demand, claim, payment, liability, fine, penalty, cost or expense, including accrued interest thereon, relating to any Taxes for which the First Party is responsible under **Article 14** or relating to any withholding Tax arising on account of the First Party being or becoming a non-resident of Canada for the purposes of the Income Tax Act. Without limiting the generality of the foregoing, and subject to the obligation of the Parties to pay HST pursuant to **Section 14.1(b)**, each Party shall be liable for and defend, protect, release, indemnify and hold the other Party harmless from and against:

(a) any and all Taxes imposed by any Authorized Authority on the other Party in respect of this Agreement, and any and all Claims including payment of Taxes which may be brought against or suffered by the other Party or which the other Party may sustain, pay or incur in conjunction with the foregoing as a result of the failure by the Party to pay any and all Taxes imposed as stated herein; and

(b) any and all Taxes imposed by any Authorized Authority in respect of the supplies contemplated by this Agreement, and any and all Claims (including Taxes) which may be brought against or suffered by the other Party or which the other Party may sustain, pay or incur in conjunction with the foregoing as a result of the failure by the Party to pay any and all Taxes imposed as stated herein.

14.11 <u>Additional Tax Indemnity</u>

If one Party (in this Section referred to as the "First Party") is, at any time, a non-resident of Canada for the purposes of the Income Tax Act or the Applicable Law of a foreign jurisdiction, the First Party agrees to pay the other Party, and to indemnify and save harmless the other Party from and against any and all amounts related to any application or withholding of Taxes required by the laws of the jurisdiction outside of Canada in which the First Party is resident at such time (in this Section referred to as the "Foreign Jurisdiction") on payments made (or consideration provided) pursuant to this Agreement by the other Party to the First Party, provided that:

(a) any such amount payable by the other Party pursuant to this Section shall be reduced by the amount of such Taxes, if any, which the other Party is able to recover by way of a Tax credit or other refund or recovery of such Taxes; and

(b) for greater certainty, this Section shall only apply to any application or withholding of Taxes imposed by the Foreign Jurisdiction on amounts payable (or consideration provided) by the other Party to the First Party under this Agreement, and shall not apply to any Taxes imposed by the Foreign Jurisdiction on the other Party (or any Affiliate thereof) that may be included in calculating any amounts payable under any other Section of this Agreement.

14.12 <u>Assignment – Tax Requirements</u>

Notwithstanding any other provision in this Agreement, except as otherwise agreed to by the Parties in writing, a Party shall not assign any of its interest in this Agreement to another Person unless:

(a) the Person is registered for HST purposes and provides the other Party with its HST registration number in writing prior to such assignment;

(b) if the Person has a tax residency status that is different than the tax residency status of the Party, the Party has obtained the prior written approval of the other Party of the proposed assignment to the Person; and

(c) the Person agrees, in writing, to comply with the provisions of this **Article 14**.

ARTICLE 15
REPRESENTATIONS AND WARRANTIES

15.1 NLH Representations and Warranties

NLH represents and warrants to NSPI that, as of the A&R Effective Date:

(a) it is duly organized and validly existing under the Applicable Law of the jurisdiction of its formation and is qualified to conduct its business to the extent necessary in each jurisdiction in which it will perform its obligations under this Agreement;

(b) the execution, delivery and performance of this Agreement are within its powers, have been duly authorized by all necessary corporate action on the part of NLH and do not violate any of the terms and conditions in its governing documents, any contracts to which it is a party or any Applicable Law;

(c) this Agreement has been duly executed and delivered on its behalf by its appropriate officers and constitutes its legally valid and binding obligation enforceable against it in accordance with its terms, except as the enforceability thereof may be limited by (i) bankruptcy, insolvency, reorganization, moratorium or other similar laws affecting the enforcement of creditors' rights generally and (ii) general principles of equity whether considered in a proceeding in equity or at law;

(d) no Insolvency Event has occurred, is pending or being contemplated by it or, to its Knowledge, threatened against it;

(e) except as disclosed by it to NSPI in writing on or before the A&R Effective Date, there are no Legal Proceedings pending or, to its Knowledge, threatened against it that may materially adversely affect its ability to perform its obligations under this Agreement; and

(f) no consent or other approval, order, authorization or action by, or filing with, any Person is required to be made or obtained by such Party for such Party's lawful execution, delivery and performance of this Agreement, except for (i) such consents, approvals, authorizations, actions and filings that have been made or obtained prior to the A&R Effective Date, (ii) such consents, approvals, authorizations, actions and filings the failure of which would not have, or could not reasonably be expected to have, a material adverse effect on such Party's ability to perform its obligations under this Agreement, and (iii) the Regulatory Approvals.

15.2 NSPI Representations and Warranties

NSPI represents and warrants to NLH that, as of the A&R Effective Date:

(a) it is duly organized and validly existing under the Applicable Law of the jurisdiction of its formation and is qualified to conduct its business to the extent necessary in each jurisdiction in which it will perform its obligations under this Agreement;

(b) the execution, delivery and performance of this Agreement are within its powers, have been duly authorized by all necessary corporate action on the part of NSPI and do not violate any of the terms and conditions in its governing documents, any contracts to which it is a party or any Applicable Law;

(c) this Agreement has been duly executed and delivered on its behalf by its appropriate officers and constitutes its legally valid and binding obligation enforceable against it in accordance with its terms, except as the enforceability thereof may be limited by (i) bankruptcy, insolvency, reorganization, moratorium or other similar laws affecting the enforcement of creditors' rights generally and (ii) general principles of equity whether considered in a proceeding in equity or at law;

(d) no Insolvency Event has occurred, is pending or being contemplated by it or, to its Knowledge, threatened against it;

(e) there are no Legal Proceedings pending or, to its Knowledge, threatened against it that may materially adversely affect its ability to perform its obligations under this Agreement; and

(f) no consent or other approval, order, authorization or action by, or filing with, any Person is required to be made or obtained by such Party for such Party's lawful execution, delivery and performance of this Agreement, except for (i) such consents, approvals, authorizations, actions and filings that have been made or obtained prior to the A&R Effective Date, (ii) such consents, approvals, authorizations, actions and filings the failure of which would not have, or could not reasonably be expected to have, a material adverse effect on such Party's ability to perform its obligations under this Agreement, and (iii) the Regulatory Approvals.

ARTICLE 16
MISCELLANEOUS PROVISIONS

16.1 **<u>Notices</u>**

Notices, where required herein, shall be in writing and shall be sufficiently given if delivered personally or by courier or sent by electronic mail or facsimile transmission, directed as follows:

To NLH:

Newfoundland and Labrador Hydro
500 Columbus Drive
P.O. Box 12800
St. John's, NL
A1B 0C9
Attention: Manager, System Operations and Integration Support
Fax: (709) 737-1782

with a copy to:

Nalcor Energy
500 Columbus Drive
P.O. Box 12800
St. John's, NL
A1B 0C9
Attention: Corporate Secretary
Fax: (709) 737-1782

To NSPI:

Nova Scotia Power Inc.
5 Long Lake Drive
Halifax, NS
B3S 1N8
Attention: Director of Reliability and Control Centre Operations
Fax: (902) 428-6112

with a copy to:

Nova Scotia Power Inc.
1223 Lower Water Street
Halifax, NS
B3J 3S8
Attention: Corporate Secretary
Fax: (902) 428-6112

Such Notice shall (i) if delivered personally or by courier, be deemed to have been given or made on the day of delivery, and (ii) if sent by electronic mail or facsimile transmission and confirmed by a copy immediately sent by courier, be deemed to have been given or made on the day it was successfully transmitted by electronic mail or facsimile transmission as evidenced by automatic confirmation of receipt, provided however that if in any case such day is not a Business Day or if the Notice is received after Regular Business Hours (time and place of receipt), the Notice shall be deemed to have been given or made on the next Business Day. Either Party may change its address or fax number hereunder from time to time by giving Notice of such change to the other Party.

16.2 Prior Agreements

This Agreement supersedes all prior communications, understandings, negotiations and agreements between the Parties, whether oral or written, express or implied with respect to the subject matter hereof (including, subject to **Section 1.6**, the Original IOA). There are no representations, warranties, collateral agreements or conditions affecting this Agreement other than as expressed herein. Each of the Parties further acknowledges and agrees that, in entering into this Agreement, it has not in any way relied upon any oral or written agreements, representations, warranties, statements, promises, information, arrangements or understandings, expressed or implied, not specifically set forth in this Agreement.

16.3 Counterparts

This Agreement may be executed in counterparts, each of which when so executed shall be deemed to be an original, and such counterparts together shall constitute but one and the same instrument. Signatures delivered by facsimile or electronic mail shall be deemed for all purposes to be original counterparts of this Agreement.

16.4 Expenses of Parties

Except as otherwise provided herein, each Party shall bear its own costs and expenses in connection with all matters relating to this Agreement, including the costs and expenses of its legal, tax, technical and other advisors.

16.5 Announcements

No announcement with respect to this Agreement shall be made by either Party without the prior approval of the other Party. The foregoing shall not apply to any announcement by a Party required in order to comply with Applicable Law; provided that such Party consults with the other Party before making any such announcement and gives due consideration to the views of the other Party with respect thereto. Both Parties shall use reasonable efforts to agree on the text of any proposed announcement.

16.6 Relationship of the Parties

The Parties hereby disclaim any intention to create by this Agreement any partnership, joint venture, association, trust or fiduciary relationship between them. Except as expressly provided herein, neither this Agreement nor any other agreement or arrangement between the Parties pertaining to the Interconnection Facilities shall be construed or considered as creating any such partnership, joint venture, association, trust or fiduciary relationship, or as constituting either Party as the agent or legal representative of the other Party for any purpose nor to permit either Party to enter into agreements or incur any obligations for or on behalf of the other Party.

16.7 Further Assurances

Each of the Parties shall, from time to time, do all such acts and things and execute and deliver, from time to time, all such further documents and assurances as may be reasonably necessary to carry out and give effect to the terms of this Agreement.

16.8 Severability

If any provision of this Agreement is determined by a court of competent jurisdiction to be wholly or partially illegal, invalid, void, voidable or unenforceable in any jurisdiction for any reason, such illegality, invalidity or unenforceability shall not affect the legality, validity and enforceability of the balance of this Agreement or its legality, validity or enforceability in any other jurisdiction. If any provision is so determined to be wholly or partially illegal, invalid or unenforceable for any reason, the Parties shall negotiate in good faith a new legal, valid and enforceable provision to replace such illegal, invalid or unenforceable provision, which, as nearly as practically possible, has the same effect as the illegal, invalid or unenforceable provision.

16.9 Time of the Essence

Time shall be of the essence.

16.10 Amendments

No amendment or modification to this Agreement shall be effective unless it is in writing and signed by both Parties.

16.11 No Waiver

Any failure or delay of either Party to enforce any of the provisions of this Agreement or to require compliance with any of its terms at any time during the Term shall not affect the validity of this Agreement, or any part hereof, and shall not be deemed a waiver of the right of such Party thereafter to enforce any and each such provision. Any consent or approval given by a Party pursuant to this Agreement shall be limited to its express terms and shall not otherwise increase the obligations of the Party giving such consent or approval or otherwise reduce the obligations of the Party receiving such consent or approval.

16.12 No Third Party Beneficiaries

Except as otherwise provided herein or permitted hereby, this Agreement is not made for the benefit of any Person not a party to this Agreement, and no Person other than the Parties or their respective successors and permitted assigns shall acquire or have any right, remedy or claim under or by virtue of this Agreement.

16.13 Assignment

Neither Party shall be entitled to assign all or any portion of its interest in this Agreement without the prior written consent of the other Party, which consent may be arbitrarily withheld, except that, at any time and from time to time, a Party may assign its interest in this Agreement to a successor entity performing the duties of a system operator in that Party's jurisdiction.

16.14 Survival

All provisions of this Agreement that expressly or by their nature are intended to survive the termination (however caused) of this Agreement, including covenants, warranties, guarantees, releases and indemnities, continue as valid and enforceable rights and obligations (as the case may be) of the Parties, notwithstanding any such termination, until they are satisfied in full or by their nature expire.

16.15 <u>Successors and Assigns</u>

This Agreement shall be binding upon and enure to the benefit of the Parties and their respective successors and permitted assigns.

[Remainder of this page intentionally left blank.]

IN WITNESS WHEREOF the Parties have executed this Agreement as of the date first written above.

Executed and delivered by Newfoundland and Labrador Hydro, in the presence of:

____
Name: Peter Hickman

NEWFOUNDLAND AND LABRADOR HYDRO

By: ______________________________
Name: Ed Martin
Title: President and Chief Executive Officer

By: ______________________________
Name: Rob Henderson
Title: Vice President

We have authority to bind the corporation.

Executed and delivered by Nova Scotia Power Incorporated, in the presence of:

____
Name: Rene Gallant

NOVA SCOTIA POWER INCORPORATED

By: ______________________________
Name: Wayne O'Connor
Title: Executive Vice President, Operations

By: ______________________________
Name: Mark Sidebottom
Title: Vice President, Power Generation and Delivery

We have authority to bind the company.

IN WITNESS WHEREOF the Parties have executed this Agreement as of the date first written above.

Executed and delivered by Newfoundland and Labrador Hydro, in the presence of:

NEWFOUNDLAND AND LABRADOR HYDRO

By: ______________________________
Name: Ed Martin
Title: President and Chief Executive Officer

____
Name: Peter Hickman

By: ______________________________
Name: Rob Henderson
Title: Vice President

We have authority to bind the corporation.

Executed and delivered by Nova Scotia Power Incorporated, in the presence of:

NOVA SCOTIA POWER INCORPORATED

By: ______________________________
Name: Wayne O'Connor
Title: Executive Vice President, Operations

____
Name: Rene Gallant

By: ______________________________
Name: Mark Sidebottom
Title: Vice President, Power Generation and Delivery

We have authority to bind the company.

INTERCONNECTION OPERATORS AGREEMENT

SCHEDULE A

SUPPLEMENTAL AGREEMENTS

SUPPLEMENTAL AGREEMENTS

A1 - Area Adequacy Reviews (Atlantic Provinces)

As part of the Reliability Assessment Program, the NPCC Task Force on Coordination of Planning and the Task Force on System Studies are charged, on an ongoing basis, with conducting reviews of resource adequacy and bulk power system Reliability of each Area in NPCC. The responsibility for the Maritimes Area Reliability Assessment Program is shared between NSPI and the NBSO.

NSPI shall be responsible for carrying out its portion of the Maritimes Area Reliability Assessment Program with reasonable assistance provided by NLH with respect to the resources used to supply the NS Bulk Power System.

The Parties shall develop a plan whereby NLH may, if it decides in its sole discretion, participate in the Reliability Assessment Program such that the assessment is no longer for the Maritimes Area but is expanded to include the resources in NL and thereby become an Atlantic Provinces area adequacy review. If NLH decides to participate in an Atlantic Provinces area adequacy review then the Interconnection Operators Committee will determine the manner in which responsibilities are shared between the Parties and with the NBSO.

The Interconnection Operators Committee will develop procedures to notify adjacent areas of new or modified facilities and their expected impact on the interconnected transmission systems.

A2 – Operating Reserve Agreement

The Parties agree to use commercially reasonable efforts to share the Reserve Responsibility for the NL Transmission System and the NS Transmission System. NLH recognizes that NSPI has reserve sharing obligations in the Maritimes Area and therefore NSPI will include other Balancing Authorities and the NSPI Reliability Coordinator as required to determine the manner in which the reserve sharing will occur so as not to adversely affect the Reliability of the Maritimes Area. Such reserve sharing arrangements shall include terms related to the amount and duration of reserve sharing assistance provided following a contingency in either of the NL Bulk Electric System and the NS Bulk Power System. If the Parties are unable to reach agreement on sharing Reserve Responsibility it shall not be considered a Dispute and the Parties shall each be responsible for their own reserves.

Schedule C10.0, Reserve Assistance shall be developed by the Interconnection Operators Committee to give effect to the Operating Reserve Agreement.

A3 - Emergency and Security Energy Transactions

The Parties acknowledge the requirement for and agree to provide Emergency Energy or Security Energy on short notice from time to time to maintain Reliable operation or as a result of unplanned events. Interchange transactions of Emergency Energy or Security Energy are temporary in nature and the Parties agree to search for and implement market solutions as replacements, where available and as soon as practicable. As scheduled interchange of Energy through market solutions are not designed to allow schedule changes in the time frame demanded by events under consideration with these products, Emergency Energy and Security Energy products are available from the Balancing Authorities.

Schedule C9.0 will provide additional details on the cost and the involvement of third parties.

A4 - Maritime Link ACE Management and Inadvertent Interchange

The Parties agree that NSPI and NLH will act as Balancing Authorities within their respective areas.

Schedule C11.0 will provide additional detail on the nature of the control required for the interconnection, and on the settlement of Inadvertent Interchange resulting from the operation of the Interconnection Facilities.

INTERCONNECTION OPERATORS AGREEMENT

SCHEDULE B

DESCRIPTION OF INTERCONNECTION FACILITIES

DESCRIPTION OF INTERCONNECTION FACILITIES

B1.0 Interconnection Facilities

B1.1 Description of Facilities

This description of the Interconnection Facilities shall address the portions of the Maritime Link from the HVdc converter station in NL to the HVdc converter station in NS (inclusively) and shall accord with the "Basis of Design" (as provided for in the Maritime Link Joint Development Agreement).

B1.2 Metering

B1.3 Facility Ratings

B1.4 Protection

B1.5 Special Protection Systems

B2.0 Control Room Operations

B2.1 NSPI

B.2.2 NLH

B.2.3 Communication Facilities

B.2.4 Relevant Phone Numbers

INTERCONNECTION OPERATORS AGREEMENT

SCHEDULE C

FUNCTIONAL OPERATING RELATIONSHIP

FUNCTIONAL OPERATING RELATIONSHIP

C1.0 Procedures for Development and Authorization of Operating Instructions

C2.0 Reliability Coordinator and Operating Authority Functional Roles

C3.0 Communications

C4.0 Information Exchange Between Control Rooms

C5.0 Outage Coordination Process

C6.0 Emergency Operations

C7.0 Voltage Management of Interconnection Facilities

C8.0 System Operating Limits (SOL) and Interconnection Reliability Operating Limits (IROL)

C9.0 Emergency and Security Energy Transactions

C10.0 Reserve Assistance

C10.5 Ramping Requirements

C11.0 Maritime Link ACE Management [Operating parameters to be determined]

C12.0 Operating Diagrams

C13.0 Switching and Tagging Procedures

C14.0 Geomagnetic Disturbances

C15.0 Maritimes Area Compliance Program

C16.0 Area Adequacy Reviews

C17.0 Procedures for Evacuation of Control Center

INTERCONNECTION OPERATORS AGREEMENT

SCHEDULE D

OUTLINE OF CONTENTS FOR THE MARTIME LINK TRANSMISSION PROCEDURES

OUTLINE OF CONTENTS FOR THE MARITIME LINK TRANSMISSION PROCEDURES

Section I. Operational Matters

A. Role of the System Operator
   - Responsibilities/Overview
   - Communications with System Operator

B. Scheduling Protocol
   - Timeframes
   - Day-Ahead/Real-Time Scheduling
   - Scheduling Changes
   - E-Tagging Protocol

C. Load Shedding, Interruptions and Curtailments
   - Procedures
   - Protocol and Priorities for Curtailments and Interruption, including for Conditional Firm Service
   - Transmission Constraints

D. Methodology to Assess Available Transfer Capability & Total Transfer Capability

E. Methodology for Calculation of Losses

F. Requirements for Regular Testing and Inspection of the Maritime Link Revenue Meters

Section II. General Matters

A. Standards of Conduct

B. Confidentiality Policy

MEMO

TO: K. TUCKER

FROM: J.MATCHEM

SUBJECT: LIL PHASED APPROACH – LABRADOR EAST SYSTEM LIMITATIONS PRIOR TO MUSKRATS FALLS GENERATION AND USE OF RECALL POWER - PHASE I WINTER 2017/2018

DATE: JUNE 27, 2017

CC: J. DESOUZA, R. HENDERSON

Power system studies and analyses have been completed on the use of available recall power from Churchill Falls to supply customers on the Island Interconnected System for the winter of 2017/2018.

Early steady state load flow studies were completed to determine the impact of delaying the in-service dates of the Muskrat Falls (MFA) generators. The updated project schedule would see the LIL HVdc transmission system commissioned and placed in service before first power at Muskrat Falls. The operation of the Labrador Transmission Assets (LTA) and LIL HVdc without synchronous machines at Muskrat Falls impacts the short circuit level and voltage support at MFA.

HVdc schemes that utilize Line Commutated Converter (LCC) technology like the Labrador Island Link are sensitive to system fault levels and overall ac system strength. The HVdc control systems are designed and tuned to specific operating conditions and the ac harmonic filter banks are sized accordingly. The reduction in overall power system fault levels without the MFA generators will impact the maximum power transfer over the LIL and voltage flicker for switching in/out filter banks.

In addition, the lack of generation at MFA will reduce voltage control on the 315 kV transmission system between CHF and MFATS2 (LTA). Due to the nature of long, lightly loaded, high-voltage transmission lines, L3101 and L3102 between CHF and MFATS2 supply high levels of reactive power to the 315 kV bus at MFATS2. This results in high bus voltages at MFA prior to switching of ac harmonic filters for operation of the LIL HVdc scheme.

A memo titled *Technical Review of Operation of LTA and LIL Prior to Completion of Muskrat Falls Generation* was prepared by the Ready for Integration team (RFI) on June 13, 2016 and submitted to LCP package CD0501. Attached to this memo was the technical note titled *Operation of Labrador Island Link HVdc Transmission System (LIL) and Labrador Transmission Assets (LTA) Prior to Completion of Muskrat Falls Generation.* The technical note dated June 13, 2016 outlined a requirement for, at a minimum, a

140 MVAR 315 kV shunt reactor to be in service at MFATS2 for the energization of each 315 kV transmission line (L3101/L3102) and deblock of the LIL HVdc scheme. The size of the reactor was determined by a steady state load flow and switching study completed using PSS®E V32. The study also determined the maximum power order on the LIL to maintain acceptable transmission system voltages on the 315 kV network. It was determined that a maximum of 218 MW of power could be scheduled on the LIL at the MFA converter (rectifier) to maintain voltages above 0.90 pu (283.5 kV) for a single contingency (N-1) loss of one 315 kV transmission line.

Further discussions with ABB, the LCP large transformer supplier, realized the sourcing of a 150 MVAR, 315 kV, three-phase oiled filled unit for temporary installation at MFATS2 prior to completion of the first two generating units at MFAGS. The technical note titled, *Operation of Labrador Island Link HVdc Transmission System (LIL) and Labrador Transmission Assets (LTA) Prior to Completion of Muskrat Falls Generation* was updated to reflect the installation of a 150 MVAR, 315 kV shunt reactor at MFATS2; dated March 24, 2017. A steady state load flow and switching study was completed using PSS®E V32. The study determined that a maximum of 194 MW of power could be scheduled on the LIL at the MFA converter (rectifier) to maintain voltages above 0.90 pu (283.5 kV) for a single contingency (N-1) loss of one 315 kV transmission line.

For low power operation, for the first phase of operation, the LIL is planned to be operated as a monopole utilizing the second overhead conductor as a metallic return path. As a result, the electrode lines and electrode sites would not be required.

Due to the non-redundant configuration of the LIL during this first phase, preliminary analysis was also performed to assess requirements for high-inertia synchronous condensers (HISCs). A dynamic power system study was performed to assess the supply of up to 220 MW of recall power to the Island Interconnected System.

A technical note titled *Labrador Island Links (LIL) HVdc Monopole Transfer Limits – Operation Prior to Availability of MFA Generation (MFAGS)* was prepared by the Ready for Integration team (RFI) on April 27, 2017 and submitted to LCP package CD0501. The results of the dynamic study indicated that while the under-frequency load shedding protection system would operate for loss of the LIL pole at 220 MW, the system frequency would remain within acceptable limits.

The analyses described above demonstrate that the LIL can be successfully operated at a reduced capacity for the supply of the Island Interconnected System. It should also be noted that Hydro is continuing with Low Power operational studies as summarized in its May 26, 2017 update relating to the *Availability of Requested Information from Hydro*. These operational studies will be completed in the Fall of 2017 and will allow for the development of system operating limits, instructions, and procedures to ensure reliable operation of the LTA, the LIL HVdc system, and the ML HVdc system.

In summary and regarding updates to the specific recommendations that had been made in the previously submitted study (PUB-NLH-630, Attachment 1 - page 49), the following comments are noted:

Recommendation 1: A 140 MVAR shunt reactor be installed on the 315 kV bus at the Muskrat Falls Terminal Station #2 (MFATS2) to eliminate over-voltages on the power system during low power operation of the LIL prior to the powerhouse being completed.

Update: The specification has been changed to a 150MVAR shunt reactor (as noted above) and the shunt reactor will be installed at Muskrat Falls Terminal Station #2 (MFATS2) as recommended.

Recommendation 2: The maximum power order scheduled over the LIL be no more than 218 MW (MFA) without voltage control capabilities available from the synchronous generators at Muskrat Falls Generating Station.

Update: As part of the studies and procedures the power transfer limits on the LIL will be established in the ECC guidelines. Note this value has been modified to be no more than 194MW as noted above.

Recommendation 3: A review of the rating for the 315 kV power cables connecting the indoor GIS equipment to the outdoor equipment be conducted.

Update. A review of the 315kV power cables was conducted and the ratings were deemed to be within acceptable limits.

Recommendation 4: GE Grid review the filter component ratings in light of the requirement to operate under low short circuit conditions with one 315 kV transmission line in service between Churchill Falls and Muskrat Falls with no generators on line at Muskrat Falls.

Update. A review of the filter component ratings was conducted and the ratings were deemed to be within acceptable limits for the identified condition.

newfoundland labrador
hydro
a nalcor energy company

MEMO

TO: R. HENDERSON, P. HUMPHRIES, G. BENNETT, J. MACISSAC

FROM: P. THOMAS

SUBJECT: TECHNICAL REVIEW OF OPERATION OF LTA AND LIL PRIOR TO COMPLETION OF MUSKRAT FALLS GENERATION

DATE: JUNE 13, 2016

CC: J. MATCHEM, C. COLLINS, C. KIRBY, S. RAJENDRAN, R. COLLETT, J. FLYNN, C. PENNEY, B. MOULTON, P. HARRINGTON

Delays in the completion of the Muskrat Falls Generating Station result in the requirement to operate the Labrador Transmission Assets (LTA) and the Labrador – Island HVdc Link (LIL) without the voltage control support provided by the synchronous generators at Muskrat Falls. During this mode of operation short circuit levels on the Labrador interconnected System will be below those used in the design of the ac harmonic filters. Consequently, voltages on the 315 kV bus at Muskrat Falls and subsequent voltage changes due to filter switching are expected to exceed the original design parameters. To this end, Ready for Integration has undertaken a review of the operation of the Labrador Transmission System following completion of the LTA and LIL, but prior to the completion of the Muskrat Falls generation Station.

The attached Technical Note provides the results of the technical analysis completed by Ready for Integration to assess voltage levels in both steady state (PSS®E load flow) and voltage changes due to filter switching (PSS®E switching study). The analysis confirms that operation of the 315 kV LTA and LIL as it exists will result in bus voltages at Muskrat Falls that exceed the rating of the 315 kV GIS equipment being installed at Muskrat Falls in steady state. Similarly, initial review of operation of LIL at reduced dc voltage does not provide acceptable 315 kV voltages at Muskrat Falls.

The analysis indicates that a 315 kV, 140 MVAR oil filled shunt reactor provides acceptable voltage control for the operation of one 315 kV line in service and LIL at low power orders. As loading on the LIL is increased to 136 MW, it is possible to energize the second 315 kV transmission line to improve overall level of reliability for the system. The 315 kV shunt reactor size of 140 MVAR is based upon an available design ABB has provided to Hydro-Québec recently. The reactor rating provides a balance between marginally low voltages during the initial energization of the 315 kV transmission line and marginally high voltages during the de-blocking of the pole. The analysis has not considered alternative reactor sizing, which would lead to splitting the reactor into multiple units. Given that the reactor installation is viewed as temporary (i.e. until generators are available at Muskrat Falls), the focus was to limit the amount of temporary equipment additions.

The analysis indicates a maximum transfer limit of 218 MW (sending) on the LIL prior to there being voltage control available from the synchronous machines at the Muskrat Falls Generating Station.

The Technical Note recommends that a review of the ratings of the 315 kV power cables connecting indoor GIS to outdoor equipment be undertaken. Ready for Integration has submitted a technical query to Component 3 – Stations and HVdc Specialties for the 315 kV power cable ratings.

Further, The Technical Note recommends that the filter vendor Alstom Grid review the filter component ratings due to operation at low short circuit level. The owner's HVdc consultant, TransGrid Solutions, has completed a preliminary review using its in house harmonic filter design tools and has found no filter component rating violations. The issue has been discussed with Alstom Grid and a request for review is in process of being prepared.

Peter Thomas
Manager Ready for Integration
(Attachment)

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TECHNICAL NOTE

OPERATION OF LABRADOR ISLAND LINK HVDC TRANSMISSION SYSTEM (LIL) and LABRADOR TRANSMISSION ASSETS (LTA) PRIOR TO COMPLETION OF MUSKRAT FALLS GENERATION

INTRODUCTION

The purpose of this technical note is to provide guidance with respect to the operation of the Labrador Island HVdc Link prior to the completion of the first hydro unit at Muskrat Falls (MFA) generating facility. The results of this steady state and filter switching study provide operating restrictions and determine the maximum switching and steady state voltages between the 735 kV bus at Churchill Falls (CHF) to the 315 kV bus at MFA.

HISTORY

The final layout of the Labrador Interconnected Transmission System post completion of the Labrador Island Link was determined by a number of technical studies and contractual requirements. Water management of the Churchill River is a major project requirement to maximize energy produced from water stored in the Churchill Reservoir. As a result, the Labrador Transmission Assets (LTA) include the extension to the existing Churchill Falls 735 kV switchyard, installation of a new 735/315/13.8 kV switchyard in CHF, and a new 315/138/25 kV Terminal Station at MFA. The LTA also includes two 250 km long, 315 kV transmission lines between CHF and MFA. LTA transformation includes six single-phase 735/315/13.8 kV, 280 MVA autotransformers at CHF (plus one spare) and two 315/138/25 kV, 75/100/125 MVA autotransformers at MFA to supply station service to the LIL and ultimately a 138 kV connection to eastern Labrador.

Newfoundland and Labrador Hydro's System Planning Department provided the original design and layout of the high voltage equipment, transmission lines, terminal stations, synchronous condensers and LCC HVdc transmission system which was, in turn, provided to LCP's contractor SNC-Lavilin Incorporated (SLI). The Planning Department provided technical guidance for development of the CD501, CD502 and CD534 Technical Specifications which would be used during the bidding process.

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There have been a number of key decisions which impact ac voltage regulation during normal and contingency operation of the ac power system on the Labrador Interconnected System post MFA. These included:

1) The selected operating voltage of the ac transmission lines interconnecting CHF to MFA. The nominal operating voltage of these lines was originally considered to be 345 kV (i.e. 362 kV class) to minimize transmission losses and maintain power system stability. Through a study by SLI, 315 kV was determined to be a suitable ac voltage. The 315 kV nominal operating voltage would reduce the number of insulators per string and reduce tower steel thereby reducing the overall capital cost of building the transmission circuits. In addition, 795 kcmil ACSR "DRAKE" conductor was selected as it reduced onset of corona and was a standard NLH conductor.

2) The 735/315/13.8kV, 840 MVA (3xsingle phase 424/182/13.8kV, 280 MVA) power autotransformer design. Original specifications developed by NLH System Planning determined that there was a preference for an On Load Tap Changer (OLTC). At a minimum, as specified in the CSA CAN/CSA-C88-M90 power transformer and reactor standard, a De-energized Tap Changer (DTC) would be sufficient to ensure satisfactory bus voltages at MFA during testing/commissioning/early operations of the LTA, MFA and LIL HVdc system.

During the detailed design and procurement of the ABB single phase units by LCP, all tap changer options were removed and a nominal winding configuration maintained. This decision reduced the operating flexibility and voltage control on the LTA during testing/commissioning at MFA; specifically the 72 MVAR filter banks. It became more important that generation at Muskrat Falls be available for testing/commissioning and operation of the Labrador Island HVdc Link.

3) HVdc filter design at MFA. Analysis by SLI and NLH System Planning determined a filter bank limit of 72 MVAR at MFA and 75 MVAR at SOP due to the minimum short circuit levels and limitations on voltage change due to filter switching. Detailed filter design was to be completed by Alstom Grid (AG). AG determined that due to harmonics, a total of 4+1 and 5+1 harmonic filters were required to be installed at MFA and SOP respectively. To de-block the converter, a minimum of 2 filters must be online at both the rectifier and inverter which would supply 144 MVAR and 150 MVAR of reactive power to the MFA 315 kV bus and SOP 230 kV bus respectively prior to power flow over

the LIL.

4) Reactive power system exchange limits were provided to Alstom to aid in the design of the filter banks in the CD0501 general technical specification. Further analysis by AG indicated that a shunt reactor may be required as part of the filter switching scheme so as to not exceed the reactive exchange limits. In an effort to reduce additional high voltage equipment in the filter switch scheme (i.e. reactors that would be switched in and out of service with varying LIL load) further analysis by Ready for Integration (RFI) determined that the reactive limits were too pessimistic and were relaxed through an Engineering Change Notice (ECN).

5) MFA Plant Schedule. The number of generators online at MFA has an impact on the ability of the Labrador Interconnected System to control voltage fluctuations due to changing system conditions. All planning with regards to the LIL have assumed a minimum of a single generator at MFA before power is transmitted over the LIL to the Island. Latest project schedules have indicated that the LIL will be ready before first power is available at MFA.

6) Power system fault level during operation of MFA and LIL. Related to item #5, the availability of generation at MFA has an impact on the fault level at MFA prior to operation of the LIL. Low fault levels have a significant impact on the ability of the LIL to transmit power to the Island and the overall design requirements of components in the filter banks. A low fault level also impacts the severity of voltage excursions for switching of shunt elements.

As a result, a recent Change Advice Notice (CAN) has updated the ac system design fault levels in the CD0501 general technical specification. In the interest in reducing filter component costs at MFA, the extreme minimum fault level assumes one MFA generator online while the minimum fault level assumes two MFA generators online with both 315 kV transmission lines (L3101/L3102) in service. The design considers filter component ratings under extreme minimum fault level conditions with a subsequent loss of a transmission line element (i.e. loss of one 315 kV transmission line or MFA generator).

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POWER SYSTEM STUDY ASSUMPTIONS

For the purpose of this study, the following assumptions have been made regarding the operation of the LIL and the ac power systems in Labrador and on the Island:

- The Muskrat Falls Hydroelectric Development is not in service.
- One or two 315 kV transmission lines are in service between Churchill Falls and Muskrat Falls, with two 315/735 kV transformers in service at Churchill Falls.
- Two 175 MW high-inertia synchronous condensers (HISC's) are online at Soldiers Pond. It is assumed that one of the three installed HISCs is offline for maintenance.
- A new gas turbine is available at Holyrood and is in service as a synchronous condenser. The generator is equivalent to a Brush BDAX 8-445ER, 165.9 MVA unit.
- It is assumed that the Labrador Island Link HVdc system (LIL) will switch in a minimum of one filter in MFA and SOP before deblocking[1] a single pole at a minimum of 45 MW, followed by the switching in of a second filter after deblocking.
- If a shunt reactor is required for voltage regulation on the MFA 315 kV bus, it will be a 140 MVAR, 315 kV, oil filled unit, which is a standard offering for HQT from vendor ABB. (See Appendix A)
- The LIL can operate continuously at a reduced dc voltage (80% of rated) in an effort to maximize firing angle α and increase reactive power consumption.
- The Muskrat Falls Terminal Station (MFATS) has four 72 MVAR rated harmonic filters plus one spare, for a total of five installed.
- The Soldiers Pond Terminal Station (SOPTS) has five 75 MVAR rated harmonic filters plus one spare, for a total of six installed.

[1] Deblocking is the process of starting the HVdc system. The power on the pole goes from 0 to 45 MW. AG have advised that the filter switching scheme is being adjusted such that one filter is placed in service followed by a deblock of the pole and then switching of the second filter.

In addition, the following System Planning Criteria for steady state analysis was used to determine adequate system performance for all operating modes:

- With a transmission element (line, transformer, synchronous condenser, shunt or series compensation device) is out of service, power flow in all other elements of the power system should be at or below normal rating;

- Transformer additions at all major terminal stations (i.e. two or more transformers per voltage class) are planned on the basis of being able to withstand the loss of the largest unit;

- For normal operations all voltages be maintained between 95% and 105% (299.25/330.75 kV @ 315 kV nominal);

- For contingency or emergency situations all voltages be maintained between 90% and 110% (283.5/346.5 kV @ 315 kV nominal); and

- Analysis will be conducted with one high inertia synchronous condenser out of service at Soldiers Pond.

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POWER SYSTEM OPERATIONAL STUDY

The operational study completed in this report provides insight into the lack of reactive power management and voltage control at MFA and restrictions it places on operation of the LIL without a synchronous machine available at the MFA powerhouse.

The analysis was completed using PSS®E Base Case 1080, which was provided to Alstom Grid for use in their system studies for the HVdc system. 1080 was chosen as it simulates an extremely lightly loaded power system which provides for an Island Interconnected System with high bus voltages as a starting point to assess impact of filter switching at Soldiers Pond and the ability to start the LIL at low power orders without significant manipulation of the Labrador and Island generation dispatches. Therefore, the worst case conditions have been simulated as it relates to over-voltages. All simulations were completed using Siemens PTI PSS®E version 32.

A total of five power system configurations were studied from Base Case 1080 as shown in Table 1. The cases cover reasonable operating scenarios and determine worst case bus voltages.

Table 1: Labrador Interconnected System Configurations Studied

Study Case	Base Case	L3101	L3102	HVdc Voltage (pu)	Reactor
1	1080	**ONLINE**	OFFLINE	1	OFFLINE
2	1080	**ONLINE**	**ONLINE**	1	OFFLINE
3	1080	**ONLINE**	OFFLINE	1	**ONLINE**
4	1080	**ONLINE**	**ONLINE**	1	**ONLINE**
5	1080	**ONLINE**	OFFLINE	0.8[1]	OFFLINE
Notes: 1. Reduced voltage operation of LIL					

The charging experienced on each 315 kV transmission following energization is on the order of 100 MVAR due to the Ferranti effect of very long, lightly loaded high voltage transmission lines. As a result, the use of a single 315 kV transmission line (L3101) will reduce the voltage increase at MFA as opposed to the operation of both lines. However, it should be noted that the operation with a single 315 kV transmission line will have several negative impacts. First, operation with only one 315 kV transmission line in service increases the risk of a single contingency outage to the HVdc system with subsequent under frequency load shedding on the Island. Second, operation with only one 315 kV transmission line in service effectively reduces the short circuit strength at the MFA 315 kV bus. This reduction of short circuit level has a negative impact on the current stresses the harmonic filter complements will experience. It also increases over-voltages during filter switching.

In addition to the 315 kV transmission line charging, the 735/315/13.8 kV autotransformers do not have any tap changers and have a winding ratio of 1:1. Therefore, the only operational method to control over-voltage at MFA is through line switching and utilizing controls in the HVdc scheme.

This study also considers the ability to operate the LIL at reduced dc voltage (0.80 pu) by increasing the firing angle and ultimately absorb more reactive power from the ac system in Labrador. As a result of reduced dc voltage operation, it is anticipated that high voltages on the 315 kV bus at MFA can be reduced during low power operation of the LIL prior to completion of a single generating unit in the powerhouse.

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STUDY CASE #1

Study case #1 assumes that the HVdc scheme is operated at rated HVdc voltage of ±350 kV_{dc}, no shunt reactor has been installed and only a single 315 kV transmission line (L3101) has been installed. The steady state operation of the system energized up to the MFA 315 kV bus can be seen in Figure 1.

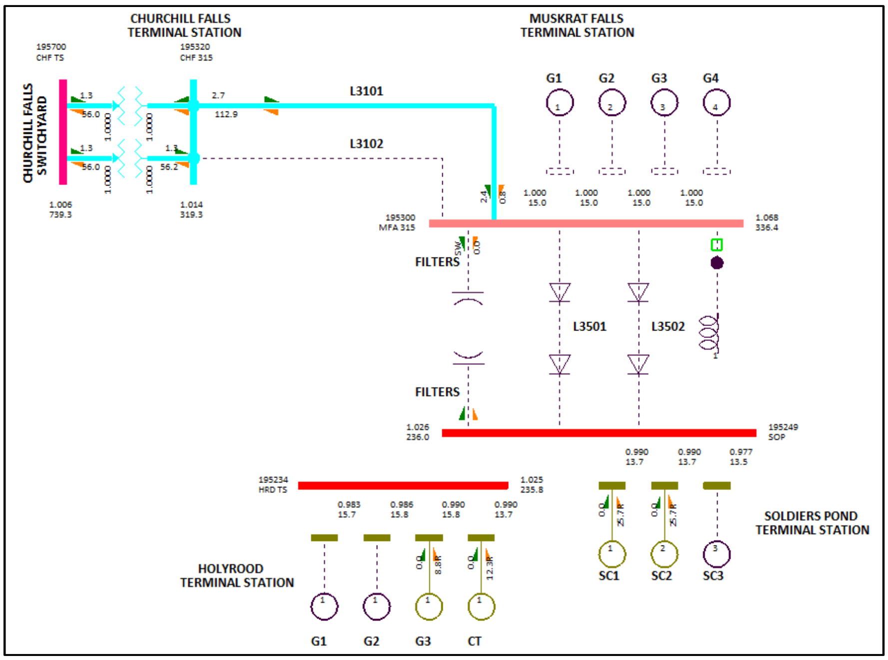

Figure 1: Study Case #1 – MFA 315 kV Bus Energization (Steady State)

It is clear from Figure 1 that prior to switching any filter banks at MFA, the bus voltage is 1.068 pu (336.42 kV). The sudden voltage rise at the MFA 315 kV bus following switching of a single 72 MVAR filter bank is on the order of 9.7% with a peak voltage calculated to equal 1.165 pu (367 kV) as shown in Figure 2.

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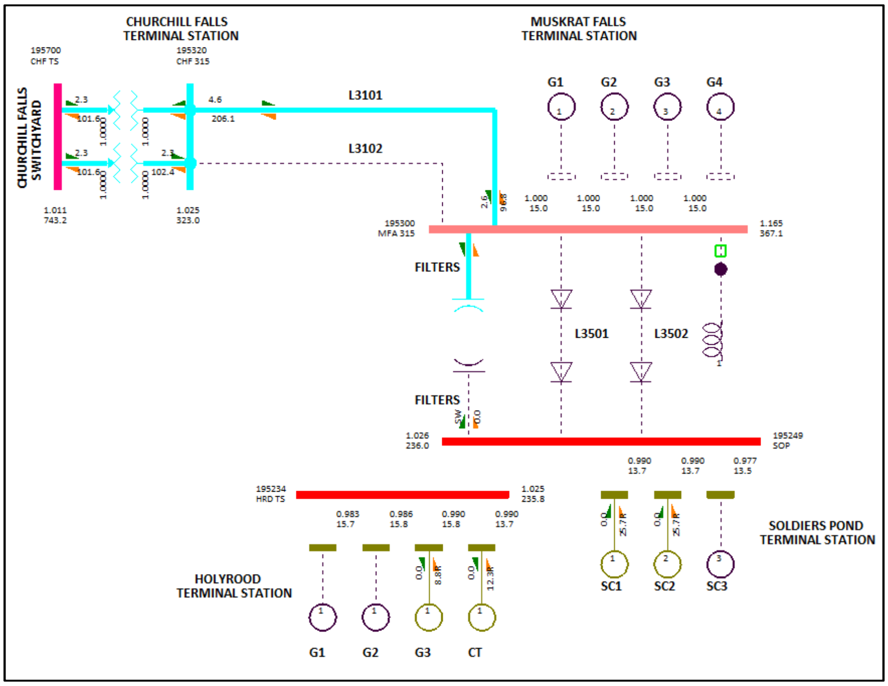

Figure 2: Study Case #1 – MFA 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus is reduced to 1.159 pu (365.09 kV) as shown in Figure 3. It should be noted that this voltage is above the 362 kV rating of the 315 kV GIS[2] equipment installed at CHF and MFA and exceeds the NLH steady state voltage criteria.

[2] GIS – Gas Insulated Switchgear – Indoor circuit breaker and disconnect switch station.

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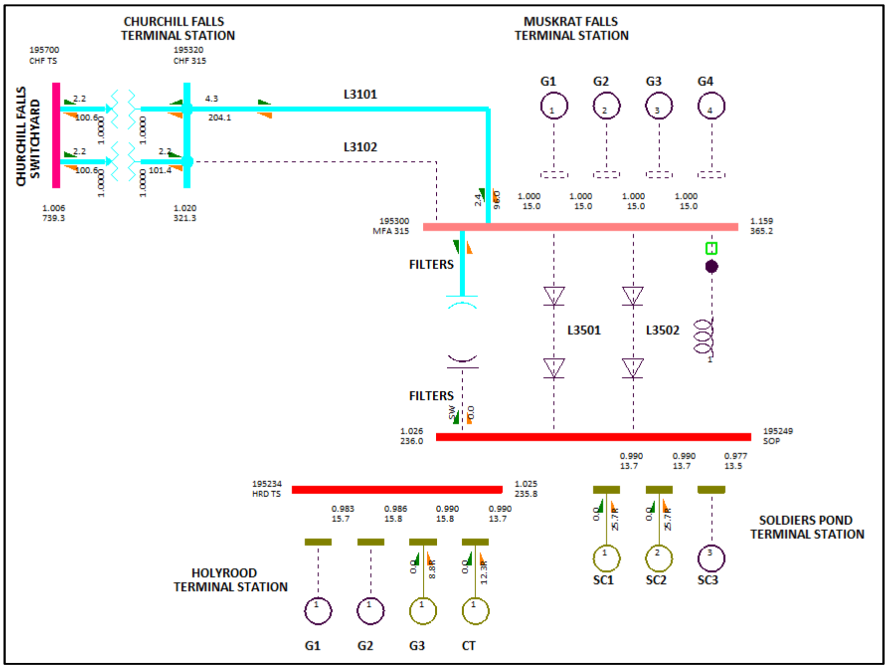

Figure 3: Study Case #1 – MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a single 75 MVAR harmonic filter at SOP, Pole 1 (L3501) can be de-blocked at a minimum of 45 MW as shown in Figure 4 before immediately switching in the second filter. During switching of the pole, the 315 kV voltage at MFA is reduced to 1.124 pu (354.06 kV); however a few moments later the bus voltage settles out at a steady state voltage of 1.141 pu (359.42 kV) as shown in Figure 5. Bus voltages at Soldiers Pond are maintained within acceptable limits.

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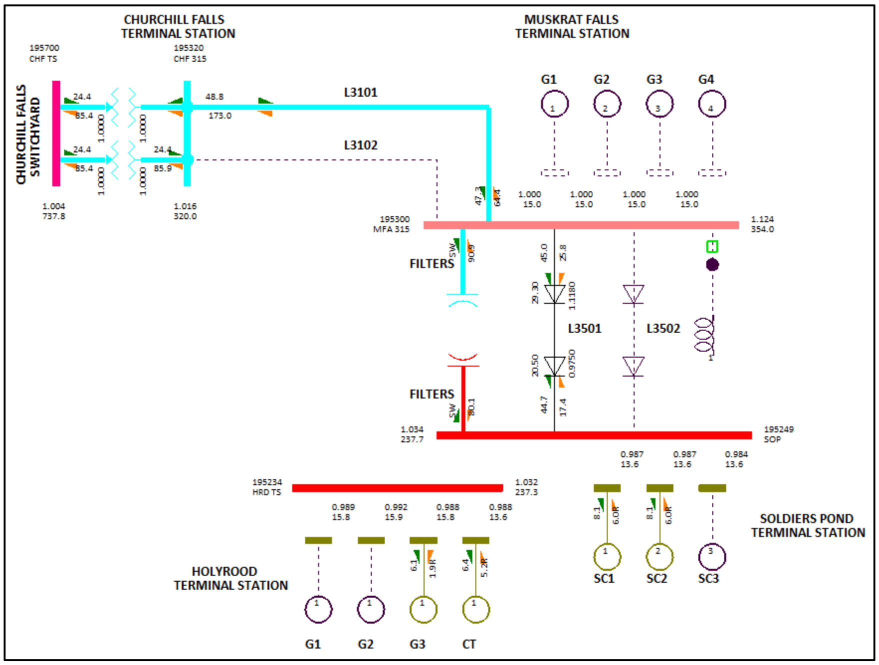

Figure 4: Study Case #1 – De-block Pole 1 (t=0+ sec)

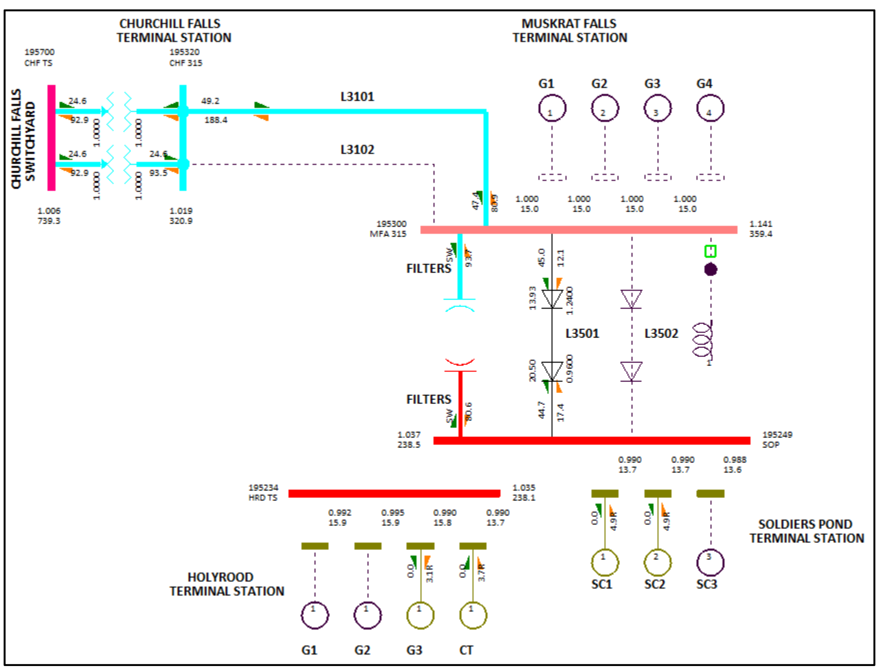

Figure 5: Study Case #1 – De-block Pole 1 (Steady State)

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Immediately after de-blocking of Pole 1 and prior to de-blocking Pole 2 (L3502), a second filter must be switched online at both MFA and SOP. The voltage rise at the MFA 315 kV bus following switching of a second 72 MVAR filter bank is on the order of 10.3% (1.244 pu) as shown in Figure 6. Bus voltages at Soldiers Pond are maintained within acceptable limits.

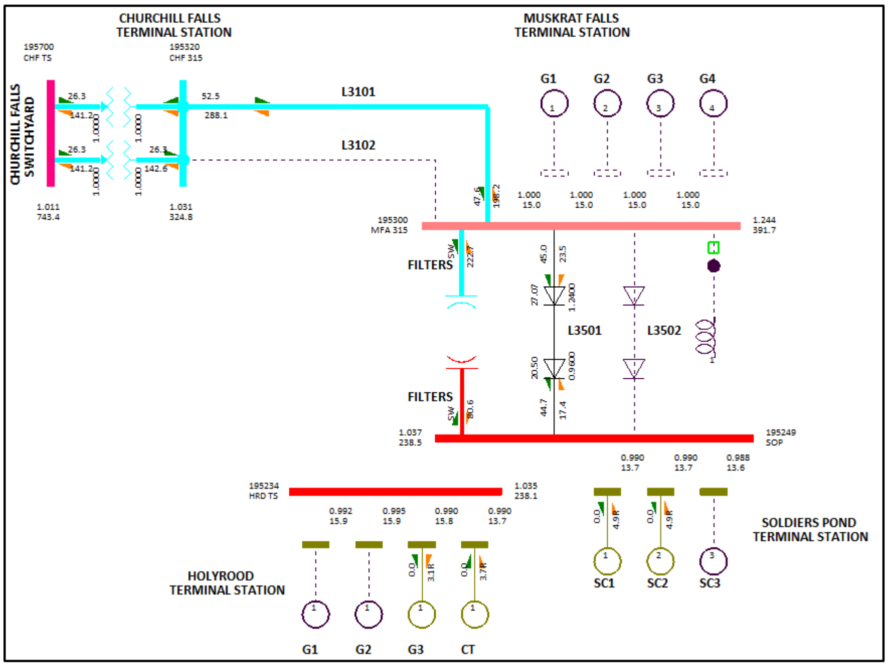

Figure 6: Study Case #1 – MFA Second 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus is reduced to 1.237 pu (389.66 kV) as shown in Figure 7. It should be noted that this voltage is above the 362 kV rating of the 315 kV GIS equipment installed at CHF and MFA and exceeds the NLH steady state voltage criteria.

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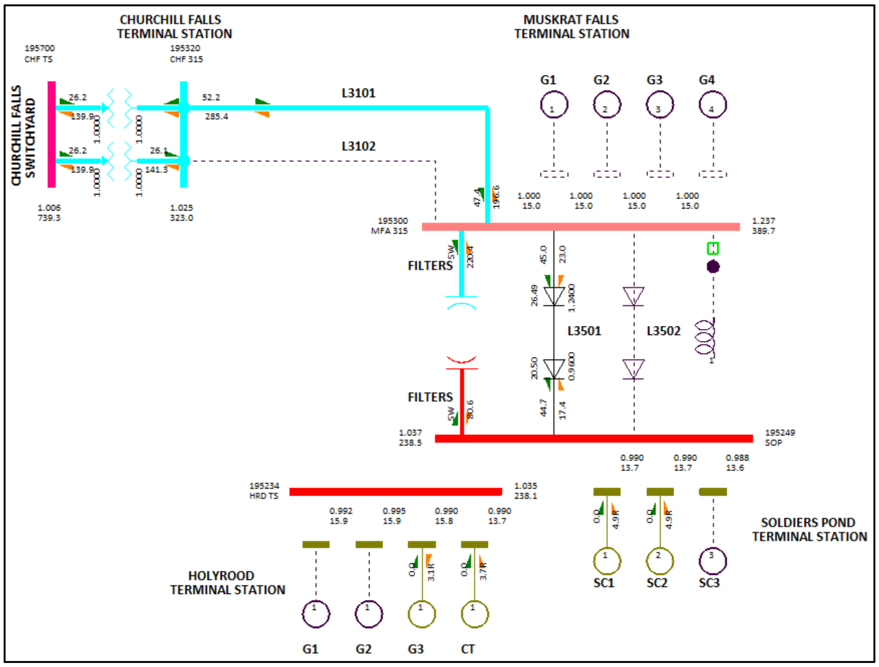

Figure 7: Study Case #1 – Second MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a second 75 MVAR harmonic filter at SOP, Pole 2 (L3502) can be de-blocked at a minimum of 45 MW as shown in Figure 8. During switching of the pole, the 315 kV voltage at MFA is reduced to 1.207 pu (380.21 kV); however a few moments later the bus voltage settles out at a steady state voltage of 1.210 pu (381.15 kV) as shown in Figure 9.

The results of the Study Case #1 which has one 315 kV line and no units online at MFA demonstrate that the resultant transmission system voltages at MFA exceed the acceptable voltage criteria. However, the synchronous condensers at Soldiers Pond ensure acceptable bus voltages at the Soldiers Pond 230 kV bus. Consequently, operation in this mode is not appropriate.

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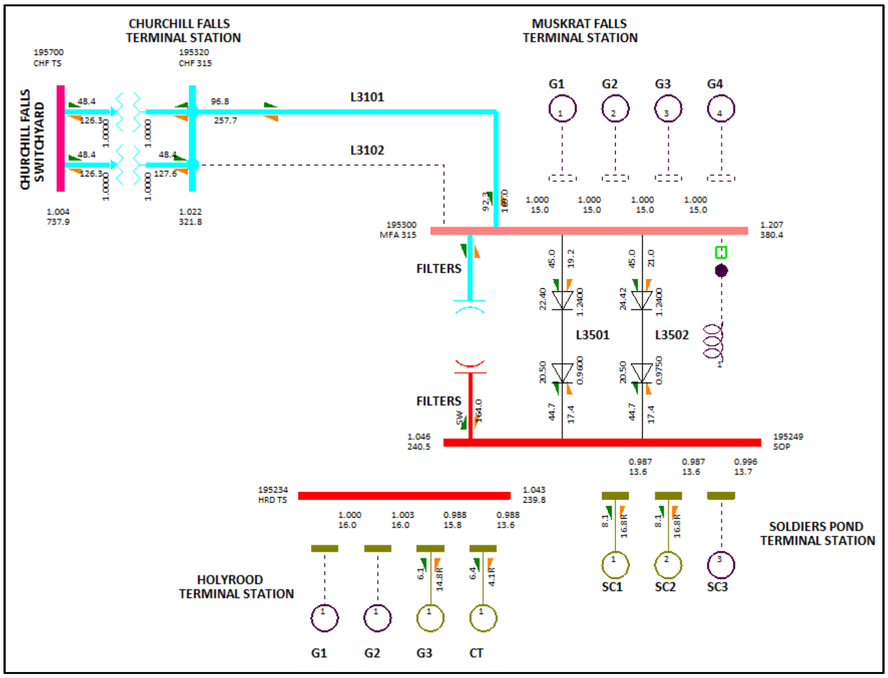

Figure 8: Study Case #1 – De-block Pole 2 (t=0+ sec)

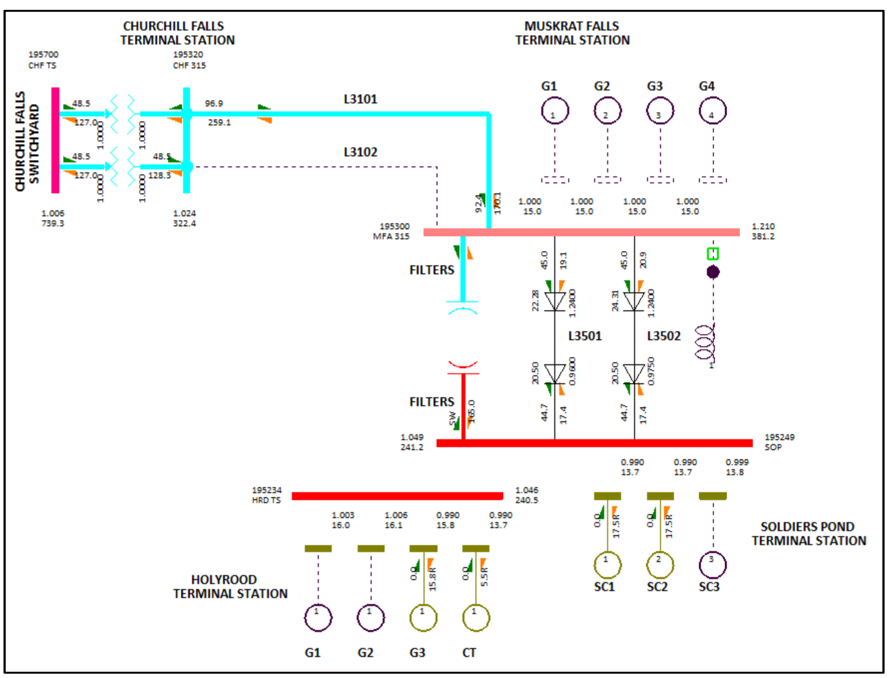

Figure 9: Study Case #1 – De-block Pole 2 (Steady State)

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TECHNICAL NOTE

STUDY CASE #2

Study case #2 assumes that the HVdc scheme is operated at rated HVdc voltage of ±350 kVdc, no shunt reactor at MFA and two 315 kV transmission lines (L3101/L3102) in service. The steady state operation of the system prior to de-block of the LIL can be seen in Figure 10.

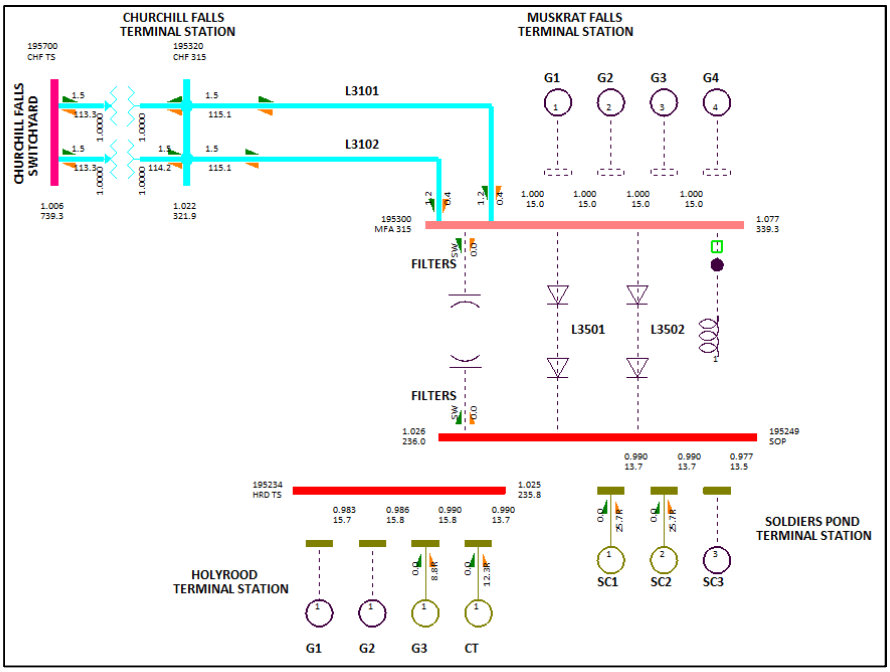

Figure 10: Study Case #2 – MFA 315 kV Bus Energization (Steady State)

It is clear from Figure 10 that prior to switching any filter banks at MFA, the bus voltage is 1.077 pu (339.26 kV). The voltage rise at the MFA 315 kV bus following switching of a single 72 MVAR filter bank is on the order of 5.3% (resultant 315 kV bus voltage of 1.13 pu) as shown in Figure 11.

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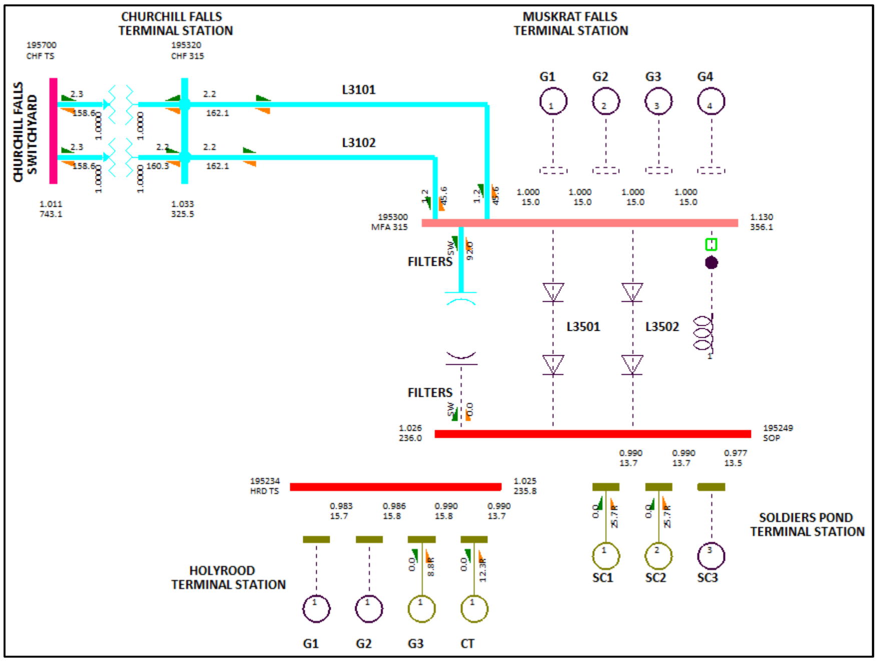

Figure 11: Study Case #2 – MFA 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus is reduced to 1.125 pu (354.38kV) as shown in Figure 12. It should be noted that this voltage is below the 362 kV rating of the 315 kV GIS equipment installed at CHF and MFA, but above both the normal and contingency transmission planning voltage criteria of 1.05 pu (330.75 kV) and 1.10 pu (346.5 kV) respectively.

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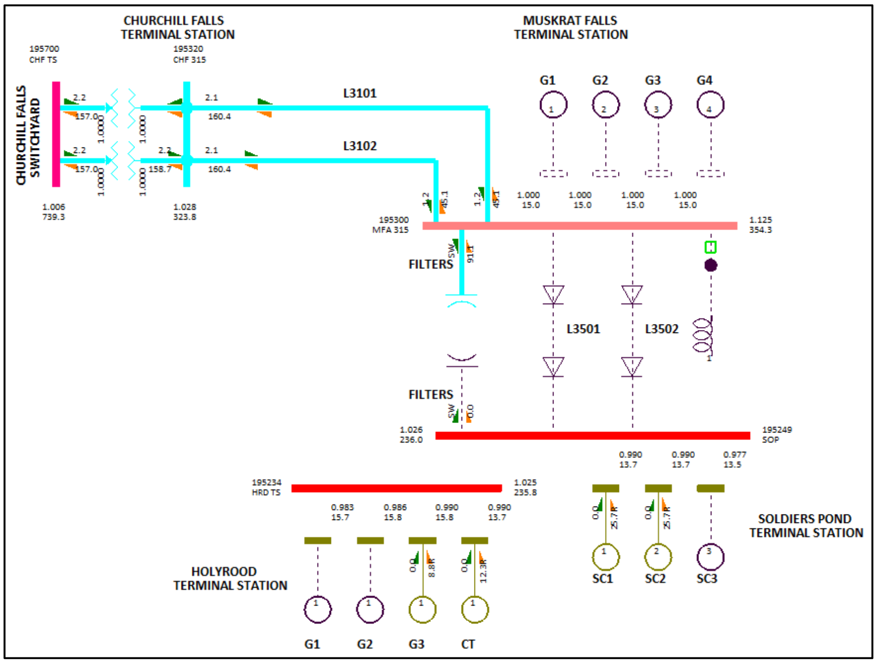

Figure 12: Study Case #2 – MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a single 75 MVAR harmonic filter at SOP, Pole 1 (L3501) can be de-blocked at a minimum of 45 MW as shown in Figure 13. During switching of the pole, the 315 kV voltage at MFA is reduced to 1.107 pu (348.71 kV); however a few moments later the bus voltage settles out at a steady state voltage of 1.116 pu (351.54 kV) as shown in Figure 14. SOP 230 kV bus voltages remain within acceptable limits during the operation.

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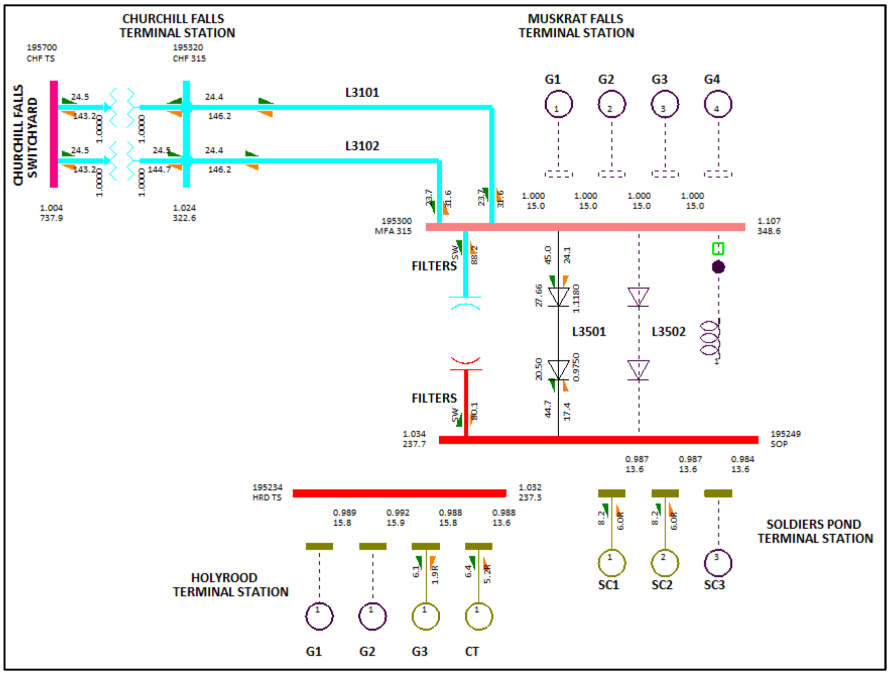

Figure 13: Study Case #2 – De-block Pole 1 (t=0+ sec)

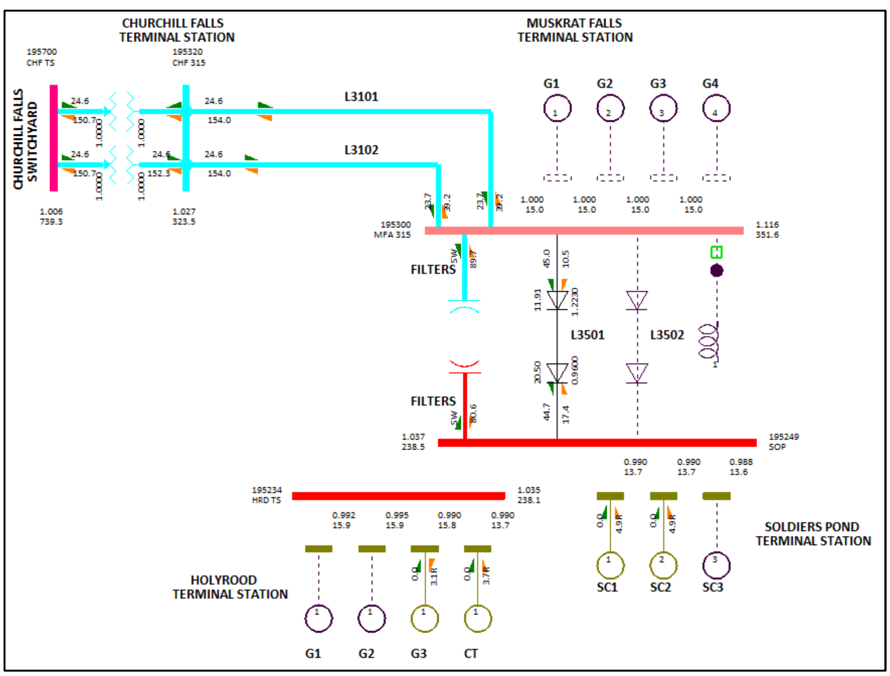

Figure 14: Study Case #2 – De-block Pole 1 (Steady State)

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TECHNICAL NOTE

Following de-block of Pole 1 and prior to de-blocking Pole 2 (L3502), a second filter must be switched online at both MFA and SOP. The voltage rise at the MFA 315 kV bus following switching of a second 72 MVAR filter bank is on the order of 5.4% (resultant 315 kV bus voltage of 1.170 pu) as shown in Figure 15.

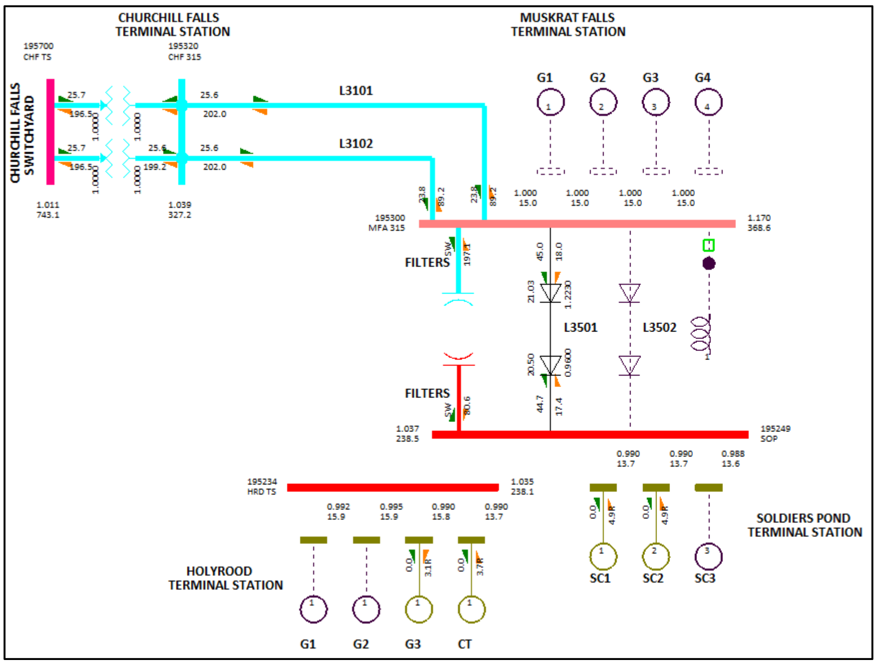

Figure 15: Study Case #1 – MFA Second 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus is reduced to 1.165 pu (366.98 kV) as shown in Figure 16. The SOP 230 kV bus voltage remains within acceptable limits during the operation. It should be noted that the 315 kV voltage is above the 362 kV rating of the 315 kV GIS equipment installed at CHF and MFA and above both the normal and contingency transmission planning voltage criteria of 1.05 pu (330.75 kV) and 1.10 pu (346.5 kV) respectively.

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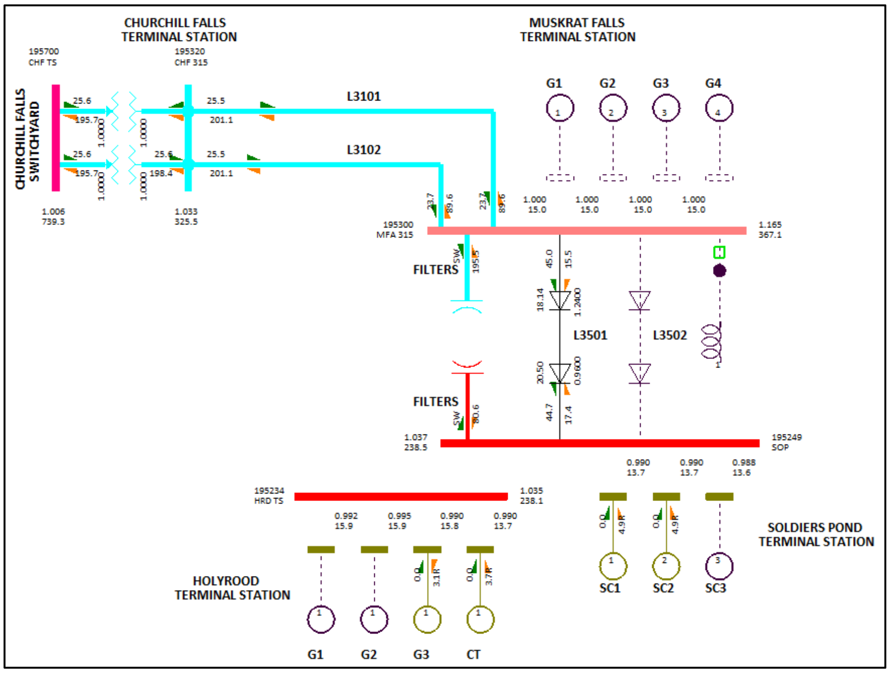

Figure 16: Study Case #2 – Second MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a second 75 MVAR harmonic filter at SOP, Pole 2 (L3502) can be de-blocked at a minimum of 45 MW as shown in Figure 17. During switching of the pole, the 315 kV voltage at MFA is reduced to 1.147 pu (361.31 kV); however a few moments later the bus voltage settles out at a steady state voltage of 1.155 pu (363.83 kV) as shown in Figure 18.

The results of the Study Case #2 (two 315 kV lines in service and no units online at MFA) demonstrate that the resultant transmission system voltages exceed the acceptable voltage criteria. Consequently, operation in this mode is not appropriate.

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TECHNICAL NOTE

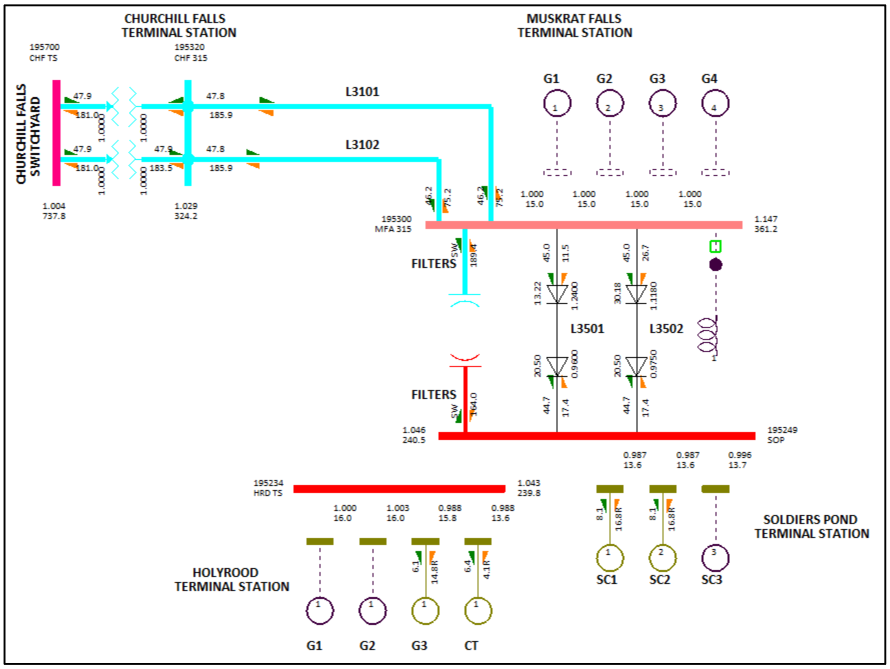

Figure 17: Study Case #2 – De-block Pole 2 (t=0+ sec)

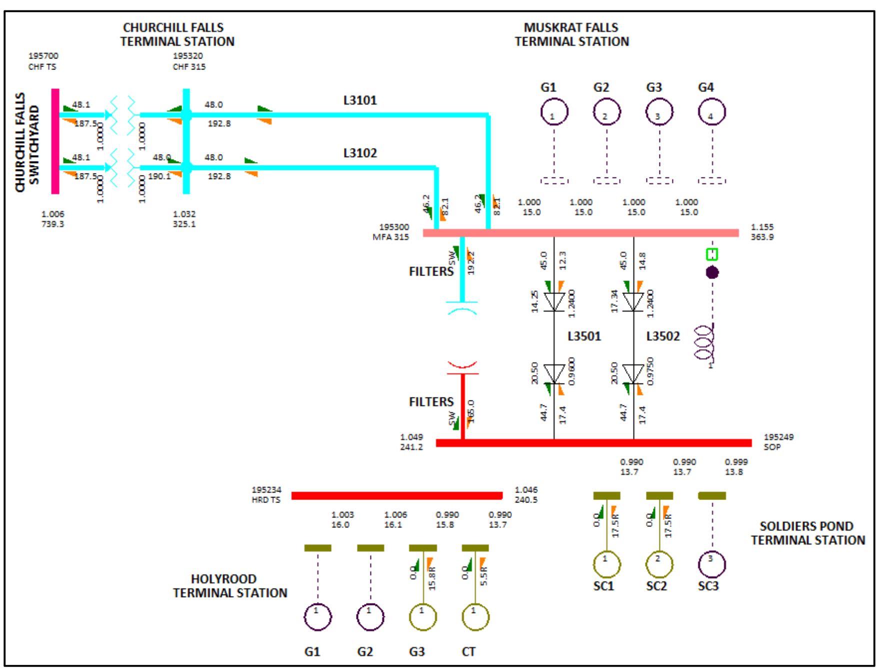

Figure 18: Study Case #2 – De-block Pole 2 (Steady State)

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STUDY CASE #3

Study case #3 assumes that the HVdc scheme is operated at rated HVdc voltage of ±350 kVdc, a 140 MVAR, 315 kV shunt reactor has been installed on the MFA 315 kV bus and one 315 kV transmission line (L3101) is in service. The steady state operation of the system can be seen in Figure 19 prior to de-block of the HVdc scheme.

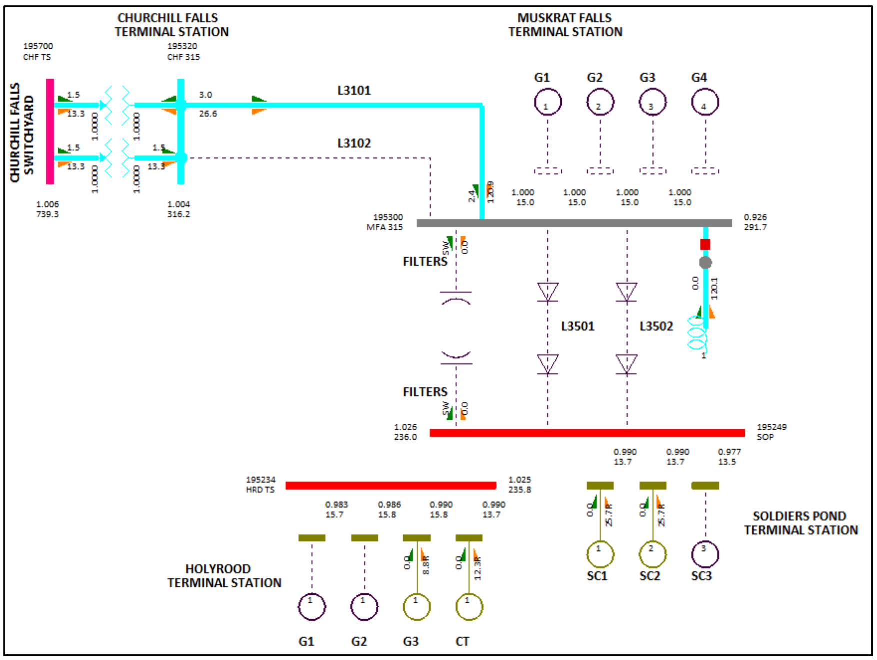

Figure 19: Study Case #3 – MFA 315 kV Bus Energization (Steady State)

It is clear from Figure 19 that prior to switching any filter banks at MFA, the 315 kV bus voltage is 0.926 pu (291.69 kV). The MFA 315 kV bus voltage is below the normal transmission planning voltage criteria of 0.95 pu (229.25 kV), but within the contingency voltage criteria of 0.90 pu (283.5 kV).

The voltage rise at the MFA 315 kV bus following switching of a single 72 MVAR filter bank is on the order of 7.2% (resultant 315 kV bus voltage of 0.998 pu) as shown in Figure 20.

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TECHNICAL NOTE

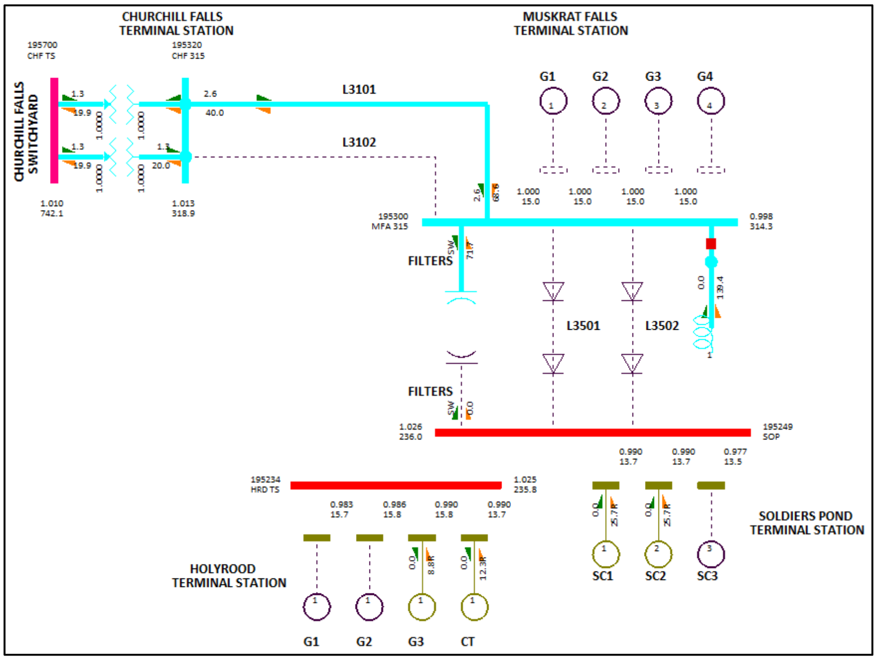

Figure 20: Study Case #3 – MFA 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus is reduced to 0.994 pu (313.11 kV) as shown in Figure 21. It should be noted that this voltage is within the rating of the 315 kV GIS equipment installed at CHF and MFA and the transmission planning voltage criteria for normal operation.

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TECHNICAL NOTE

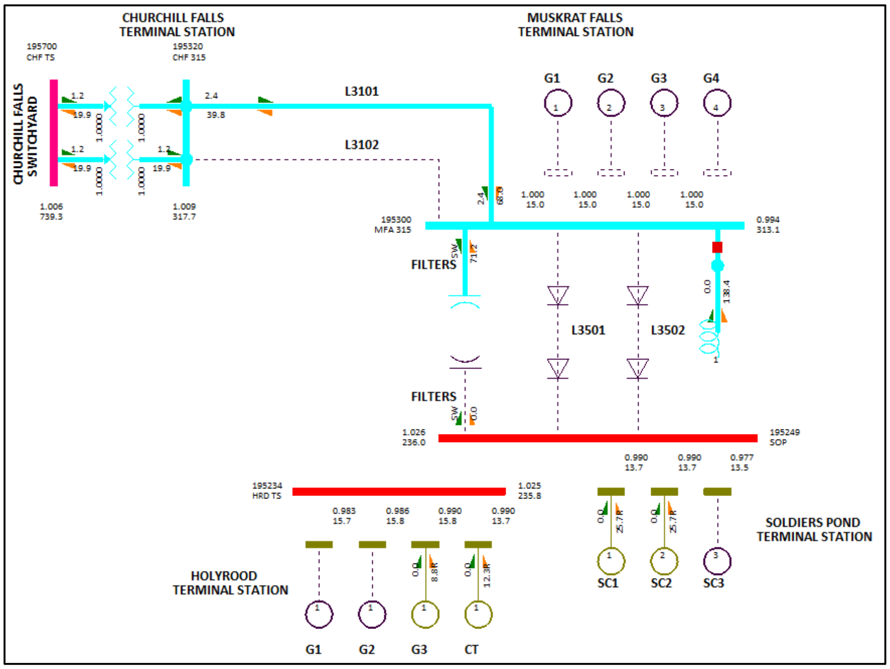

Figure 21: Study Case #3 – MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a single 75 MVAR harmonic filter at SOP, Pole 1 (L3501) can be de-blocked at a minimum of 45 MW as shown in Figure 22. During switching of the pole, the 315 kV voltage at MFA is reduced to 0.98 pu (308.70 kV); however a few moments later the bus voltage settles out at a steady state voltage of 0.978 pu (308.07 kV) as shown in Figure 23. Voltages on the 230 kV bus at SOP are within acceptable limits during the operation.

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TECHNICAL NOTE

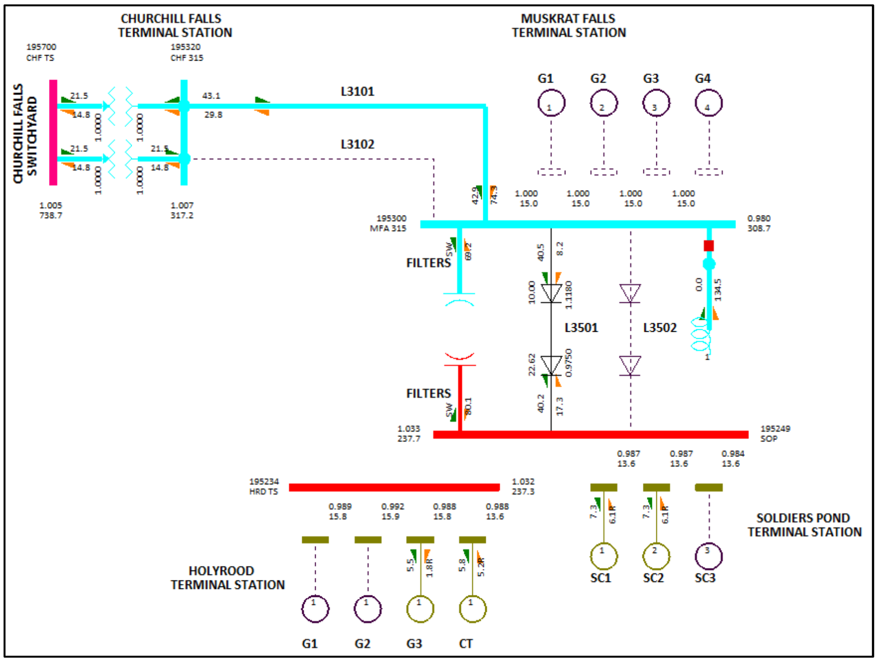

Figure 22: Study Case #3 – De-block Pole 1 (t=0+ sec)

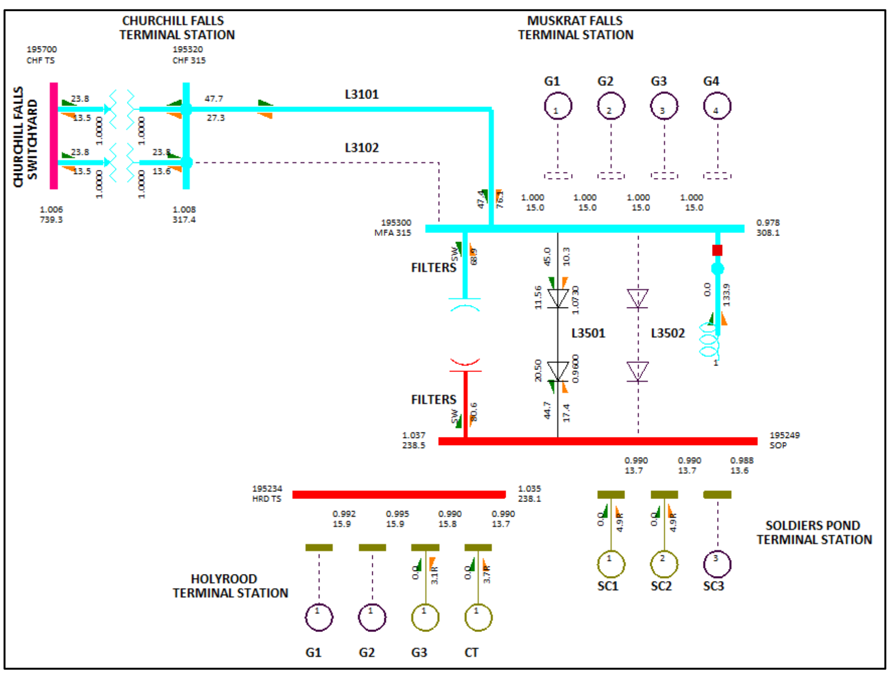

Figure 23: Study Case #3 – De-block Pole 1 (Steady State)

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TECHNICAL NOTE

Following de-blocking of Pole 1 and prior to de-blocking Pole 2 (L3502), a second filter must be switched online at both MFA and SOP. The voltage rise at the MFA 315 kV bus following switching of a second 72 MVAR filter bank is on the order of 7.1% (resultant 315 kV bus voltage of 1.049 pu) as shown in Figure 24.

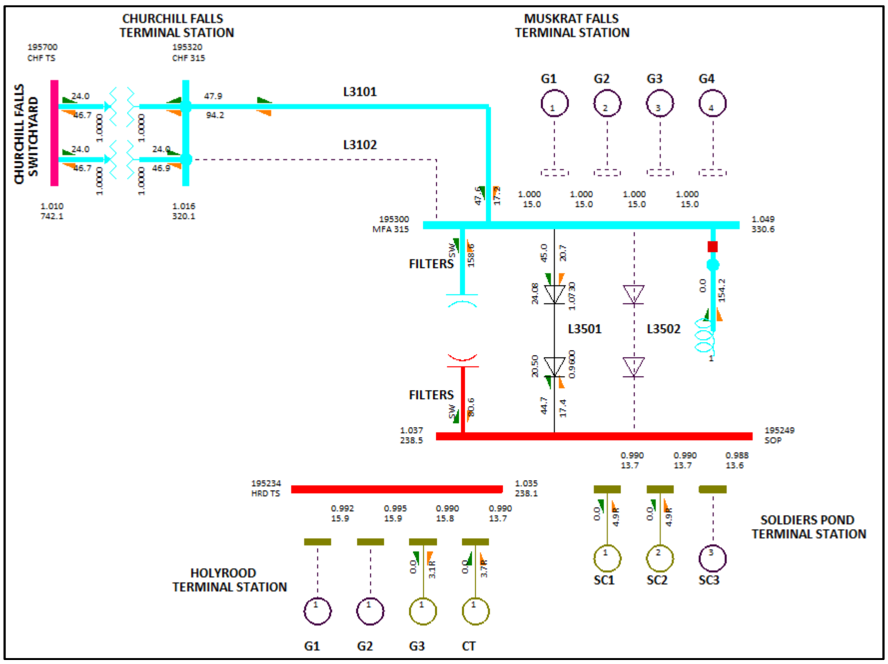

Figure 24: Study Case #3 – MFA Second 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus increases to 1.055 pu (332.33 kV) as shown in Figure 25. It should be noted that this voltage is below the 362 kV rating of the 315 kV GIS equipment installed at CHF and MFA and marginally above the transmission planning voltage criteria for normal operation (i.e. 1.05 pu). Voltages on the 230 kV bus at SOP are maintained within acceptable limits.

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TECHNICAL NOTE

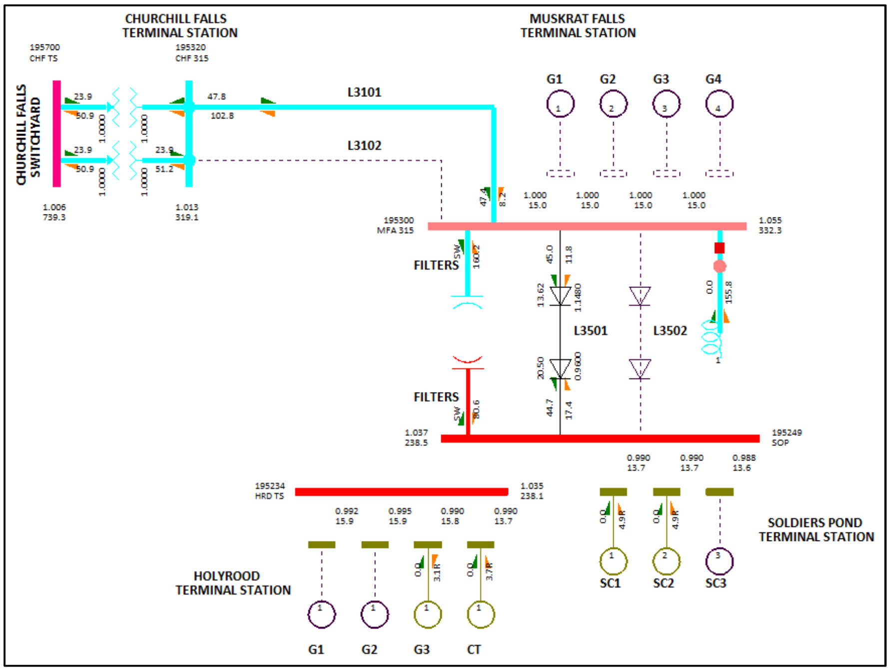

Figure 25: Study Case #3 – Second MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a second 75 MVAR harmonic filter at SOP, Pole 2 (L3502) can be de-blocked at a minimum of 45 MW as shown in Figure 26. During switching of the pole, the 315 kV voltage at MFA is reduced to 1.035 pu (326.03 kV); however a few moments later the bus voltage settles out at a steady state voltage of 1.035 pu (326.03 kV) as shown in Figure 27.

With the exception of the initial energization of one 315 kV transmission line with the 140 MVAR shunt reactor, bus voltages remain within the planning criteria for Study Case #3; one 315 kV line, one 140 MVAR shunt reactor and no MFA units in service.

Further analysis into this transmission configuration in Labrador was warranted to determine the maximum power transfer over the LIL at such a low short circuit level and high impedance transmission circuit connection between CHF and MFA. As shown in Figure 28, a maximum power order of 218 MW, at the rectifier, can be transferred over the LIL before a lack of reactive power at MFA prevents the system from establishing a stable mode of operation. A total of 214 MW is delivered at the inverter in Soldiers Pond (approximately 4 MW of HVdc transmission system losses). Beyond 218 MW at the rectifier, the MFA 315 kV bus voltage will fall below 0.95 pu (299.25 kV), the transmission planning voltage limit for normal operation.

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TECHNICAL NOTE

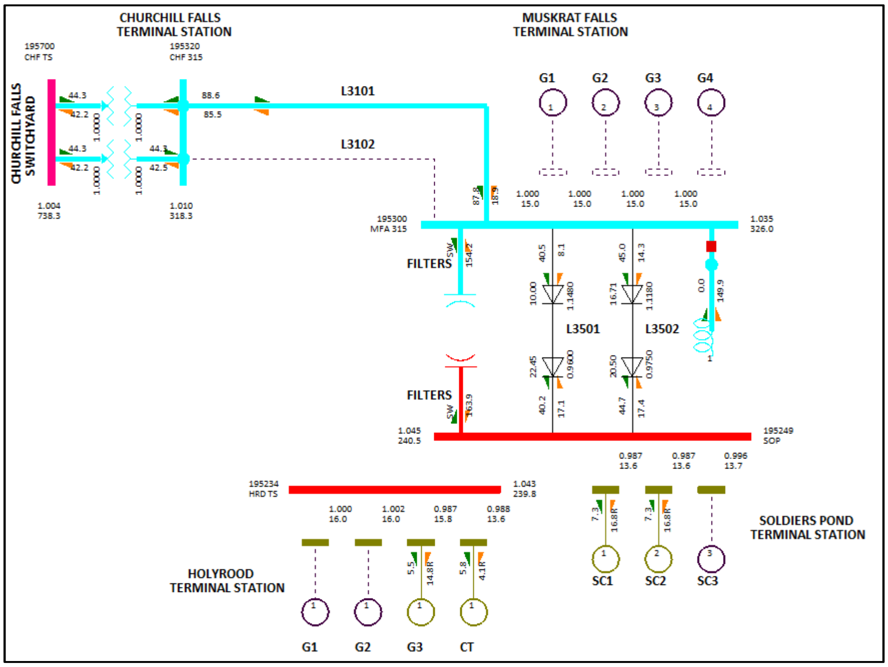

Figure 26: Study Case #3 – De-block Pole 2 (t=0+ sec)

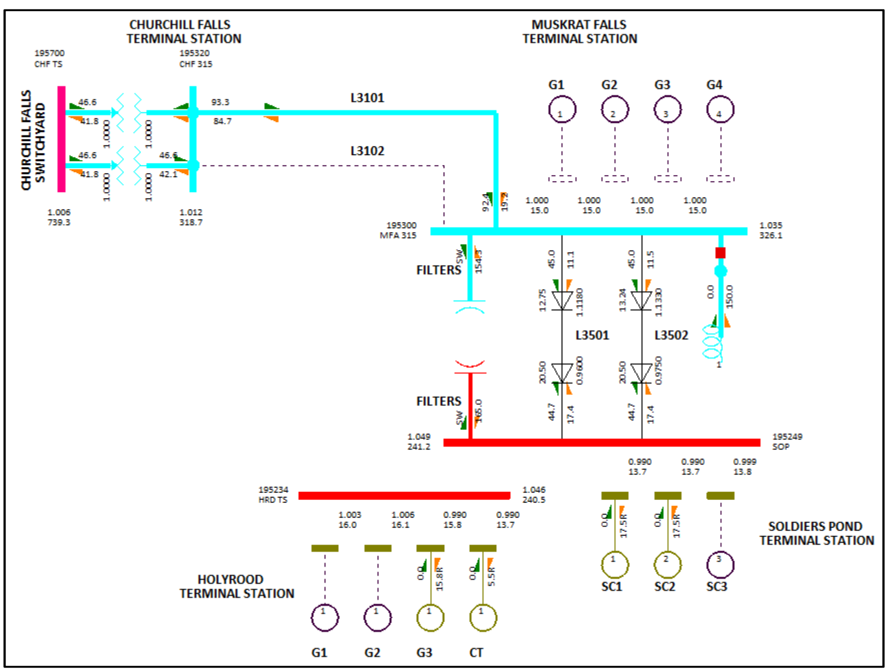

Figure 27: Study Case #3 – De-block Pole 2 (Steady State)

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TECHNICAL NOTE

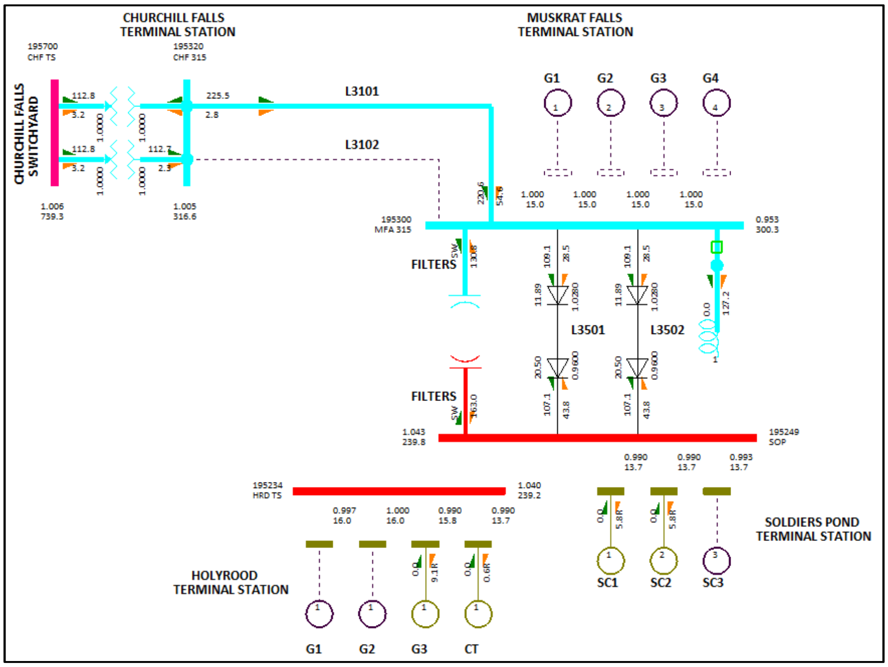

Figure 28: Study Case #3 – Maximum Power Order on LIL (218 MW) – Reactive Power Limits

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TECHNICAL NOTE

STUDY CASE #4

Study case #4 assumes that the HVdc scheme is operated at rated HVdc voltage of ±350 kVdc, a 140 MVAR, 315 kV shunt reactor has been installed on the MFA 315 kV bus and two 315 kV transmission lines (L3101/L3102) are in service. The steady state operation of the system can be seen in Figure 29, prior to de-block of the HVdc scheme.

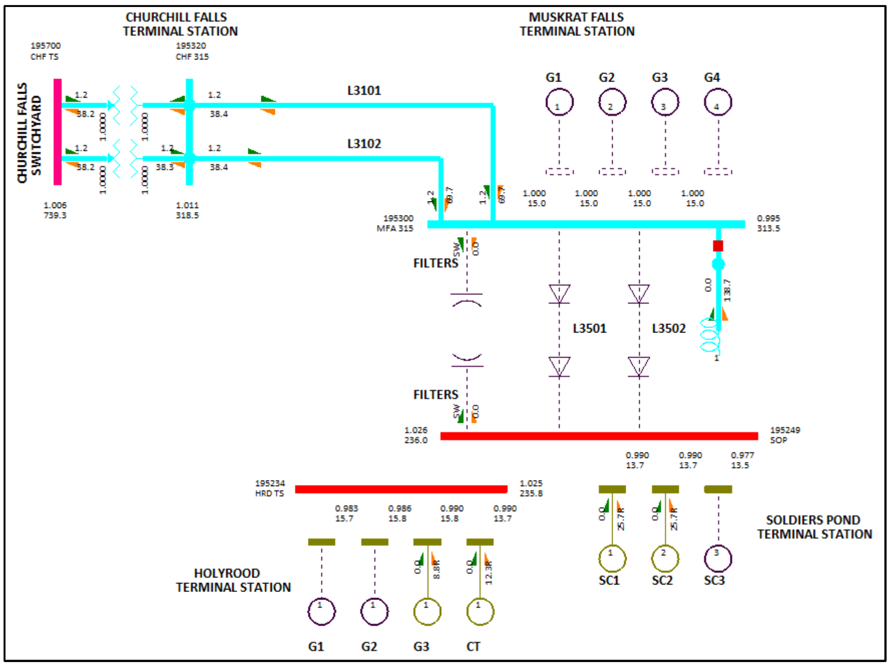

Figure 29: Study Case #4 – MFA 315 kV Bus Energization (Steady State)

It is clear from Figure 28 that prior to switching any filter banks at MFA, the bus voltage is 0.995 pu (313.43 kV). The voltage rise at the MFA 315 kV bus following switching of a single 72 MVAR filter bank is on the order of 4.5% (resultant 315 kV bus voltage of 1.04 pu) as shown in Figure 30. The MFA bus voltage is maintained within the transmission planning voltage criteria for normal operation.

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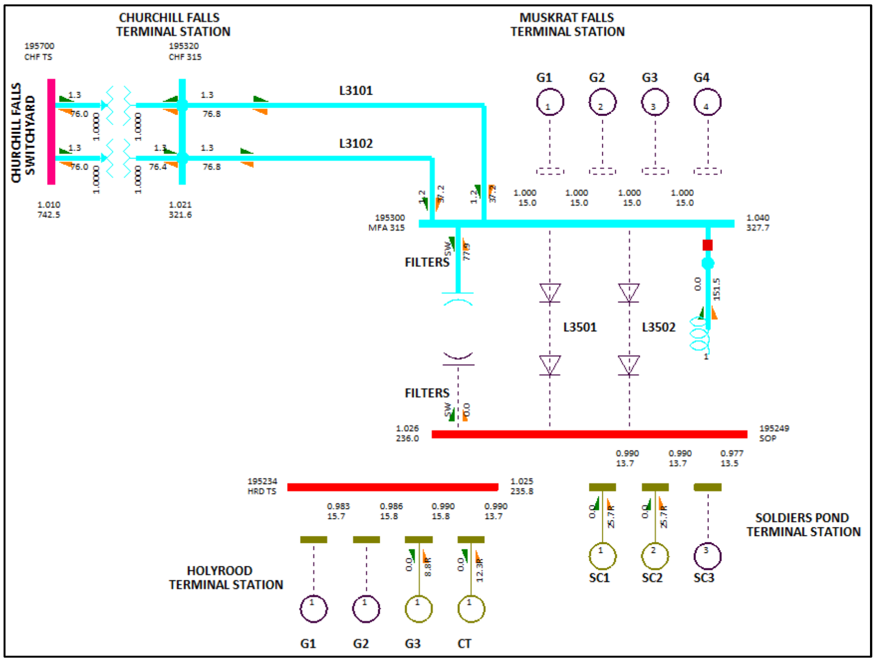

Figure 30: Study Case #4 – MFA 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus is reduced to 1.036 pu (326.34 kV) as shown in Figure 31. It should be noted that this voltage is below the 362 kV rating of the 315 kV GIS equipment installed at CHF and MFA and within the transmission planning voltage criteria for normal operation (0.95 to 1.05 pu).

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TECHNICAL NOTE

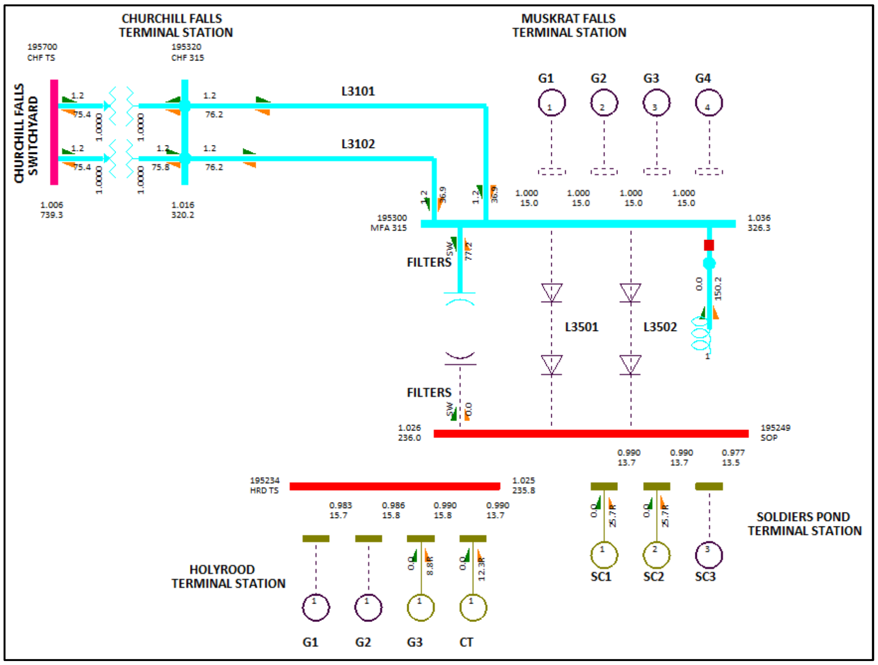

Figure 31: Study Case #4 – MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a single 75 MVAR harmonic filter at SOP, Pole 1 (L3501) can be de-blocked at a minimum of 45 MW as shown in Figure 32. During switching of the pole, the 315 kV voltage at MFA is reduced to 1.024 pu (322.56 kV); however a few moments later the bus voltage settles out at a steady state voltage of 1.027 pu (323.51 kV) as shown in Figure 33. Bus voltages at Soldiers Pond are maintained within the acceptable limits during the operation.

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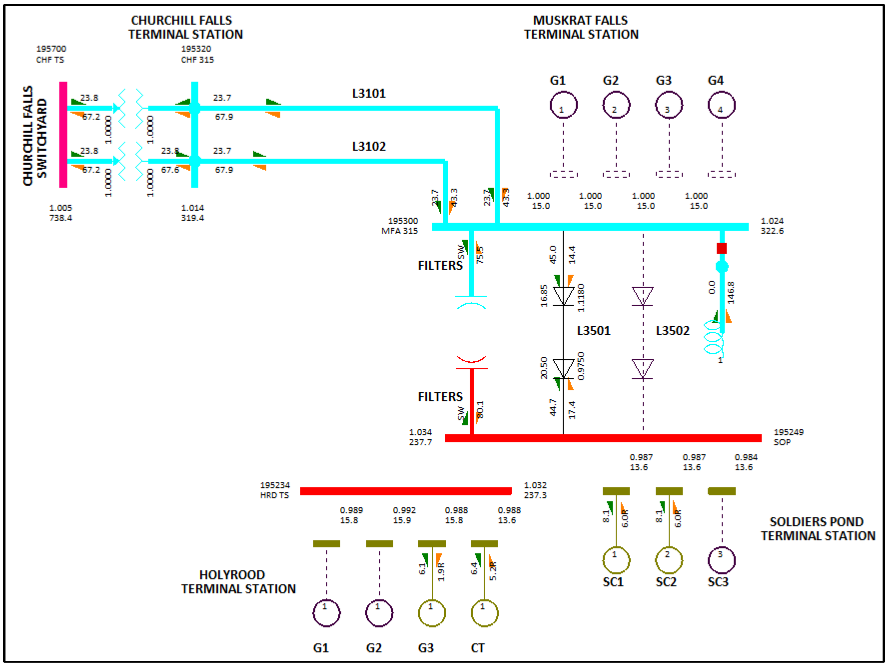

Figure 32: Study Case #4 – De-block Pole 1 (t=0+ sec)

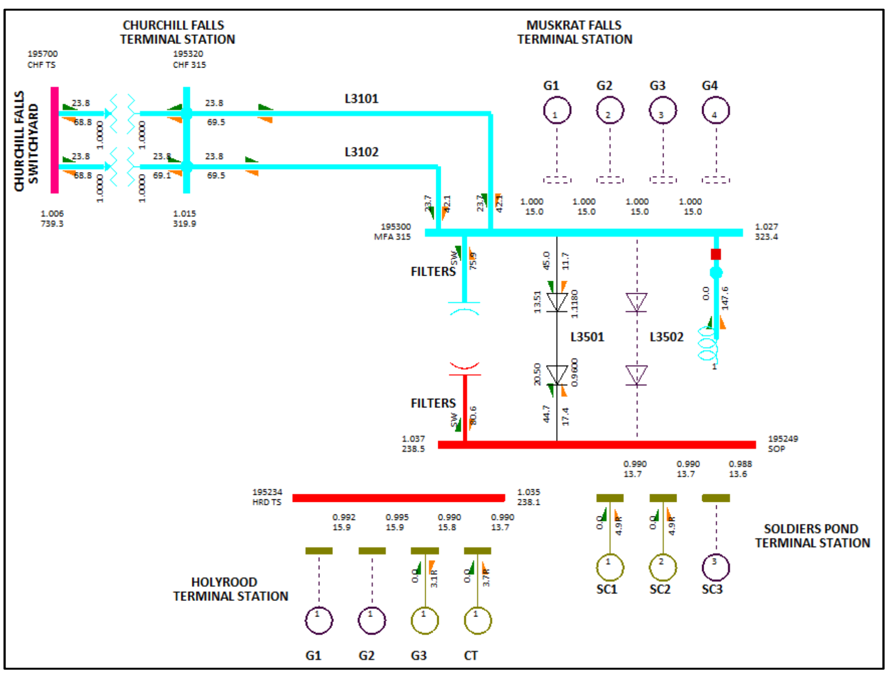

Figure 33: Study Case #4 – De-block Pole 1 (Steady State)

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TECHNICAL NOTE

Following de-blocking of Pole 1 and prior to de-blocking Pole 2 (L3502), a second filter must be switched online at both MFA and SOP. The voltage rise at the MFA 315 kV bus following switching of a second 72 MVAR filter bank is on the order of 4.5% (resultant 315 kV bus voltage of 1.072 pu) as shown in Figure 34.

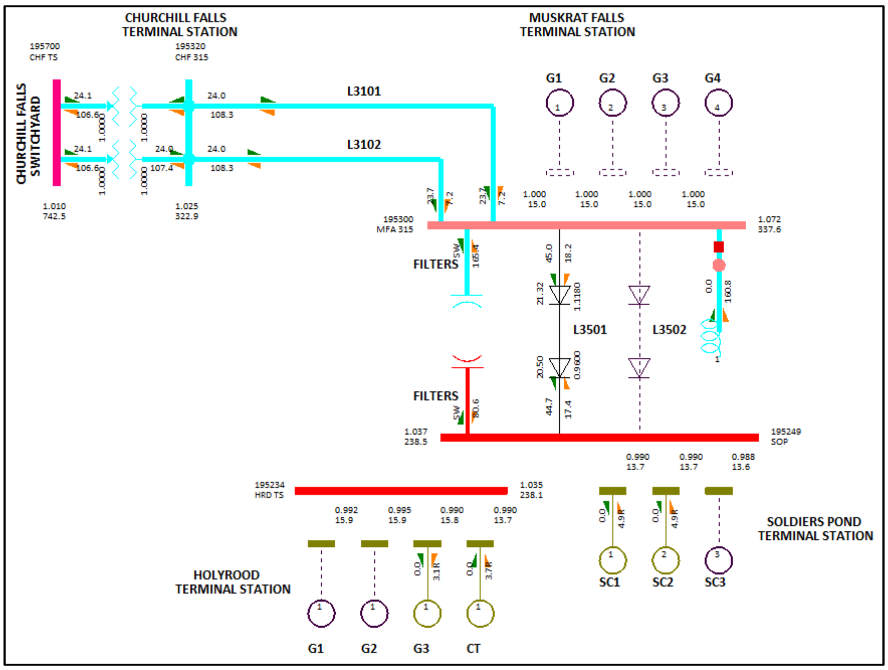

Figure 34: Study Case #4 – MFA Second 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus decreases to 1.07 pu (337.05 kV) as shown in Figure 35. It should be noted that this voltage is below the 362 kV rating of the 315 kV GIS equipment installed at CHF and MFA but above the transmission planning voltage criteria of 1.05 pu (330.75 kV) for normal operation.

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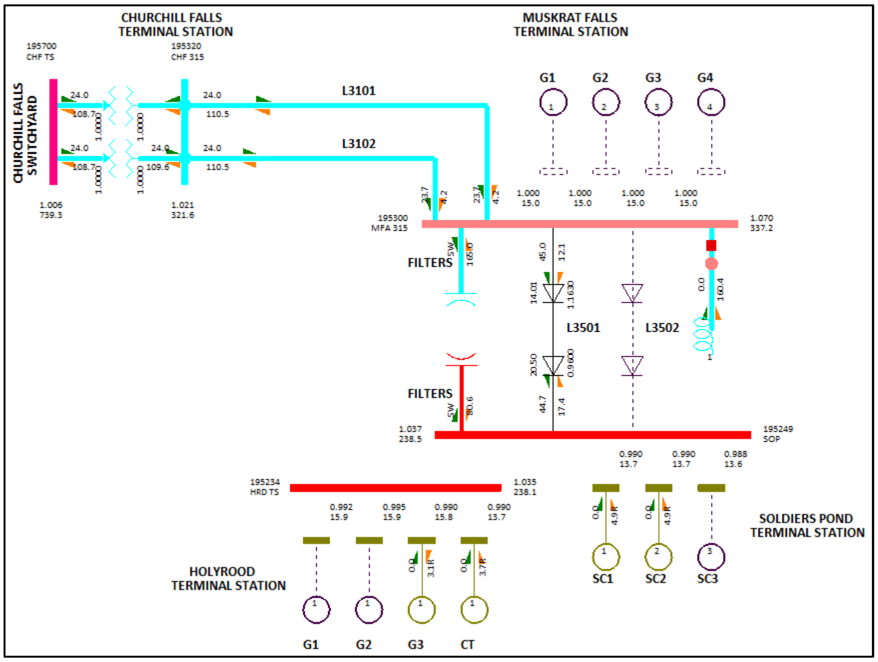

Figure 35: Study Case #4 – Second MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a second 75 MVAR harmonic filter at SOP, Pole 2 (L3502) can be de-blocked at a minimum of 45 MW as shown in Figure 36. During switching of the pole, the 315 kV voltage at MFA is reduced to 1.059 pu (333.59 kV); however a few moments later the bus voltage settles out at a steady state voltage of 1.062 pu (334.53kV) as shown in Figure 37.

The results of the Study Case #4 (two 315 kV lines in service, a 140 MVAR, 315 kV shunt reactor in service and no units online at MFA) demonstrate that the resultant transmission system voltages exceed the acceptable voltage criteria for normal operation with a LIL power order of 45 MW in monopolar mode or 90 MW in bipolar mode. The analysis does indicate that this mode of operation is within the transmission planning voltage criteria for contingency or emergency situations. While continued operation at low power in this mode is not appropriate, the mode does demonstrate that as load continues to increase, switching in of the second 315 kV transmission line would result in acceptable voltage at MFA and provide an increased level of reliability over Study Case #3.

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TECHNICAL NOTE

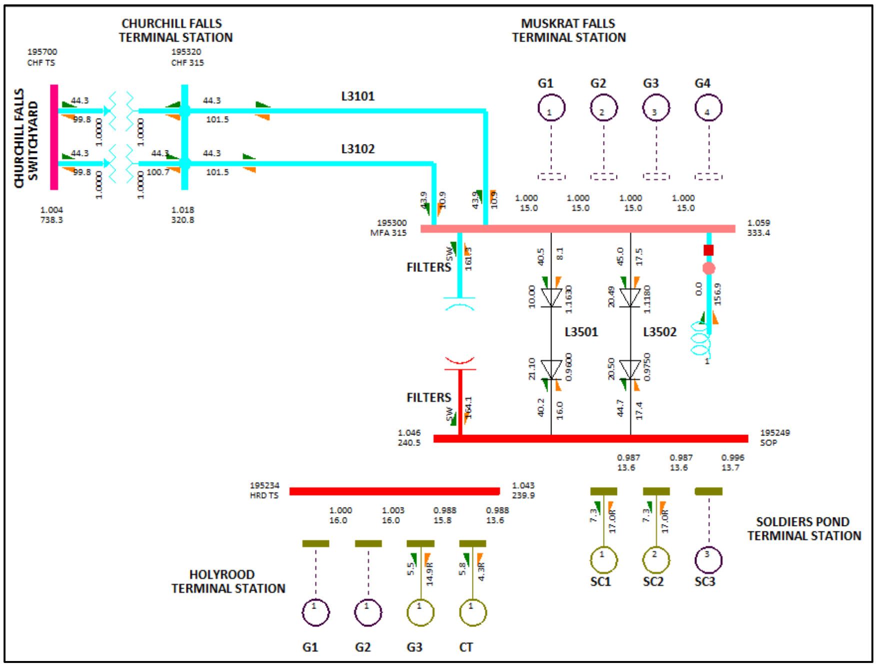

Figure 36: Study Case #4 – De-block Pole 2 (t=0+ sec)

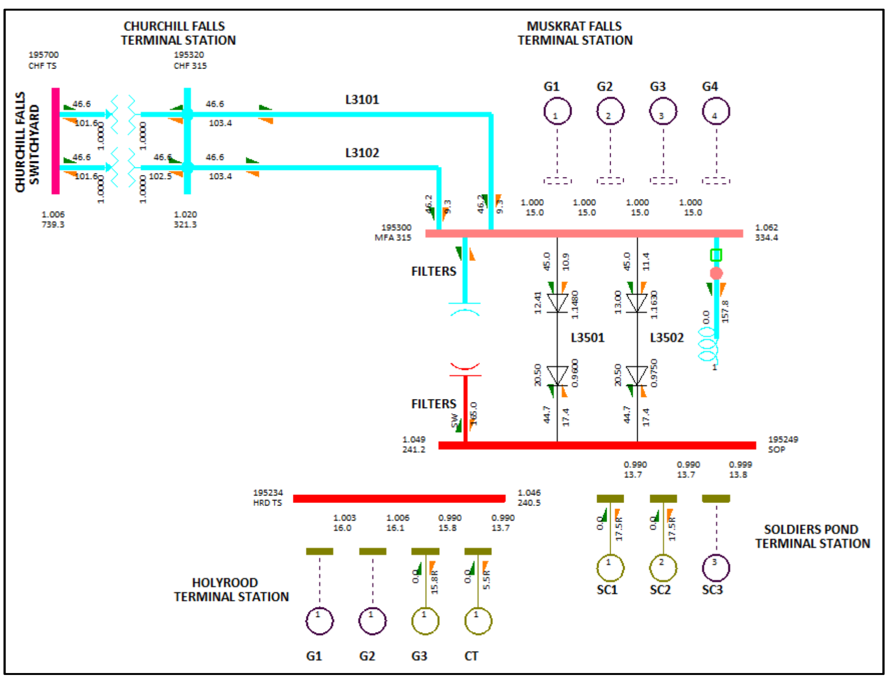

Figure 37: Study Case #4 – De-block Pole 2 (Steady State)

Further analysis into this transmission configuration in Labrador was warranted to determine:

1. The power transfer over the LIL to bring the bus voltage at MFA to 1.05 pu; and
2. The maximum power transfer over the LIL before a lack of reactive power prevents stable operation.

With two 315 kV transmission lines and a 140 MVAR reactor in service, the LIL must be loaded to 136 MW to increase reactive power absorption and bring the MFA 315 kV bus voltage down to the maximum voltage criteria of 1.05 pu as shown in Figure 38.

As shown in Figure 39, a maximum power order of 402 MW, at the rectifier, can be transferred over the LIL before a lack of reactive power at MFA prevents the system from establishing a stable mode of operation. A total of 390 MW is delivered to the inverter in Soldiers Pond (approximately 12 MW of HVdc line losses). Beyond this loading level the 315 kV bus voltage at MFA falls below the acceptable limits.

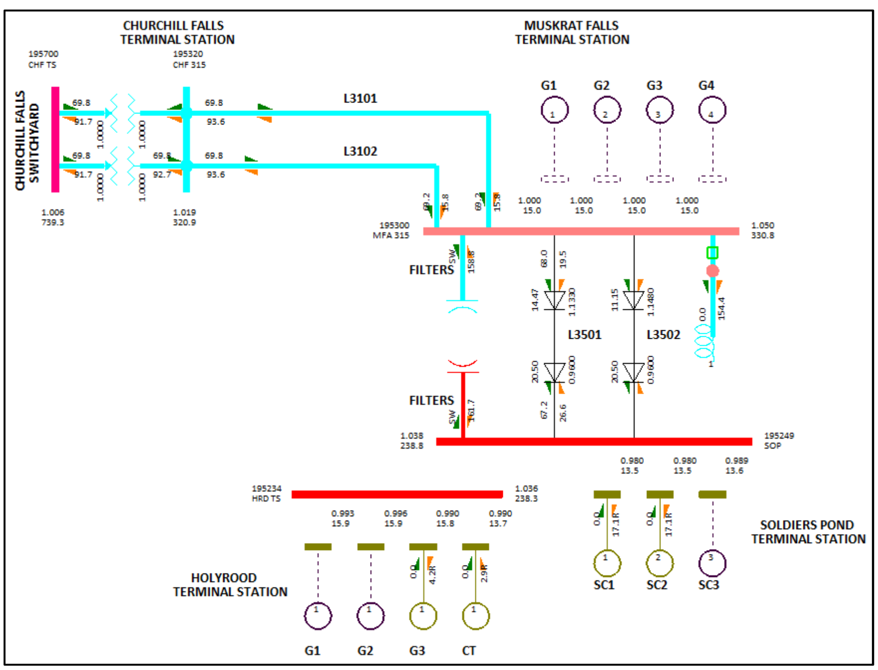

Figure 38: Study Case #4 – Power Order Required (136 MW) to Operate at 1.05 pu Voltage at MFA

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TECHNICAL NOTE

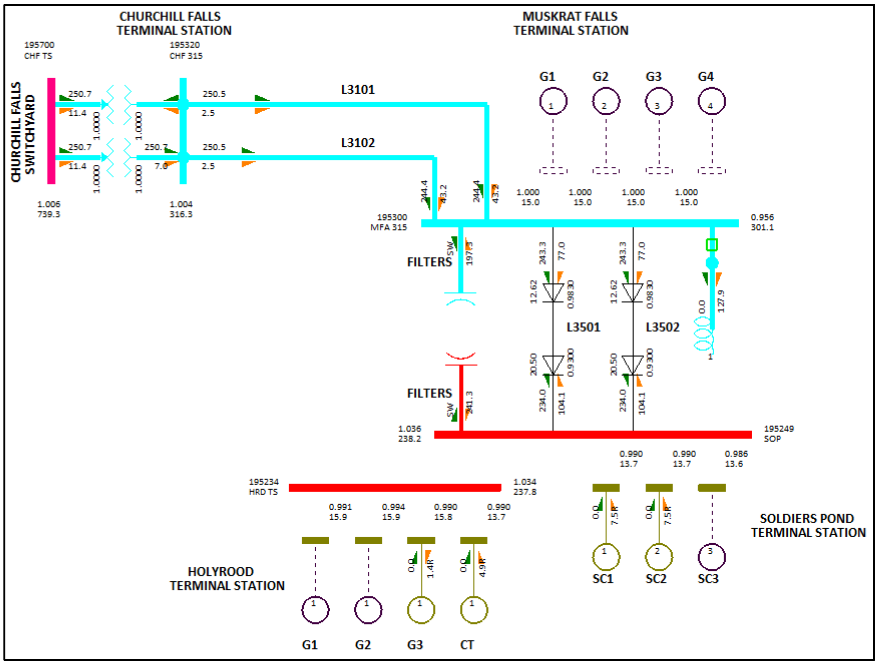

Figure 39: Study Case #4 – Maximum Power Order on LIL (486 MW) – Reactive Power Limits

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TECHNICAL NOTE

STUDY CASE #5

Study case #5 assumes that the HVdc scheme is operated at 80% of rated HVdc voltage (±280 kVdc), no shunt reactor has been installed and one 315 kV transmission line (L3101) is in service. The steady state operation of the system can be seen in Figure 40, prior to de-block of the HVdc scheme.

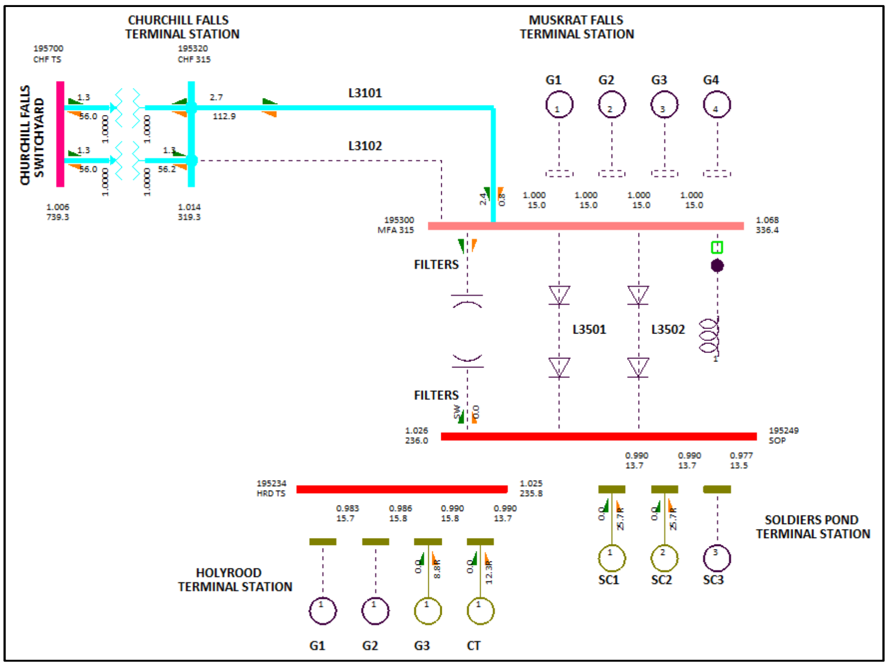

Figure 40: Study Case #5 – MFA 315 kV Bus Energization (Steady State)

It is clear from Figure 37 that prior to switching any filter banks at MFA, the bus voltage is 1.068 pu (336.42 kV). The voltage rise at the MFA 315 kV bus following switching of a single 72 MVAR filter bank is on the order of 9.7% (resultant 315 kV bus voltage of 1.165 pu) as shown in Figure 41.

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TECHNICAL NOTE

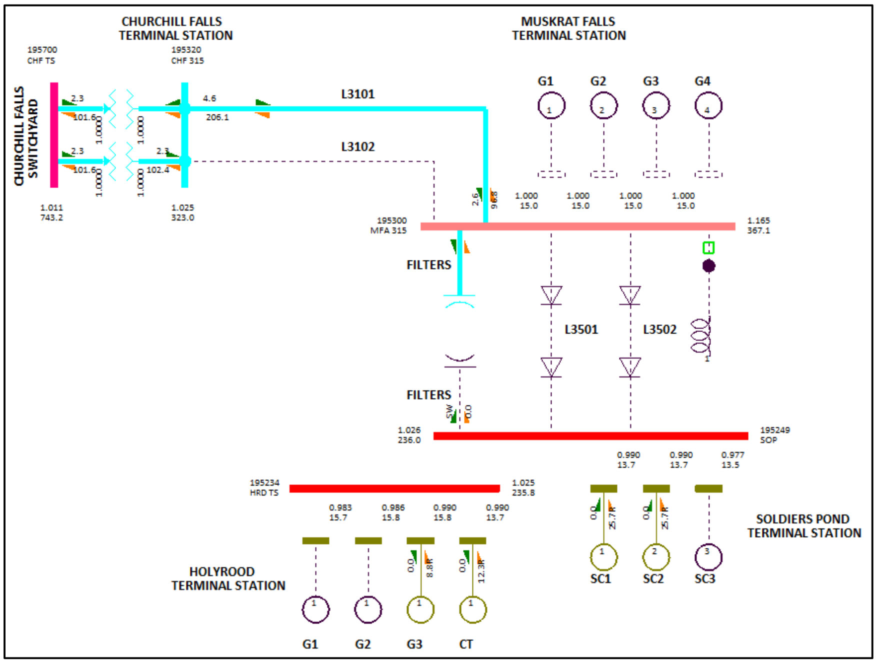

Figure 41: Study Case #5 – MFA 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus is reduced to 1.159 pu (365.09 kV) as shown in Figure 42. It should be noted that this voltage is above the 362 kV rating of the 315 kV GIS equipment installed at CHF and MFA and exceeds the transmission planning voltage criteria.

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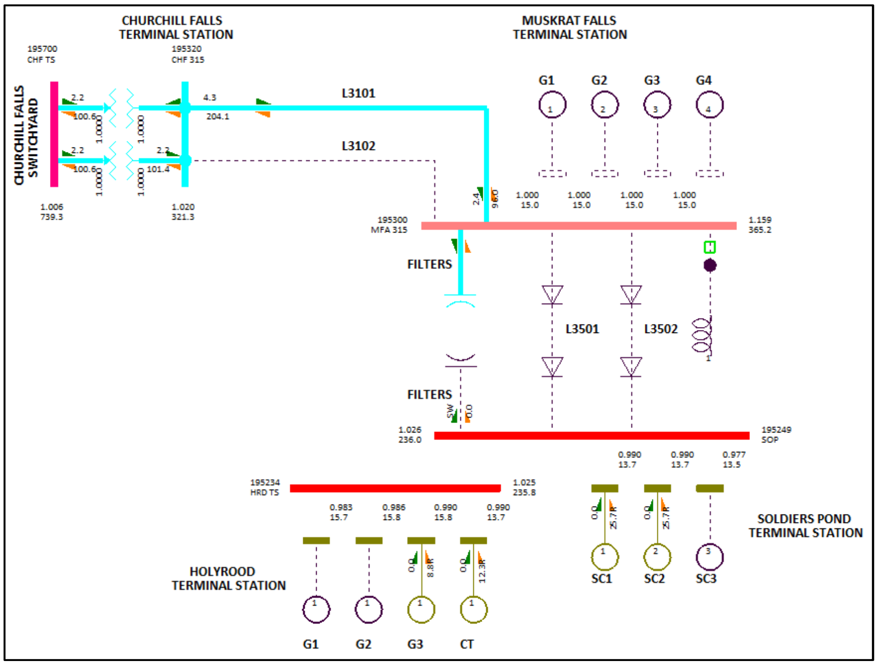

Figure 42: Study Case #5 – MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a single 75 MVAR harmonic filter at SOP, Pole 1 (L3501) can be de-blocked at a minimum of 45 MW as shown in Figure 43. During switching of the pole, the 315 kV voltage at MFA is reduced to 1.124 pu (354.06 kV); however a few moments later the bus voltage settles out at a steady state voltage of 1.116 pu (351.54 kV) as shown in Figure 44. The 315 kV bus voltage at MFA exceeds the transmission planning voltage criteria. The bus voltages at SOP are maintained within acceptable limits during the operation.

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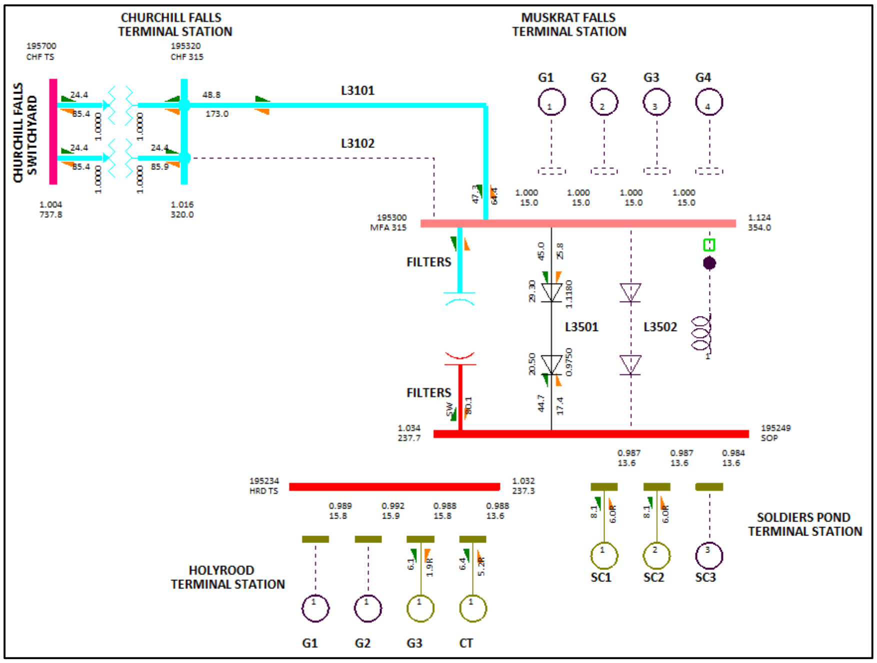

Figure 43: Study Case #5 – De-block Pole 1 (t=0+ sec)

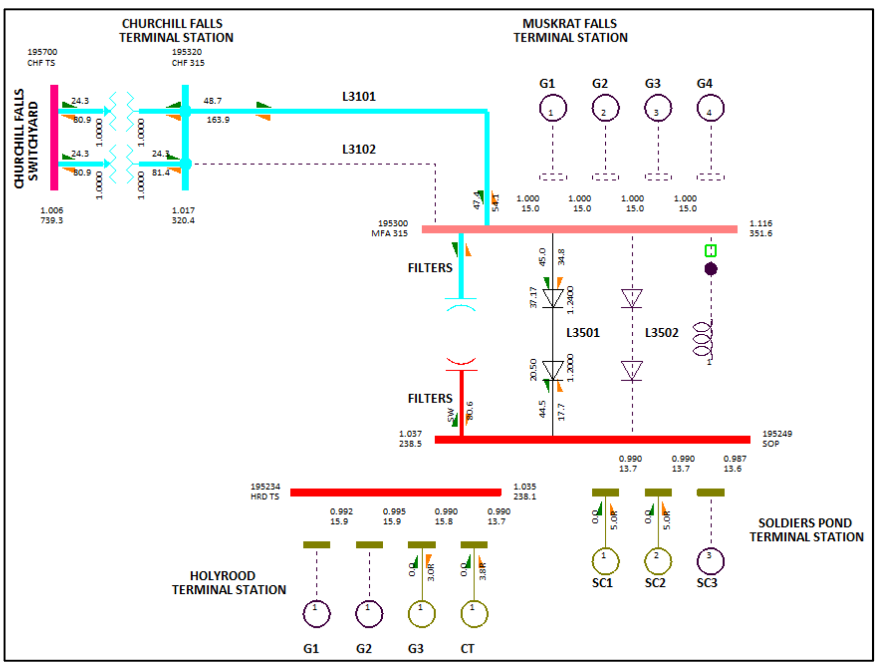

Figure 44: Study Case #5 – De-block Pole 1 (Steady State)

Following de-blocking of Pole 1 and prior to de-blocking Pole 2 (L3502), a second filter must be switched online at both MFA and SOP. The voltage rise at the MFA 315 kV bus following switching of a second 72 MVAR filter bank is on the order of 10.7% (resultant 315 kV bus voltage of 1.223 pu) as shown in Figure 45.

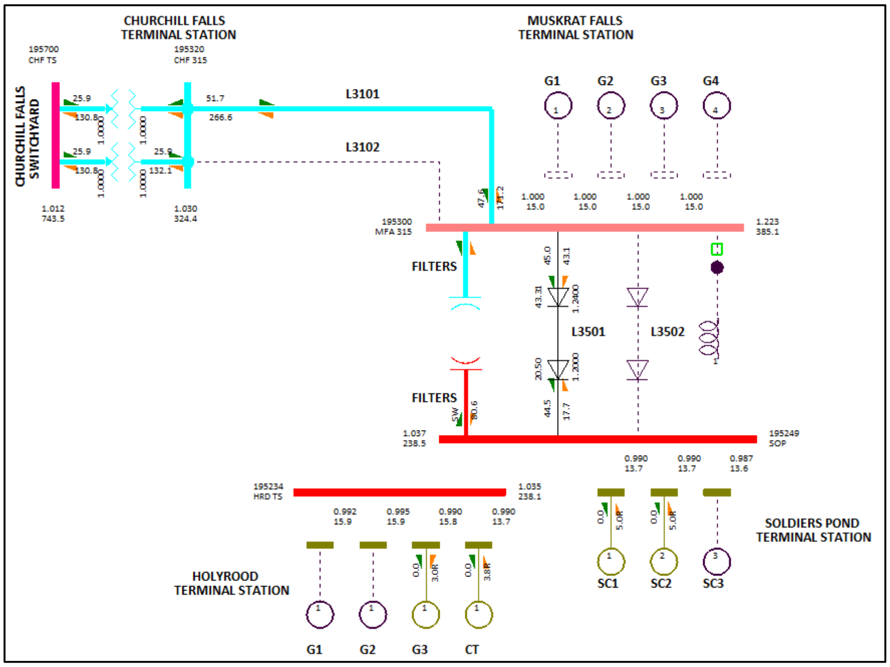

Figure 45: Study Case #5 – MFA Second 72 MVAR Harmonic Filter Switching (t=0+ sec)

Following switching, the steady state voltage at MFA 315 kV bus increases to 1.216 pu (383.04 kV) as shown in Figure 46. It should be noted that this voltage is above the 362 kV rating of the 315 kV GIS equipment installed at CHF and MFA and exceeds the transmission planning voltage criteria.

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TECHNICAL NOTE

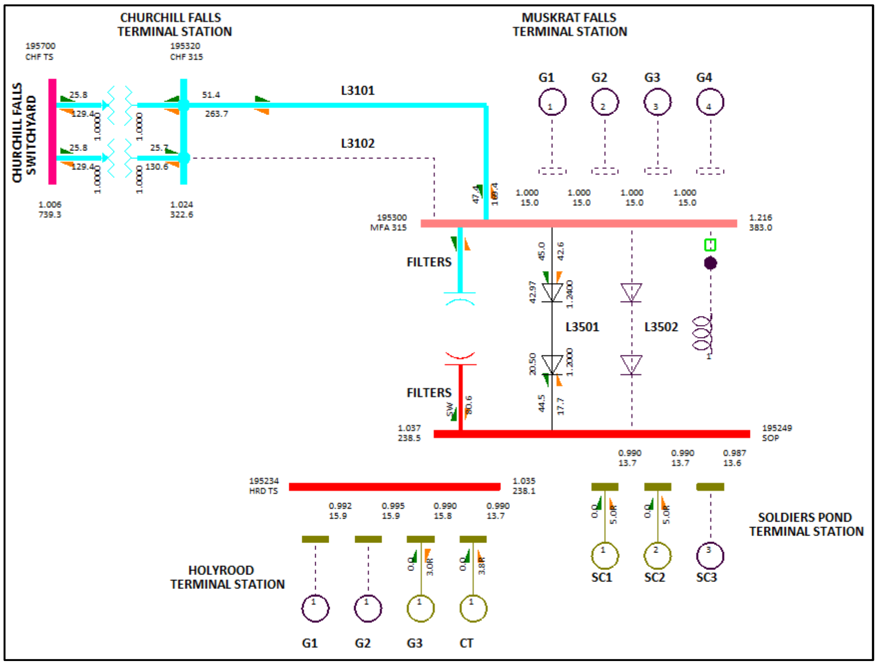

Figure 46: Study Case #5 – Second MFA 72 MVAR Harmonic Filter Online (Steady State)

Following the switching of a second 75 MVAR harmonic filter at SOP, Pole 2 (L3502) can be de-blocked at a minimum of 45 MW as shown in Figure 47. During switching of the pole, the 315 kV voltage at MFA is reduced to 1.175 pu (370.13 kV); however a few moments later the bus voltage settles out at a steady state voltage of 1.168 pu (367.92 kV) as shown in Figure 48.

The results of the Study Case #5 (one 315 kV line in service, reduced dc voltage and no units online at MFA) demonstrates that the resultant transmission system voltages exceed the acceptable voltage criteria. Consequently, operation in this mode is not appropriate.

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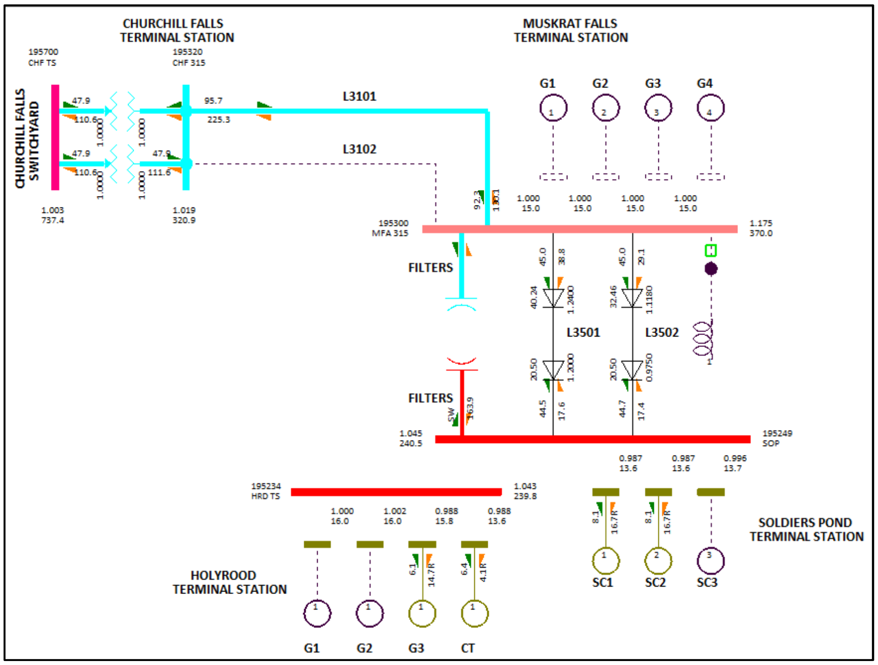

Figure 47: Study Case #5 – De-block Pole 2 (t=0+ sec)

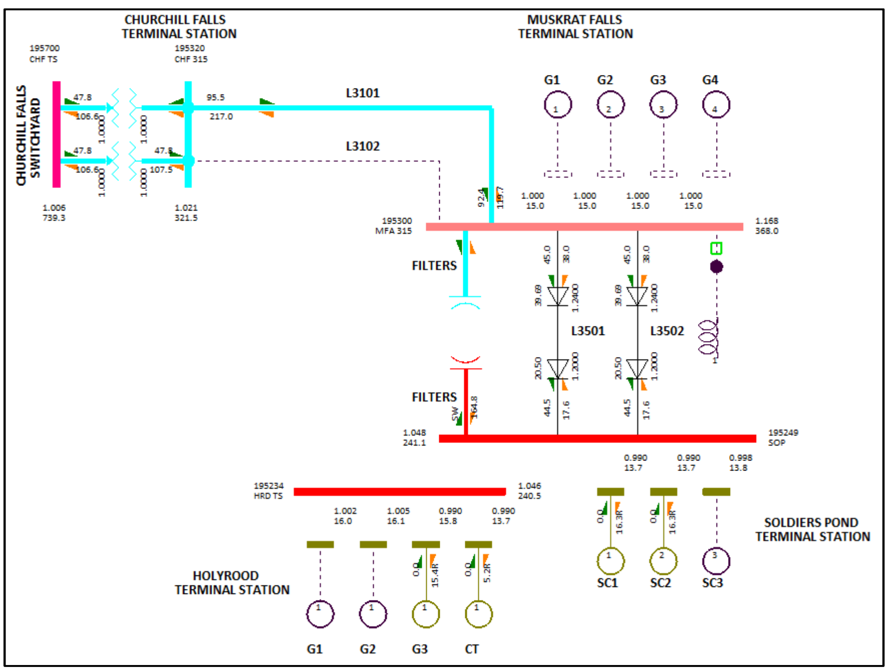

Figure 48: Study Case #5 – De-block Pole 2 (Steady State)

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CONCLUSIONS AND RECOMMENDATIONS

The results of this study indicate that in order to maintain acceptable bus voltages at the MFA 315 kV bus during operation of the LIL without the voltage control capabilities of the synchronous generators at Muskrat Falls Generating Station, a 140 MVAR, 315 kV shunt reactor must be installed at MFA to absorb excess reactive power during 315 kV system energization and LIL filter switching for de-block of each HVdc pole. To maintain acceptable transmission system voltages at MFA, particularly during low power orders on the LIL, the Labrador Interconnected Transmission System should be configured as shown in Study Case #3 - one 315 kV transmission line in service and a single 140 MVAR, 315 kV shunt reactor in service. To avoid unnecessary voltage dips on the transmission system, the size of the shunt reactor requires that it be energized at the same time as the 315 kV transmission line. That is, the 315 kV circuit breaker connecting the shunt reactor to the 315 kV bus at MFA must be closed along with the 315 kV line breakers prior to the energization of the 315 kV transmission line (i.e. L3101) from Churchill Falls.

Analysis of Study Case #4 – two 315 kV transmission lines in service and a single 140 MVAR, 315 kV shunt reactor in service indicates a number of points during the energization sequence in which the 315 kV bus voltage exceeds the normal transmission planning voltage criteria of 1.05 pu, but below the contingency voltage criteria of 1.10 pu. Consequently, operation of with the second 315 kV line in service at LIL power orders above 136 MW will provide for an increased level of reliability.

The results for all five study cases are summarized in Table 2.

Table 2: Labrador Interconnected System Configurations – Study Results

Study Case	Base Case	L3101	L3102	HVdc Voltage (pu)	Reactor	Study Results	LIL Max Power (MW)	
							MFA	SOP
1	1080	**ONLINE**	OFFLINE	1	OFFLINE	Unacceptable Voltages	N/A	N/A
2	1080	**ONLINE**	**ONLINE**	1	OFFLINE	Unacceptable Voltages	N/A	N/A
3	1080	**ONLINE**	OFFLINE	1	**ONLINE**	**Acceptable**	**218**	**214**
4	1080	**ONLINE**	**ONLINE**	1	**ONLINE**	Unacceptable Voltages	**486**	**468**
5	1080	**ONLINE**	OFFLINE	0.8	OFFLINE	Unacceptable Voltages	N/A	N/A

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Additional steady state power system analysis was completed on Study Cases 3 and 4, which include the installation of a 315 kV, 140 MVAR shunt reactor at MFA to control bus voltages during energization and de-blocking of the HVdc scheme. Case 3 assumes a single 315 kV transmission circuit connection between CHF and MFA while Case 4 assumes both 315 kV transmission circuits are in service.

It was determined that due to reactive power limitations at MFA for operation of the LIL prior to completion of unit 1 at MFA, a maximum power order of 218 MW and 486 MW could be transferred over the LIL for case 3 and 4 respectively. Therefore, with the 140 MVAR shunt reactor in service, a total of 214 MW can be delivered to SOP with one 315 kV circuit in service and 468 MW can be delivered to SOP with two 315 kV circuits in service. Study Case #3 becomes the governing case in this study as a loss of a single 315 kV transmission line would require the reduction of LIL transfers to 214 MW at SOP.

Detailed resultant bus voltages for all five study cases can be seen in Table 4.

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Table 3: Power System Study Results – Bus Voltages (Steady State and Transient)

Study Case	Base Case	HVdc Mode	System Conditions									Bus Voltages							
			T1	T2	L3101	L3102	FILTERS (MVAR)		POLE 1 (MW)	POLE 2 (MW)	MFA REACTOR	CHF 735		CHF 315		MFA 315		SOP 230 kV	
							MFA	SOP				pu	kV	pu	kV	pu	kV	pu	kV
1	1080 One 315 kV Line In Service - No Reactor - Rated HVdc Voltage Operation	BLOCKED	ON	ON	ON	OFF	0	0	0	0	OFF	1.006	739.41	1.014	319.41	1.068	336.42	1.026	235.98
		BLOCKED SWITCH MFA FILTER	ON	ON	ON	OFF	72	0	0	0	OFF	1.011	743.09	1.025	322.88	1.165	366.98	1.026	235.98
		BLOCKED MFA FILTER ONLINE	ON	ON	ON	OFF	72	0	0	0	OFF	1.006	739.41	1.020	321.30	1.159	365.09	1.026	235.98
		BLOCKED SWITCH SOP FILTER	ON	ON	ON	OFF	72	75	0	0	OFF	1.006	739.41	1.020	321.30	1.159	365.09	1.051	241.73
		BLOCKED SOP FILTER ONLINE	ON	ON	ON	OFF	72	75	0	0	OFF	1.006	739.41	1.020	321.30	1.159	365.09	1.038	238.74
		DEBLOCK POLE 1 - 45 MW ($t=0^{+}$)	ON	ON	ON	OFF	72	75	45	0	OFF	1.004	737.94	1.016	320.04	1.124	354.06	1.034	237.82
		DEBLOCK POLE 1 - 45 MW	ON	ON	ON	OFF	72	75	45	0	OFF	1.006	739.41	1.019	320.99	1.141	359.42	1.037	238.51
		POLE 1 45 MW - SWITCH MFA FILTER	ON	ON	ON	OFF	144	75	45	0	OFF	1.011	743.09	1.031	324.77	1.244	391.86	1.037	238.51
		POLE 1 - 45 MW - MFA FILTER ONLINE	ON	ON	ON	OFF	144	75	45	0	OFF	1.006	739.41	1.025	322.88	1.237	389.66	1.037	238.51
		POLE 1 - 45 MW - SWITCH SOP FILTER	ON	ON	ON	OFF	144	150	45	0	OFF	1.006	739.41	1.026	323.19	1.240	390.60	1.063	244.49
		POLE 1 - 45 MW - SOP FILTER ONLINE	ON	ON	ON	OFF	144	150	45	0	OFF	1.006	739.41	1.026	323.19	1.238	389.97	1.050	241.50
		POLE 1 - 45 MW - DEBLOCK POLE 2 (t=0+)	ON	ON	ON	OFF	144	150	45	45	OFF	1.003	737.21	1.020	321.30	1.197	377.06	1.046	240.58
		POLE 1 - 45 MW - POLE 2 45 MW	ON	ON	ON	OFF	144	150	45	45	OFF	1.006	739.41	1.024	322.56	1.210	381.15	1.049	241.27
2	1080 Two 315 kV Line In Service - No Reactor - Rated HVdc Voltage Operation	BLOCKED	ON	ON	ON	ON	0	0	0	0	OFF	1.006	739.41	1.022	321.93	1.077	339.26	1.026	235.98
		BLOCKED SWITCH MFA FILTER	ON	ON	ON	ON	72	0	0	0	OFF	1.011	743.09	1.033	325.40	1.130	355.95	1.026	235.98
		BLOCKED MFA FILTER ONLINE	ON	ON	ON	ON	72	0	0	0	OFF	1.006	739.41	1.028	323.82	1.125	354.38	1.026	235.98
		BLOCKED SWITCH SOP FILTER	ON	ON	ON	ON	72	75	0	0	OFF	1.006	739.41	1.028	323.82	1.125	354.47	1.051	241.73
		BLOCKED SOP FILTER ONLINE	ON	ON	ON	ON	72	75	0	0	OFF	1.006	739.41	1.028	323.82	1.125	354.38	1.038	238.74
		DEBLOCK POLE 1 - 45 MW (t=0+)	ON	ON	ON	ON	72	75	45	0	OFF	1.004	737.94	1.024	322.56	1.107	348.71	1.034	237.82
		DEBLOCK POLE 1 - 45 MW	ON	ON	ON	ON	72	75	45	0	OFF	1.006	739.41	1.027	323.51	1.116	351.54	1.037	238.51
		POLE 1 45 MW - SWITCH MFA FILTER	ON	ON	ON	ON	144	75	45	0	OFF	1.011	743.09	1.039	327.29	1.170	368.55	1.037	238.51
		POLE 1 - 45 MW - MFA FILTER ONLINE	ON	ON	ON	ON	144	75	45	0	OFF	1.006	739.41	1.033	325.40	1.165	366.98	1.037	238.51
		POLE 1 - 45 MW - SWITCH SOP FILTER	ON	ON	ON	ON	144	150	45	0	OFF	1.006	739.41	1.034	325.71	1.168	367.92	1.063	244.49
		POLE 1 - 45 MW - SOP FILTER ONLINE	ON	ON	ON	ON	144	150	45	0	OFF	1.006	739.41	1.033	325.40	1.166	367.29	1.050	241.50
		POLE 1 - 45 MW - DEBLOCK POLE 2 (t=0+)	ON	ON	ON	ON	144	150	45	45	OFF	1.004	737.94	1.029	324.14	1.147	361.31	1.046	240.58
		POLE 1 - 45 MW - POLE 2 45 MW	ON	ON	ON	ON	144	150	45	45	OFF	1.006	739.41	1.032	325.08	1.155	363.83	1.049	241.27
3	1080 One 315 kV Line In Service - 140 MVAR/315kV Reactor - Rated HVdc Voltage Operation	SWITCH L3101 AND MFA REACTOR	ON	ON	ON	OFF	0	0	0	0	ON	1.006	739.41	1.004	316.26	0.926	291.69	1.026	235.98
		BLOCKED SWITCH MFA FILTER	ON	ON	ON	OFF	72	0	0	0	ON	1.010	742.35	1.013	319.10	0.998	314.37	1.026	235.98
		BLOCKED MFA FILTER ONLINE	ON	ON	ON	OFF	72	0	0	0	ON	1.006	739.41	1.009	317.84	0.994	313.11	1.026	235.98
		BLOCKED SWITCH SOP FILTER	ON	ON	ON	OFF	72	75	0	0	ON	1.006	739.41	1.009	317.84	0.994	313.11	1.051	241.73
		BLOCKED SOP FILTER ONLINE	ON	ON	ON	OFF	72	75	0	0	ON	1.006	739.41	1.009	317.84	0.994	313.11	1.038	238.74
		DEBLOCK POLE 1 - 45 MW (t=0+)	ON	ON	ON	OFF	72	75	45	0	ON	1.005	738.90	1.007	317.21	0.980	308.70	1.033	237.59
		DEBLOCK POLE 1 - 45 MW	ON	ON	ON	OFF	72	75	45	0	ON	1.006	739.41	1.008	317.52	0.978	308.07	1.037	238.51
		POLE 1 45 MW - SWITCH MFA FILTER	ON	ON	ON	OFF	144	75	45	0	ON	1.010	742.35	1.016	320.04	1.049	330.44	1.037	238.51
		POLE 1 - 45 MW - MFA FILTER ONLINE	ON	ON	ON	OFF	144	75	45	0	ON	1.006	739.41	1.013	319.10	1.055	332.33	1.037	238.51
		POLE 1 - 45 MW - SWITCH SOP FILTER	ON	ON	ON	OFF	144	150	45	0	ON	1.006	739.41	1.014	319.41	1.060	333.90	1.063	244.49
		POLE 1 - 45 MW - SOP FILTER ONLINE	ON	ON	ON	OFF	144	150	45	0	ON	1.006	739.41	1.013	319.10	1.057	332.96	1.050	241.50
		POLE 1 - 45 MW - DEBLOCK POLE 2 (t=0+)	ON	ON	ON	OFF	144	150	45	45	ON	1.004	737.94	1.010	318.15	1.035	326.03	1.045	240.35
		POLE 1 - 45 MW - POLE 2 45 MW	ON	ON	ON	OFF	144	150	45	45	ON	1.006	739.41	1.012	318.78	1.035	326.03	1.049	241.27
		POLE 1 - 109 MW / POLE 2 - 109 MW	ON	ON	ON	OFF	144	150	109	109	ON	1.006	739.41	1.005	316.58	0.953	300.20	1.043	239.89
4	1080 Two 315 kV Line In Service - 140 MVAR/315kV Reactor - Rated HVdc Voltage Operation	SWITCH L3101 AND MFA REACTOR	ON	ON	ON	ON	0	0	0	0	ON	1.006	739.41	1.011	318.47	0.995	313.43	1.026	235.98
		BLOCKED SWITCH MFA FILTER	ON	ON	ON	ON	72	0	0	0	ON	1.010	742.35	1.021	321.62	1.040	327.60	1.026	235.98
		BLOCKED MFA FILTER ONLINE	ON	ON	ON	ON	72	0	0	0	ON	1.006	739.41	1.016	320.04	1.036	326.34	1.026	235.98
		BLOCKED SWITCH SOP FILTER	ON	ON	ON	ON	72	75	0	0	ON	1.006	739.41	1.016	320.04	1.036	326.34	1.051	241.73
		BLOCKED SOP FILTER ONLINE	ON	ON	ON	ON	72	75	0	0	ON	1.006	739.41	1.016	320.04	1.036	326.34	1.038	238.74
		DEBLOCK POLE 1 - 45 MW (t=0+)	ON	ON	ON	ON	72	75	45	0	ON	1.005	738.68	1.014	319.41	1.024	322.56	1.034	237.82
		DEBLOCK POLE 1 - 45 MW	ON	ON	ON	ON	72	75	45	0	ON	1.006	739.41	1.015	319.73	1.027	323.51	1.037	238.51
		POLE 1 45 MW - SWITCH MFA FILTER	ON	ON	ON	ON	144	75	45	0	ON	1.010	742.35	1.025	322.88	1.072	337.68	1.037	238.51
		POLE 1 - 45 MW - MFA FILTER ONLINE	ON	ON	ON	ON	144	75	45	0	ON	1.006	739.41	1.021	321.62	1.070	337.05	1.037	238.51
		POLE 1 - 45 MW - SWITCH SOP FILTER	ON	ON	ON	ON	144	150	45	0	ON	1.006	739.41	1.022	321.93	1.073	338.00	1.063	244.49
		POLE 1 - 45 MW - SOP FILTER ONLINE	ON	ON	ON	ON	144	150	45	0	ON	1.006	739.41	1.021	321.62	1.072	337.68	1.050	241.50
		POLE 1 - 45 MW - DEBLOCK POLE 2 (t=0+)	ON	ON	ON	ON	144	150	45	45	ON	1.004	737.94	1.018	320.67	1.059	333.59	1.046	240.58
		POLE 1 - 45 MW - POLE 2 45 MW	ON	ON	ON	ON	144	150	45	45	ON	1.006	739.41	1.020	321.30	1.062	334.53	1.049	241.27
		POLE 1 - 243 MW / POLE 2 - 243 MW	ON	ON	ON	OFF	216	225	243	243	ON	1.006	739.41	1.004	316.26	0.956	301.14	1.036	238.28
5	1080 One 315 kV Line In Service -80% HVdc Voltage Operation	BLOCKED	ON	ON	ON	OFF	0	0	0	0	OFF	1.006	739.41	1.014	319.41	1.068	336.42	1.026	235.98
		BLOCKED SWITCH MFA FILTER	ON	ON	ON	OFF	72	0	0	0	OFF	1.011	743.09	1.025	322.88	1.165	366.98	1.026	235.98
		BLOCKED MFA FILTER ONLINE	ON	ON	ON	OFF	72	0	0	0	OFF	1.006	739.41	1.020	321.30	1.159	365.09	1.026	235.98
		BLOCKED SWITCH SOP FILTER	ON	ON	ON	OFF	72	75	0	0	OFF	1.006	739.41	1.020	321.30	1.159	365.09	1.051	241.73
		BLOCKED SOP FILTER ONLINE	ON	ON	ON	OFF	72	75	0	0	OFF	1.006	739.41	1.020	321.30	1.159	365.09	1.038	238.74
		DEBLOCK POLE 1 - 45 MW (t=0+)	ON	ON	ON	OFF	72	75	45	0	OFF	1.004	737.94	1.016	320.04	1.124	354.06	1.034	237.82
		DEBLOCK POLE 1 - 45 MW	ON	ON	ON	OFF	72	75	45	0	OFF	1.006	739.41	1.027	323.51	1.116	351.54	1.037	238.51
		POLE 1 45 MW - SWITCH MFA FILTER	ON	ON	ON	OFF	144	75	45	0	OFF	1.012	743.82	1.030	324.45	1.223	385.25	1.037	238.51
		POLE 1 - 45 MW - MFA FILTER ONLINE	ON	ON	ON	OFF	144	75	45	0	OFF	1.006	739.41	1.024	322.56	1.216	383.04	1.037	238.51
		POLE 1 - 45 MW - SWITCH SOP FILTER	ON	ON	ON	OFF	144	150	45	0	OFF	1.006	739.41	1.024	322.56	1.218	383.67	1.063	244.49
		POLE 1 - 45 MW - SOP FILTER ONLINE	ON	ON	ON	OFF	144	150	45	0	OFF	1.006	739.41	1.024	322.56	1.217	383.45	1.050	241.50
		POLE 1 - 45 MW - DEBLOCK POLE 2 (t=0+)	ON	ON	ON	OFF	144	150	45	45	OFF	1.003	737.21	1.019	320.99	1.175	370.13	1.045	240.35
		POLE 1 - 45 MW - POLE 2 45 MW	ON	ON	ON	OFF	144	150	45	45	OFF	1.006	739.41	1.021	321.62	1.168	367.92	1.048	241.04

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TECHNICAL NOTE

It is recommended that:

- a 140 MVAR shunt reactor be installed on the 315 kV bus at the Muskrat Falls Terminal Station #2 (MFATS2) to eliminate over-voltages on the power system during low power operation of the LIL prior to the powerhouse being completed;
- the maximum power order scheduled over the LIL be no more than 218 MW (MFA) without voltage control capabilities available from the synchronous generators at Muskrat Falls Generating Station;
- a review of the rating 315 kV power cables connecting the indoor GIS equipment to the outdoor equipment be conducted; and
- Alstom Grid review the filter component ratings in light of the requirement to operate under low short circuit conditions with one 315 kV transmission line in service between Churchill Falls and Muskrat Falls with no generators on line at Muskrat Falls.

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TECHNICAL NOTE

APPENDIX A

Budgetary Quotation

Date: February 26th, 2016
Project: Nalcor - Muskrat Falls 140 MVAr SR Budget Quote

IMPORTANT NOTICE

This ABB budgetary offer is preliminary and not final and as such non-binding. It is tendered for discussion only, does not constitute a term to contract and ABB can, without notice, make any change in ABB own discretion.

Transformers Details:

1. Quantity	1 Shunt Reactor
2. Power Rating	140 MVAr
3. Voltage Rating	**HV:** 315 kV
4. Frequency; Phase; Temperature	60 Hz; 3 phase; 55°C/65°C
5. Cooling Stages	ONAN
6. Oil	Petro Canada Luminol Oil class A, Type I & II.
7. Payment Terms	10% of unit price upon PO reception. 10% of unit price upon submittal of outline drawings for approval. 20% of unit price upon receipt of copper. 30% of unit price upon final assembly at factory before factory testing. 30% of unit price upon delivery EXW.
8. Shipment	November 2017 (or earlier depending on Nalcor needs).
9. Delivery Terms	DDP to site (Incoterms 2010).
10. Manufacturing Facility:	ABB Varennes, Qc
11. Budgetary unitary Price	CAD 2,763,000.00 **per unit** without assembly and installation, sales taxes excluded. Oil price included. NOTE: this price is assuming that the issue with the rail portion in Pointe-Noire Terminal (CN), Sept-Iles, QC is already solved. If not we will need to add around $300k CAD to the price.

Additional notes:

1. Nevertheless the quoted delivery time is given in good faith, based on present indications of workshop loading and must be confirmed when placing the order. Moreover it does include routine and type tests operations only. Should you confirm the request of any special tests (specially the long-duration tests) we propose to discuss the repercussion of this on the above delivery time accordingly. Also the delivery time is subject to receive all technical documentation with the purchase order and acceptance of our proposed designs with no major changes at the time of the design review. Specification or data changes may result in changes to quoted prices and/or delivery date.

2. ABB will provide a service engineer (Technical Assistance) for warranty validation for a maximum of six (6) consecutive days per transformer, including transportation, at no additional charge.

3. Any possible change (both technical and commercial, respect to what we offered) has to be agreed upon with us.

4. Routine and type tests according to CSA Standards, included in the price.

5. Price for erection, commissioning, start-up will be submitted in case of interest.

6. Price for spare parts will be submitted in case of interest.

7. Warranty validity is subject to the execution of transformer assembling and site testing/commissioning at least under supervision of a Vendor specialist or of personnel approved in writing by the Vendor.

8. Notwithstanding anything to the contrary, the Vendor is not liable for any loss of profit or revenue, loss of production, loss of contract, or of field stock or of any indirect, and consequential losses of any nature whatsoever. In any case the maximum liability of the Vendor is limited to 100% of the contract value.

9. In relation to liquidated damages, Vendor reckons that a reasonable agreement on this issue would deem the liability for delay to be 0,5% per week for the EXW delivery of the delayed transformer whereas the total limit should be fixed at 5% maximum of the unit price of the delayed transformer.
The total liability concerning any kind of liquidated damages (delay or non-performance) should be fixed at 10% maximum of the contract value.
Regarding the liquidated damages, the application of this penalty in case of delay or non-performance, constitutes the sole remedy of the Buyer and replaces any other possible indemnification of damages and damages claimed by this cause.

Thank you for considering ABB for your power transformer requirements. If there are any questions please contact me.

Gabriel Andrade
+1 450 652 2901 x: 1416
Alliance Manager – Power Transformers
Canada
gabriel.andrade@ca.abb.com

RAPPORT D'ESSAI

Inductance shunt triphasée

140 MVAr

315kV

Client:

Hydro-Québec

Poste de l'Outaouais

Référence:

Client: 4510181832

ABB: 15079-01

Préparé par	Kevin Ndereyimana Jérôme Ndayizamba	Kevin .N	2015-12-10	**Service des essais**
Vérifié par	Naoual Rar	Naoual Rar	2015-12-10	**Conception électrique**
Approuvé par	Abderrahmane Zouaghi, ing	Zouaghi ing.	2015-12-10	**Conception électrique.**

PRÉSENTATION

ESSAI INDIVIDUEL
Les résultats ainsi que tous les paramètres des essais sont donnés à l'annexe 2. Messieurs Grégoire Gagné et/ou Richard Vigneault, représentants du client, ont témoigné des essais.
Fin des essais: 2015-10-27

TABLE DES MATIÈRES

1.0 DONNÉES TECHNIQUES

Bornes	Tension (kV)	Puissance (MVAr)	Ampérage (A)	Couplage
H1, H2, H3	315	140	256.6	Yn
H0	-	-	256.6	-

Nombre de phase(s) : 3

Traversées	Type	No de série
H1, H2, H3	GOE-1175, ABB Components	1ZSCT14004728/01, 1ZSCT14004728/02, 1ZSCT14004728/03
H0	E81H, Electrocomposites	5780-5392-1505001

Refroidissement : ONAN

Équipement de refroidissement (ONAN)		
Nombre	**Type**	**Caractéristiques**
17	Radiateur	Menk, 32 sections, hauteur 2000

2.0 RÉSISTANCE

Température d'enroulement : 75°C

Bornes	Résistance (Ω)
H1-H0	0.800133
H2-H0	0.799537
H3-H0	0.798225

3.0 LINÉARITÉ

H1

p.u.	Impédance (Ohms)	Erreur (%)
1.00	710.8	0.00
1.05	710.1	-0.10
1.20	707.2	-0.52
1.50	697.8	-1.83

H2

p.u.	Impédance (Ohms)	Erreur (%)
1.00	711.4	0.00
1.05	710.4	-0.14
1.20	706.7	-0.65
1.50	696.5	-2.10

H3

p.u.	Impédance (Ohms)	Erreur (%)
1.00	711.1	0.00
1.05	710.2	-0.13
1.20	706.7	-0.62
1.50	696.2	-2.09

4.0 PERTES ET IMPEDANCES

SOMMAIRE:

	Pertes totales (kW) à 75°C		Impédance Moyenne (ohms)	
Bornes	**Mesurée** (à 315 kV)	**Garantie** (à 315 kV)	**Mesurée** (à 315 kV)	**Garantie** (à 315 kV)
H1, 2, 3 - H0	242.73	265	712.6	708.75

Mesure #1: à **100%** Vn Avant échauffement

Phase	Tension (kV)	Pertes (kW)	Pertes à la tension nominale (kW)	Température moyenne des enroulements (°C)
1	314.54	77.90	78.13	20.90
2	315.54	67.50	67.27	20.90
3	314.34	78.50	78.83	20.90
Total			224.23	

Mesure #2: à **100%** Vn, Après échauffement

Phase	Tension (kV)	Pertes (kW)	Pertes à la tension nominale (kW)	Température moyenne des enroulements (°C)
1	315.49	83.70	83.44	73.60
2	317.83	74.60	73.28	73.60
3	316.22	86.20	85.54	73.60
Total			242.25	

Coefficient (kW/°C) = (Pertes totaux à chaud – Pertes totaux à froid) / (Moyenne Temp. chaud – Moyenne Temps à froid)

Coefficient (kW/°C) à 100% Vn = 0.3421

Pertes corrigées à 75°C = Pertes totaux à chaud + (75 – Moyenne temp. chaud) x coefficient

Pertes corrigées à 75°C = 242.73 kW

Mesure #3: à **105%** Vn Avant échauffement

Phase	Tension (kV)	Pertes (kW)	Pertes à la tension nominale (kW)	Température moyenne des enroulements (°C)
1	330.60	88.20	88.28	20.90
2	332.36	74.40	73.68	20.90
3	330.11	87.20	87.54	20.90
Total			249.5	

Mesure #4: à **105%** Vn, Après échauffement

Phase	Tension (kV)	Pertes (kW)	Pertes à la tension nominale (kW)	Température moyenne des enroulements (°C)
1	330.06	89.10	89.5	73.60
2	332.60	79.60	78.7	73.60
3	331.09	94.00	93.8	73.60
Total			262.0	

Coefficient (kW/°C) = (Pertes totaux à chaud – Pertes totaux à froid) / (Moyenne Temp. chaud – Moyenne Temp. à froid)

Coefficient (kW/°C) à 105% Vn =   0.2371

Pertes corrigées à 75°C = Pertes totaux à chaud + (75 – Moyenne temp. chaud) x coefficient

Pertes corrigées à 75°C =   262.33 kW

5.0 VÉRIFICATION DES ACCESSOIRES

- Les rapports de transformation et les connections des transformateurs de courant ont été vérifiés et correspondent à la plaque signalétique.

- Le fonctionnement du détecteur de gaz a été vérifié selon les spécifications du fournisseur.

- Les différentes fonctions des contrôles de l'armoire de commande ont été vérifiées et correspondent au schéma électrique.

- L'essai d'étanchéité a été effectué sur l'unité entière à 5 livres au pouce carré pendant 24 heures à une température minimale de 20°C. Aucune fuite n'est apparue.

- Tous les appareils auxiliaires ont été vérifiés et opèrent adéquatement. La filerie des accessoires a subi un essai de tension appliquée à 60 Hz, pendant 60 secondes, comme suit:
  Filerie des accessoires : 1.5 kV
  Transformateurs de courant : 2.5 kV

6.0 ÉCHAUFFEMENT

Échauffement au-dessus de l'ambiant à 105% Vn (°C) ***Refroidissement ONAN***										
Huile			**Bobines**				**Point Chauds**			
Haut	**Moyenne**	**Garantie**	**H1**	**H2**	**H3**	**Garantie**	**H1**	**H2**	**H3**	**Garantie**
49.1	38.5	55	49.3	49.8	49.4	55	62.6	63.3	62.8	65

Le facteur du point chaud utilisé est égal à 1.25.

7.0 IMPULSIONS (POLARITÉ NÉGATIVE)

SPÉCIFICATION		BORNE H1 1.29 / 49 µs		BORNE H2 1.27 / 50 µs		BORNE H3 1.32 / 51 µs	
TYPE D'ONDE	TENSION (kV)	FILM NO.	ESSAI (kV)	FILM NO.	ESSAI (kV)	FILM NO.	TEST (kV)
OPR	662	31	666	41	665	51	671
OP	1050	33	1059	43	1068	53	1060
OC	1155	36	1167	46	1169	56	1172
OC	1155	37	1168	47	1167	57	1165
OP	1050	38	1063	48	1060	58	1063
OP	1050	39	1070	49	1060	59	1061

SPÉCIFICATION		BORNE H0 3.60 / 49 µs	
TYPE D'ONDE	TENSION (kV)	FILM NO.	ESSAI (kV)
OPR	158	73	158
OP	250	75	250
OP	250	76	250
OP	250	77	250

8.0 SURTENSION DE MANŒUVRE (POLARITÉ POSITIVE)

SPÉCIFICATION		BORNE H1 193 / 217 / 1029 µs		BORNE H2 192 / 215 / 1028 µs		BORNE H3 193 / 218 / 1029 µs	
ESSAI	TENSION (kV)	FILM NO.	ESSAI (kV)	FILM NO.	ESSAI (kV)	FILM NO.	TEST (kV)
OPR	529	09	527	17	528	23	528
OP	850	13	856	19	856	25	853
OP	850	14	855	20	855	26	855
OP	850	15	854	21	854	27	852

9.0 TENSION APPLIQUÉ ET INDUITE

TENSION APPLIQUÉE			
BORNES		TENSION	DURÉE
APPLIQUÉES	MISES À LA TERRE	(KV)	(SEC.)
H1, H2, H3, H0	Cuve	95	60

TENSION INDUITE TRIPHASÉE (180 HZ)		
TENSION (KV PHASE- TERRE)	FACTEUR DE SURTENSION	DURÉE
H1	(%)	(--)
181.8	100	-
272.3*	157	60 minutes
181.8	100	-

*La tension a été limitée à cause de la capacité des équipements du laboratoire.

Décharges partielles < 500 pC durant une heure. L'augmentation du niveau des décharges partielles n'a pas dépassé 100 pC durant une heure. Il n'y a pas eu d'augmentation soutenue du niveau de décharges partielles durant les dernières 20 minutes de l'essai.

10.0 BRUIT AUDIBLE À CHAUD

Tension (phase- terre) (kV)	Tension nominale (%)	Refroidissement	Température de l'huile (°C)			Moyenne de bruit en puissance acoustique*	
			Haut	Bas	Moyenne	Mesurée dB(A)	Garantie dB (A)
191	105	ONAN	65.7	50.1	57.9	85.1	91.0

*Mesure en mode intensité acoustique.

11.0 Analyse Des Gaz Dissous

DATE, HEURE, LIEU DE PRÉLÈVEM.	HYDROGÈNE (PPM)	OXYGÈNE (PPM)	AZOTE (PPM)	MONOXYDE DE CARBONE (PPM)	MÉTHANE (PPM)	BIOXYDE DE CARBONE (PPM)	ÉTHYLÈNE (PPM)	ÉTHANE (PPM)	ACÉTYLÈNE (PPM)	% DE GAZ
	H2	O2	N2	CO	CH4	CO2	C2H4	C2H6	C2H2	
14/10/2015, Avant les essais, haut cuve	< 3	2050	4200	< 5	0.2	19	< 0.1	< 0.1	< 0.1	0.63
18/10/2015, Avant l'échauff, Bas cuve	< 3	2110	4330	< 5	0.1	29	< 0.1	< 0.1	< 0.1	0.65
18/10/2015, Avant l'échauff, Haut cuve	< 3	2700	5540	< 5	0.2	22	< 0.1	< 0.1	< 0.1	0.83
19/10/2015, Après l'échauff, Bas cuve	< 3	2440	5000	< 5	0.2	57	< 0.1	< 0.1	< 0.1	0.75
19/10/2015, Après l'échauff, Haut cuve	< 3	2580	5290	< 5	0.1	60	< 0.1	< 0.1	< 0.1	0.79
19/10/2015, Après l'échauff 3heures après, Haut cuve	< 3	3140	6440	< 5	0.4	61	< 0.1	< 0.1	< 0.1	0.96
19/10/2015, Après l'échauff 3heures après, Bas cuve	< 3	2780	5700	< 5	0.5	55	< 0.1	< 0.1	< 0.1	0.85
21/10/2015 Avant impulses, Bas cuve	< 3	3400	6970	< 5	0.3	64	< 0.1	< 0.1	< 0.1	1.04
27/10/2015, Après tous les essais, Bas cuve	< 3	2930	6010	< 5	0.3	62	< 0.1	< 0.1	< 0.1	0.90

ANNEXE 1 - PLAQUE SIGNALETIQUE ET ENCOMBREMENT CIVIL

6 — 228 — ∅5 (4X)

333 — 345 — 6 — 240

ABB

INDUCTANCE SHUNT TRIPHASÉE 60 Hz

No DE SÉRIE 15079–01

140 Mvar 315 000 V 256,6 A

À BAIN D'HUILE AVEC CIRCULATION NATURELLE CLASSE ONAN

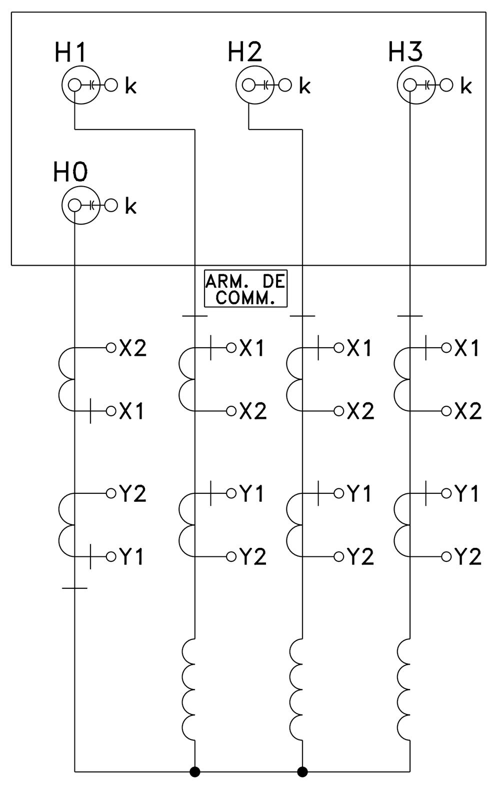
	DESCRIPTION DES TRAVERSÉES			
	TENSION NOMINALE	COURANT NOMINAL	TENUE AU CHOC DE FOUDRE	TYPE
H.T.	362 kV	2 500 A	1 175 kV	GOE
NEUTRE	46 kV	1 200 A	250 kV	250–012–T –081–02

	TENUE AU CHOC DE FOUDRE
	ENROULEMENT
H.T.	1 050 kV
NEUTRE	250 kV

TRANSFORMATEURS DE COURANT			
TRAVERSÉES	BORNES	RAPPORT:A	CLASSE
H1,H2,H3	X1 – X2	400:1	10VA 5P20
	Y1 – Y2		
H0	X1 – X2		
	Y1 – Y2		
k	PRISE CAPACITIVE		

NORME SN–14.1h (A1, A2, A3)
NO DE COMMANDE H.Q. 4510181832
NOTICE D'ENTRETIEN 15079
ÉCHAUFFEMENT 55°C
SCHÉMA XV15079004–B
LIQUIDE ISOLANT CAN/CSA–C50–97 CLASSE A, TYPE II
ANNÉE DE FABRICATION [redacted]
ENROULEMENT DE CUIVRE
TYPE D'ISOLATION DES CONDUCTEURS PAPIER THERMOSTABILISÉ

15079–01 EST LE No DE SÉRIE DE L'APPAREIL AYANT SUBI LES ESSAIS DE TYPE POUR LA COMMANDE 4510181832 D'HYDRO–QUÉBEC



PUISSANCE ACOUSTIQUE À 105% Vn [redacted] dB(A)
TENUE DE LA CUVE & DES RADIATEURS –101 kPa à +69 kPa
LE CONSERVATEUR TIENT LE VIDE
TENUE SISMIQUE SELON LA TET–APG–N–0001 = 0,45 g
ÉCHAUFFEMENT DE L'HUILE AU SOMMET DE LA CUVE
ΔT [redacted] °C À 140 Mvar
ÉCHAUFFEMENT DU POINT CHAUD À 140 Mvar ΔT [redacted] °C
PERTES TOTALES À 75°C À 140 Mvar [redacted] kW

MASSES ±2%
NOYAU ET ENROULEMENTS [redacted] kg
CUVE ET ACCESSOIRES [redacted] kg
LIQUIDE ISOLANT [redacted] kg
TOTAL [redacted] kg
QUANTITÉ DE LIQUIDE ISOLANT ±2% À 15°C [redacted] L
VOLUME D'HUILE TOTAL DU CONSERVATEUR PRINCIPAL 6 155 L

FABRIQUÉ À VARENNES, QUÉBEC

NO	NOTES
1	PLAQUE EN ACIER INOXDABLE SÉRIE 300, T=0,037"
2	LETTRAGE ACIER SUR FOND NOIR AVEC PROCÉDÉ "ETCHING"
3	LES DONNÉES MANQUANTES SERONT GRAVÉES AVANT L'EXPÉDITION
4	LES ESPACES À GRAVER DOIVENT AVOIR UN CONTOUR ACIER ET LE FOND NOIR

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
A	2014/11/05	TRAVERSÉE NEUTRE ÉTAIT E81H		RB/AZ	

NO	RÉFÉRENCES	NO

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
HYDRO–QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ______________________ DATE : ____-__-__

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

Cette vérification ne constitue d'aucune façon une vérification détaillée et complète de la conception

Recommandation
☐ Aucun commentaire
☐ Accepté tel que noté (doit être validé par un ingénieur si ça modifie le concept)
☐ Corriger et resoumettre avant les travaux
☐ Refusé

Signature ☐ Ingénieur ☐ Autre Date
Nom No de membre de l'OIQ

La vérification est restreinte à celle indiquée et ne garantit pas que les données du document revu sont exactes ou exhaustives. Elle ne dégage nullement la personne ou la firme qui l'a préparé de ses obligations de quelque nature que ce soit.

ABB Inc.
1600 Boul. Lionel Boulet
Varennes, Québec
J3X 1S4

DESSINÉ	R BRUNELLE	DATE	2014/03/11
VÉRIFIÉ	A BOUAICHA	DATE	2014/03/12
APPROUVÉ	A BOUAICHA	DATE	

POSTE DE L'OUTAOUAIS

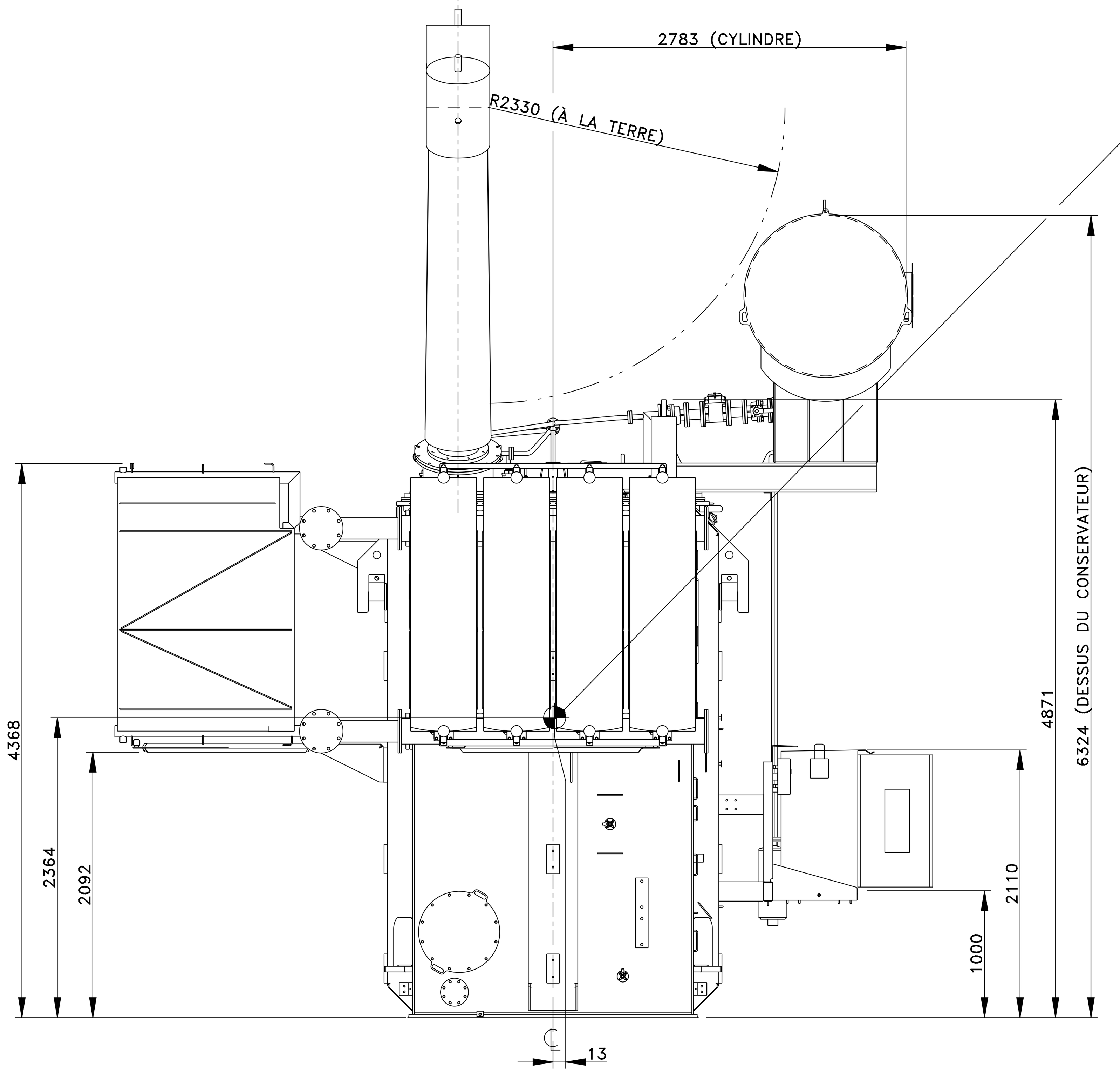
PLAQUE SIGNALÉTIQUE
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079–01
POSITION XL73

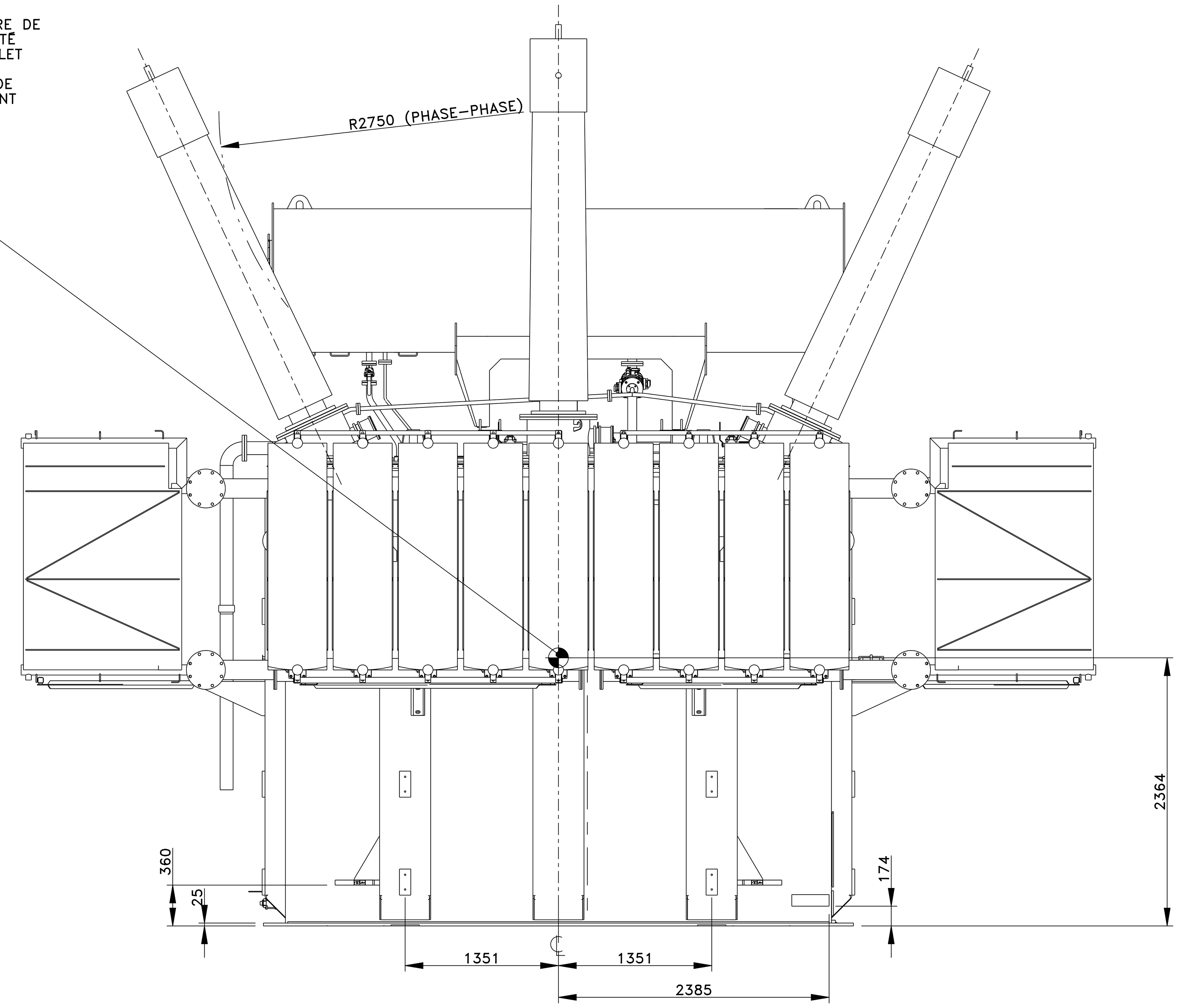
RAPPORT 1:1
DIMENSIONS EN mm

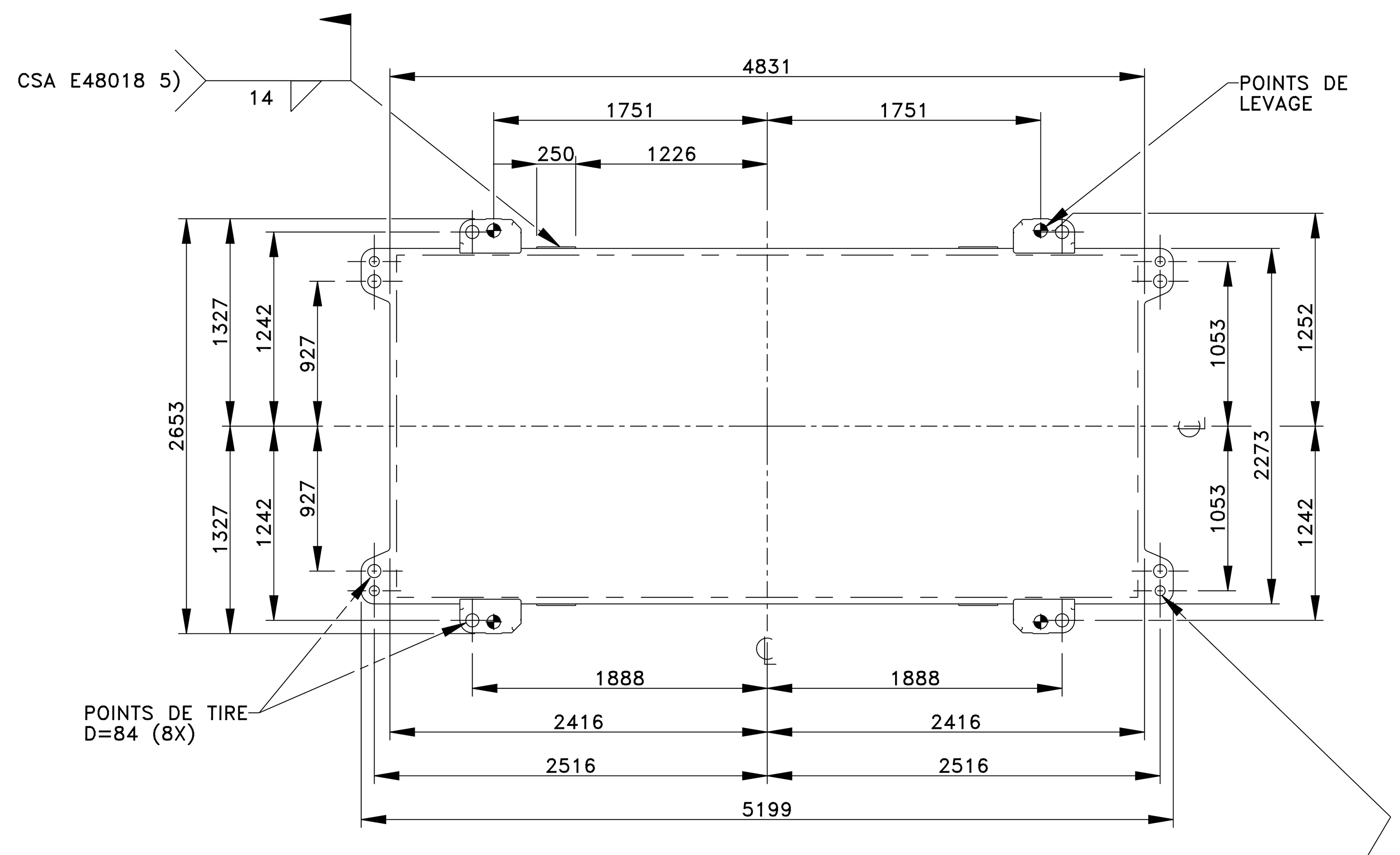
INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOR.
6403	40140	A000060	XV15079004–B	01	A	1

FEUILLE SUIVANTE —

M. DRAPEAU
(2009–03)

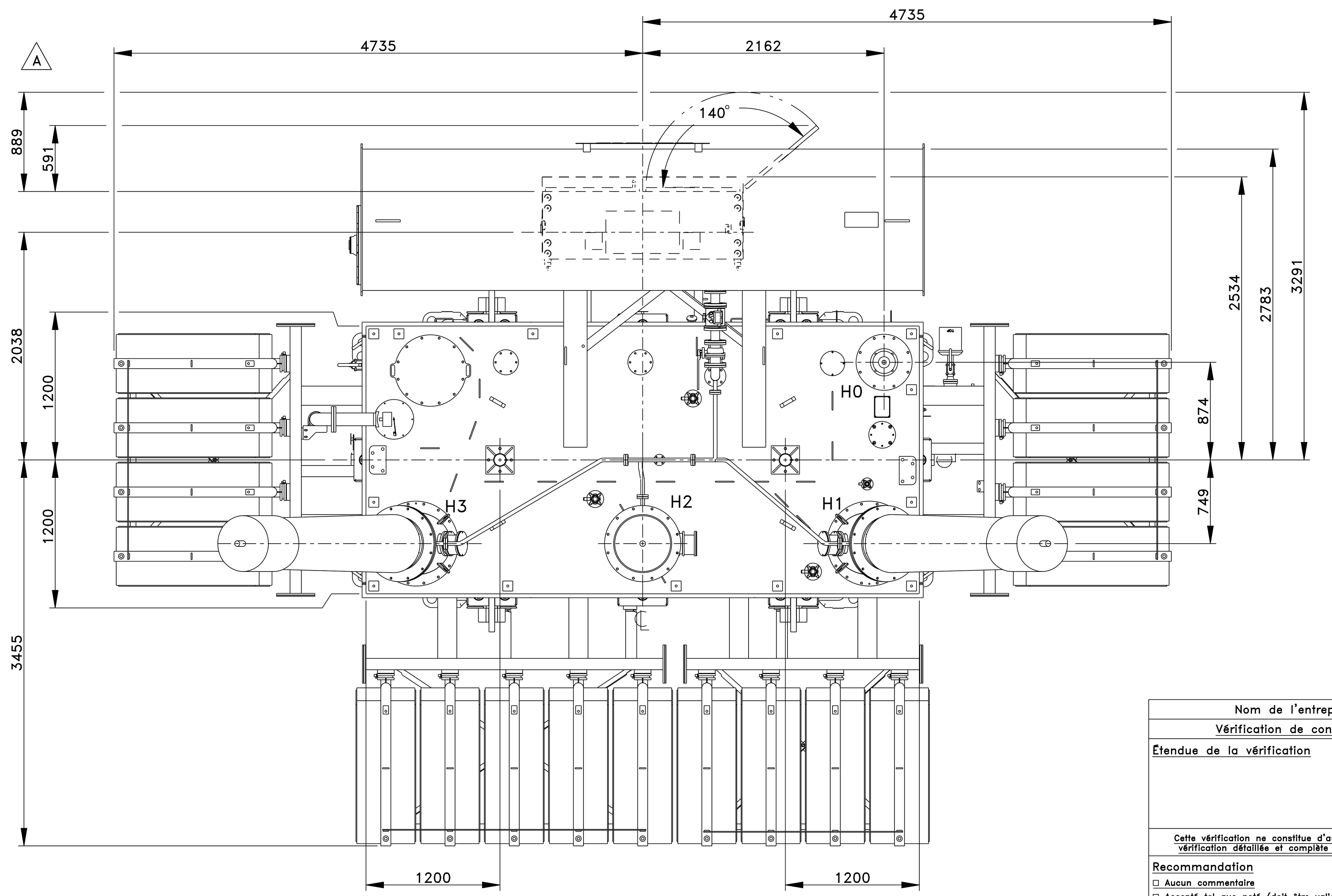






DIMENSIONS DU FOND

4 TROUS DE ∅64 POUR ANCRAGE AVEC TIGES FILETÉES M56 (ACIER CAN/CSA G40.21–M350W)



MASSES (±2%)		QUANTITÉ DE LIQUIDE ISOLANT À 15°C (±2%)	
NOYAU ET ENROULEMENTS	60458 kg	CUVE	32616 L
CUVE ET ACCESSOIRES	37631 kg	RADIATEURS	3417 L
LIQUIDE ISOLANT*	33949 kg	CONSERVATEUR(S) (50%)	3078 L
* DENSITÉ DU LIQUIDE ISOLANT 868 kg/m3 À 15°C			
TOTAL	132038 kg	TOTAL	39111 L

FINAL

NO	NOTES

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
B	2015/11/04	STATUT ÉTAIT PRÉLIMINAIRE, MASSES MODIFIÉES		DSH/PGR	
A	2014/08/28	CONSERVATEUR, DIM. 2534 RELOCALISÉS. VUES À JOUR. TEXTE POINTS DE LEVAGE MODIFIÉ. DIM. 889, 591 AJOUTÉES.		DSH/PGR	

NO	RÉFÉRENCES	NO

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
HYDRO–QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ______________________ DATE : ____-__-__

SCEAUX

INGÉNIEUR Patrice Lamothe 116337 QUÉBEC
2015-11-06

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

Cette vérification ne constitue d'aucune façon une vérification détaillée et complète de la conception

Recommandation
☐ Aucun commentaire
☐ Accepté tel que noté (doit être validé par un ingénieur si ça modifie le concept)
☐ Corriger et resoumettre avant les travaux
☐ Refusé

Signature ☐ Ingénieur ☐ Autre Date
Nom No de membre de l'OIQ

La vérification est restreinte à celle indiquée et ne garantit pas que les données du document reçu sont exactes ou exhaustives. Elle ne dégage nullement la personne ou la firme qui l'a préparé de ses obligations de quelque nature que ce soit.

ABB Inc.
1600 Boul. Lionel Boulet
Varennes, Québec
J3X 1S4

DESSINÉ	D. ST–HILAIRE	DATE	2014/05/12
VÉRIFIÉ	P. GAUTHIER	DATE	2014/05/12
APPROUVÉ	P. LAMOTHE	DATE	

POSTE DE L'OUTAOUAIS

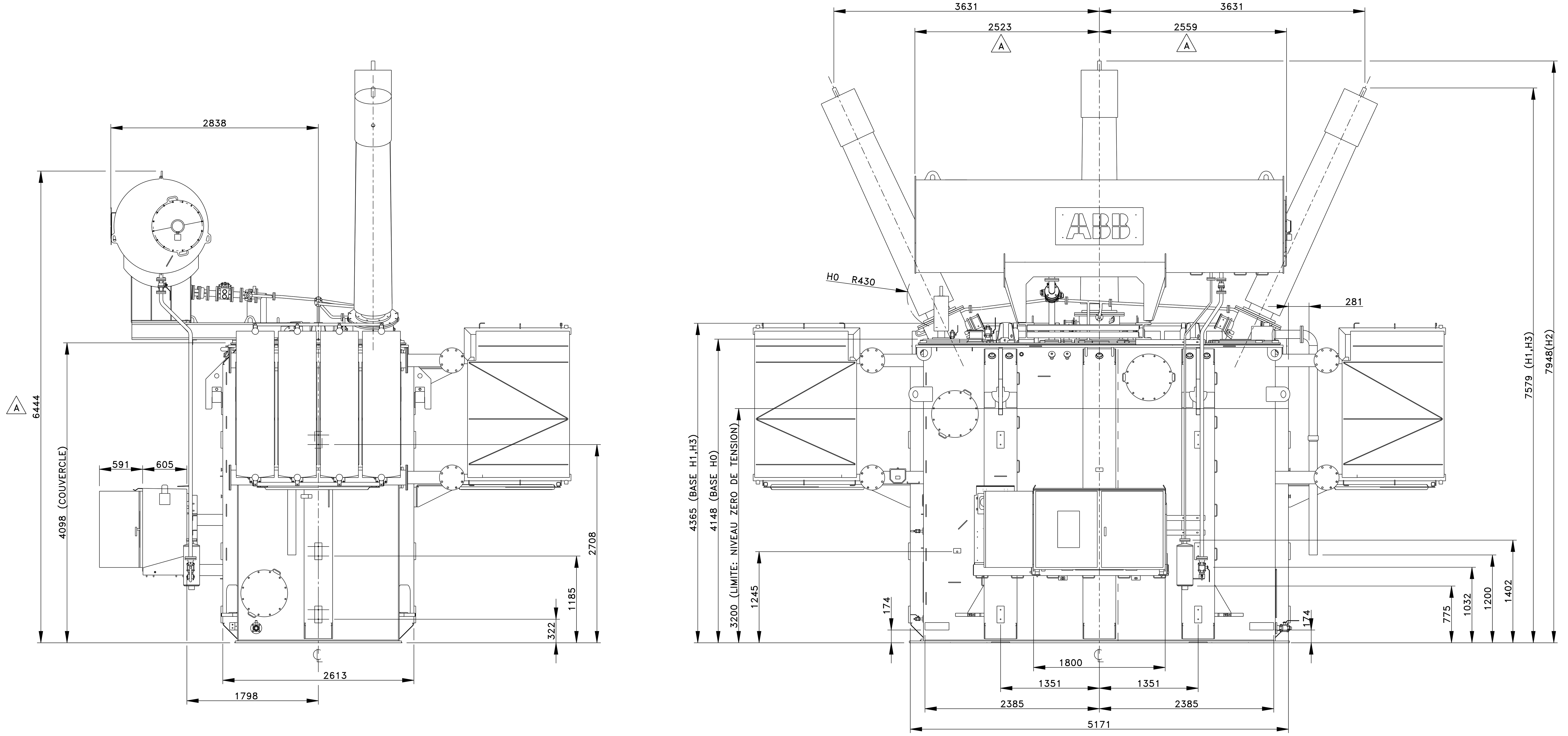
ENCOMBREMENT CIVIL
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079–01
POSITION XL73

RAPPORT 1:35
DIMENSIONS EN mm

FEUILLE SUIVANTE 02

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOR.
6403	40140	A000060	XV15079004–C	01	B	1

M. DRAPEAU (2009–03)



M. DRAPEAU (2009-03)

NO	NOTES

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
B	2015/11/04	STATUT ÉTAIT PRÉLIMINAIRE. NOTES 2, 3, 4 MODIFIÉES		DSH/PGR	
A	2014/08/28	DIM. 2523, 2559, 6444 ÉTAIENT 2720, 2362, 6408. VUES À JOUR.		DSH/PGR	

NO	RÉFÉRENCES	NO

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ____________________ DATE : ____-__-__

SCEAUX

INGÉNIEUR Patrice Lamothe 118337 QUÉBEC
2015-11-06

NOTES

1- CE DESSIN EST CRÉÉ POUR QUE LE CLIENT PUISSE COMMENCER LES TRAVAUX D'INGÉNIERIE CIVILE ET POUR L'INFORMER DE L'EMPLACEMENT GÉNÉRAL DES ACCESSOIRES MAJEURS.

REV. B

4- TOLÉRANCES: ±50 mm POUR LES DIMENSIONS > 1000 mm.
±13 mm POUR LES DIMENSIONS < 1000 mm.

5- ANCRAGE RECOMMANDÉ EST 4 JOINTS SOUDÉS DE 250 mm.

6- TOLÉRANCE DE CONSTRUCTION POUR LA BASE DE BÉTON (HQ): SELON LA NORME SN-30.2. EXIGENCES MINIMALES POUR L'APPAREIL (ABB) : UNE DÉNIVELLATION MAXIMALE DE 2,5 mm PAR MÈTRE OU DE 8 mm ENTRE DEUX POINTS QUELCONQUES AU SOMMET DE LA FONDATION. Réf.(ABB Varennes Transformateur de Puissance, Installation, 2011-05-04, 1ZCV4000-002, page1)
PRENDRE LES MESURES SELON LA NORME ASTM E1155M ET SIGNALER TOUT ÉCART DE CES TOLÉRANCES AU DÉPARTEMENT D'INGÉNIERIE MÉCANIQUE DE ABB VARENNES.

7- POUR LA QUALIFICATION PARASISMIQUE DE L'ÉQUIPEMENT SELON TET-APG-N-0001, VOIR LE RAPPORT SISMIQUE: XV15079004-FB

8- LES CHARGES SISMIQUES SONT DONNÉES SUR LE DESSIN XV15079004-F.

9- POUR LE COUPLE DE SERRAGE DES BOULONS, VOIR LE DOCUMENT 1ZCV460001-B DANS LE MANUEL D'ENTRETIEN ET D'EXPLOITATION.

FINAL

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

Cette vérification ne constitue d'aucune façon une vérification détaillée et complète de la conception

Recommandation
☐ Aucun commentaire
☐ Accepté tel que noté (doit être validé par un ingénieur si ça modifie le concept)
☐ Corriger et resoumettre avant les travaux
☐ Refusé

Signature ☐ Ingénieur ☐ Autre Date
Nom No de membre de l'OIQ

La vérification est restreinte à celle indiquée et ne garantit pas que les données du document reçu sont exactes ou exhaustives. Elle ne dégage nullement la personne ou la firme qui l'a préparé de ses obligations de quelque nature que ce soit.

ABB Inc.
1600 Boul. Lionel Boulet
Varennes, Québec
J3X 1S4

DESSINÉ	D. ST-HILAIRE	DATE	2014/05/12
VÉRIFIÉ	P. GAUTHIER	DATE	2014/05/12
APPROUVÉ	P. LAMOTHE	DATE	

POSTE DE L'OUTAOUAIS

ENCOMBREMENT CIVIL
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

RAPPORT 1:35
DIMENSIONS EN mm

FEUILLE SUIVANTE —

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOR.
6403	40140	A000060	XV15079004-C	02	B	1

ANNEXE 2 - RAPPORT D'ESSAI IREQ

Hydro Québec
Institut de recherche

Rapport d'essais

Inductance 3 ph.

IREQ - J794315045

Numéro de série : 15079-01

ABB Inc.

Agent d'essai : Réal Boissonneault
Ingénieur d'essais : Nicolas Plante

ISO / CEI 17025 Accrédité

Laboratoire haute tension

1802, boul. Lionel-Boulet, Varennes (Québec) Canada J3X 1S1

Hydro Québec

LABORATOIRE HAUTE TENSION

INFORMATIONS

Nom et adresse du client :	ABB Inc. 1600 boul. Lionel-Boulet, Varennes, Québec J3X 1S4
Rapport d'essais No. :	J794315045
Objet d'essais :	Inductance 3 ph.
Type d'objet d'essais :	Inductance Shunt
Connexions :	Yn
Numéro de série :	15079-01
Puissance nominale :	140 MVA
Tension nominale :	315 kV
Fréquence nominale :	60Hz
Les essais effectués sont de	Type
Les essais ont été effectués du	2015-10-14 au 2015-10-27
Références ou Normes :	SN-14.2H
Représentant du Client :	Jérome Ndayizamba
Essais effectués par :	Réal Boissonneault, tech. Paul Charest, tech. Benoît Choquette, tech. Raynald Martel, tech. Réjean Picard, tech. Guy Pichette, tech.

Nombre de pages : 135

(135230)

Vérifié par : Nicolas Plante ing. **Date :** 2015-11-17
Nicolas Plante ing.
Ingénieur d'essais

Approuvé par : Pierre Guyon **Date :** 2015-11-24
Pierre Guyon
Chef Laboratoire d'essais haute tension

Institut de recherche d'Hydro-Québec (IREQ), Laboratoire haute tension
1802, boul. Lionel-Boulet, Varennes, Québec, Canada J3X 1S1 Tél.: (450) 652-8500 Fax (450) 652-8555, lht@ireq.ca

Hydro Québec	Objet d'essais	Inductance 3 ph.	140 MVA
	N° Série	15079-01	
	N° Contrat	J794315045	
	Client	ABB Inc.	
LABORATOIRE HAUTE TENSION	Tension	315 kV	

TABLE DES MATIÈRES **PAGE**

LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance 3 ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.
Tension	315 kV

DATE DE LA RÉCEPTION 2015-10-14

ÉTAT À LA RÉCEPTION

APPAREIL:	neuf
RADIATEURS:	installés
RÉSERVOIR D'EXPANSION:	installé
TRAVERSÉES:	installées

PRÉPARATION

PRÉPARATION STANDARD

NOTE :

Les dessins ou données qui peuvent nous être transmis par le client ne sont pas vérifiés par le Laboratoire haute tension. Le client est responsable de prouver à des tiers leur conformité avec l'objet d'essais.

Hydro Québec
LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance 3 ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

INCERTITUDE MAXIMALE ÉVALUÉE DES CHAÎNES DE MESURE

No	Chaîne de mesure du laboratoire Haute Tension	Incertitude %
1	Mesure de tension c.a. avec capacité std, BBTA mobile et wattmètre Yokogawa - 60Hz	0,1
2	Mesure de tension c.a. avec capacité std, BBTA maison et wattmètre Yokogawa - 60Hz	0,2
3	Mesure de tension c.a. avec transfo. de potentiel MWB et wattmètre Yokogawa - 60Hz	0,1
4	Mesure de courant avec transfo. de courant MIL et wattmètre Yokogawa (Aire #4) - 60Hz	0,3
5	Mesure de courant avec transfo. de courant MIL et wattmètre Yokogawa (Aire #6) - 60Hz	0,2
6	Mesure de courant avec transfo. de courant MWB et wattmètre Yokogawa - 60Hz	0,5
7	Mesure de pertes : avec facteur de puissance : fp>0.5%	0,3
8	Mesure de courant avec pince ampèremétrique	3
9	Rapport de transformation des transformateurs de courant	0,3
10	Mesure d'impédance	0,3
11	Mesure de résistance	0,5
12	Mesure de température	1°C
13	Mesure de bruits audibles	1.6dB
14	Mesure de vibrations	5,3
15	Mesure de décharges partielles (système numérique)	8,5
16	Mesure de RIV (système numérique)	55
17	Mesure de tension avec diviseurs et système d'acquisition (Chocs et SM.)	-
	mesure de tension, onde pleine	2
	mesure de tension, onde coupée	3,5
	mesure de temps	5

Les valeurs d'incertitudes contenues dans ce tableau sont supportées par
le rapport interne #10009A, version 2009-11.

No	Chaînes de mesure pour essais spécifiques (Grand Hall)	Incertitude %
1	Mesure de tension c.a. avec diviseur de tension et multimètre Fluke 45	0,6
2	Mesure de tension c.c. avec diviseur de tension et multimètre Fluke 45	0,6
3	Mesure de courant c.a. avec shunt et multimètre Fluke 45	0,5
4	Mesure de courant c.c. avec shunt et multimètre Fluke 45	0,1
5	Mesure de décharges partielles avec Robinson	20
6	Mesure de R.I.V	27
7	Mesure de la capacitance avec pont Guildline	0,3
8	Mesure de la tangente delta avec pont Guildline	0,6

Les valeurs d'incertitudes contenues dans ce tableau sont supportées par
le rapport interne #10009B, version 2009-11.

Les incertitudes élargies sont fonction du facteur d'élargissement k=2, selon un degré de confiance d'environ 95% en supposant une répartition normale.

Hydro Québec

LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance 3 ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Utilisation de services d'appoint non couverts par l'accréditation 17025

Service requis	Nom fournisseur
Analyse d'huile	Morgan Schaffer

Hydro Québec

LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance 3 ph.	140 MVA
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

RÉSUMÉ DES ESSAIS

DESCRIPTION	NORME	ESSAI RÉUSSI	
		OUI	NON
Linéarité en CC	SN-14,2H	X	
Pertes en charges et impédance	SN-14,2H	X	
Échauffement à 331 kV (105% Un)	SN-14,2H	X	
Bruit audible à 331 kV (105% Un)	SN-14,2H	X	
Chocs de foudre H1, H2, H3	SN-14,2H	X	
Chocs de foudre H0	SN-14,2H	X	
Surtension de manœuvre	SN-14,2H	X	
Tension appliquée à 60Hz, 60 secondes	SN-14,2H	X	
Tension induite en triphasé et mesure des décharges partielles	SN-14,2H	X	

Défaillances constatées :

Non-Conformité N° :
NC-2015-08

Préparé par : NP

Date : 2015-11-16

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Tension appliquée	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

DÉTAILS DES CONSTANTES DE MESURE POUR TRANSFORMATEUR DE POTENTIEL ET Yokogawa

Courant :	Pince		
Tension :	2000/1	=	2000

Tension Mesurée (V)	Tension Appliquée (kV eff.)	Bornes sous Tension	Bornes "MALT"	Temps (s)	Courant (A)	REMARQUES
47,7	95,3	H1,H2,H3 H01,H02,H03	Cuve	60	0,50	

Remarques :

Essais par : R.B., R.M.

Date : 2015-10-26

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Tension appliquée	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

IDENTIFICATION DES INSTRUMENTS UTILISÉS

INSTRUMENT	Nº IREQ
Wattmètre Yokogawa	2070122
Pince	2080074
Capacité de référence	10A083
B.B.T.A.	36C183
Capacité Standard	10A077

Essais par : R.B., R.M.

Date : 2015-10-26

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Tension induite 3 phases	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
N° Série	15079-01	
N° Contrat	J794315045	
Client	ABB Inc.	

CALIBRATION EN TENSION

		Fréquence de l'essai	177.2	Hz
		Position du changeur de prises	na	
pport de la capacité std :	2000/1	Tension induite (H.T.) Ph.terre	75	kV
		Tension B.T.	11.0	kV

DÉTAILS DES CONSTANTES DE MESURE

Niveau de garantie R.I.V	---	µV		
Niveau de garantie D.P.	500	pC		
Au 175 MVA, Courant :	2000/1	=	2000	
Tension (rms) :	800/1	=	800	

Yokogawa

Shunt : Auto mA

Facteur d'échelle

2000
2000
2000
800

SÉQUENCE D'ESSAIS	TEMPS	% U NOMINALE	ESSAI D'INDUIT			REMARQUES
		%U Nominale	H.T. (kV) ϕ–n	B.T. 310 (kV)	(kV)	
	(mm:ss)		ϕ–n	ϕ–n	ϕ–n	
	05.00	100%	181.8	26.9	- - - -	
	05.00	150%	272.3	40.2	- - - -	
	00.40	150%	272.3	40.2	- - - -	
	60.00	150%	272.3	40.2	- - - -	
	01.00	100%	181.8	26.9	- - - -	
			Calibration			
			H.T. (kV) ϕ–n	B.T. (kV)	Tertiare (kV)	
			ϕ–n	ϕ–n	ϕ–n	
		41%	75.0	11.1	- - - -	
		10%	18.1	2.67	- - - -	

	% U NOMINALE	MESURES DE LA SOURCE "Yokogawa"				REMARQUES
		H.T. (kV) ϕ–ϕ	I (A)	P (kW)	cos ϕ %	
		(Moyenne)	(Moyenne)	(Somme)	(Moyenne)	
	150%	40.2	972.0			La mesure est prise au 175 MVA, ne comprend pas le 310 MVA.

Remarques :

Tension maximale atteinte, limité par les banques à 119% du courant nominal (69.8 kV à 177.2 Hz).

Essais R.B., R.M. Date : 2015-10-27

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Version : 2013-11

Induit triphasée.XLS

Hydro Québec
LABORATOIRE HAUTE TENSION

Type d'essai	Tension induite 3 phases
Objet d'essais	Inductance shunt 3-ph 140 MVARS
N° Série	15079-01
N° Contrat	J794315045
Client	ABB Inc.

IDENTIFICATION DES INSTRUMENTS UTILISÉS

INSTRUMENT	N° IREQ	INSTRUMENT	N° IREQ
BBT mobile:	36C183		
Capacité réf.:	10R083		
Voltmètre:	2060307		
Yokogawa:	2070122		
Capacité STD:	10A059		

CALIBRATION Omicron

		pC		Gain pC	Calib kV	Gain Tension
H1	200.4	500	1000	7.508	75.02	66534
H2	200.4	500	1001	7.238	74.99	70190
H3	200.2	500	998	7.556	75.02	69504

Essais R.B., R.M. Date : 2015-10-27

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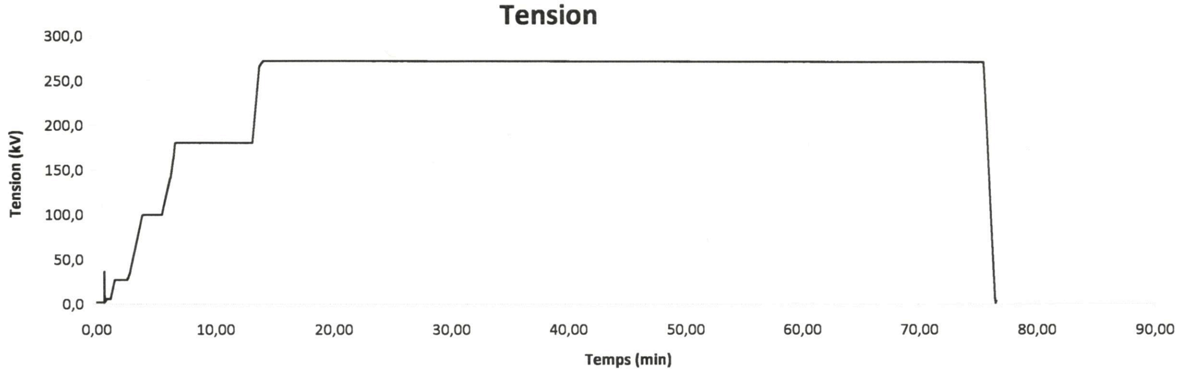
Hydro Québec
LABORATOIRE HAUTE TENSION

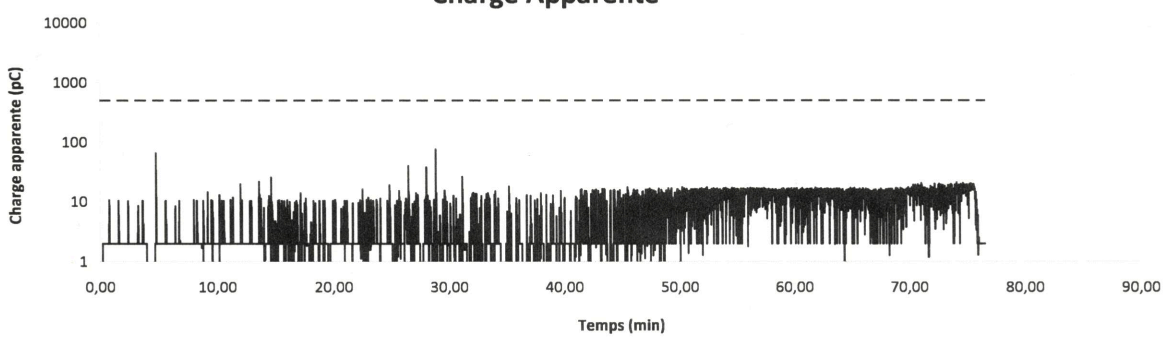
Type d'essai	Tension induite 3 phases
Objet d'essais	Inductance shunt 3-ph. 140 MVARS
N° Série	15079-01
N° Contrat	J794315045
Client	ABB Inc.

Terminal: H1

Tension



Charge Apparente



Essais par: RB, RM   Date : 2015-10-27

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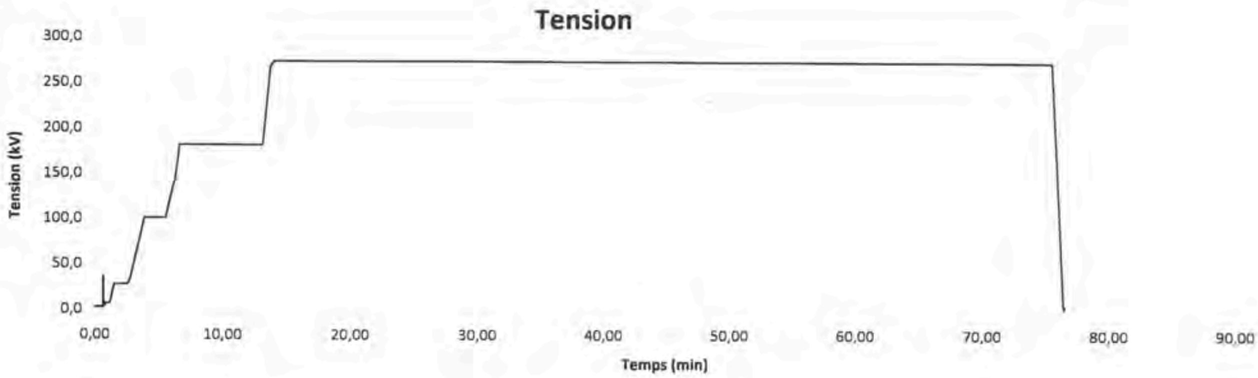
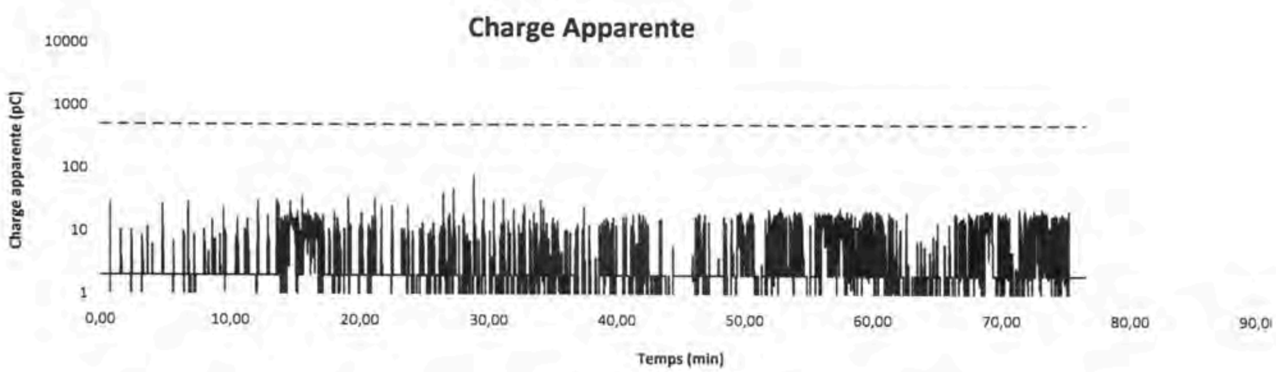
Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Tension induite 3 phases
Objet d'essais	Inductance shunt 3-ph. 140 MVARS
N° Série	15079-01
N° Contrat	J794315045
Client	ABB Inc.

Terminal: H2





Essais par: RB, RM	Date : 2015-10-27

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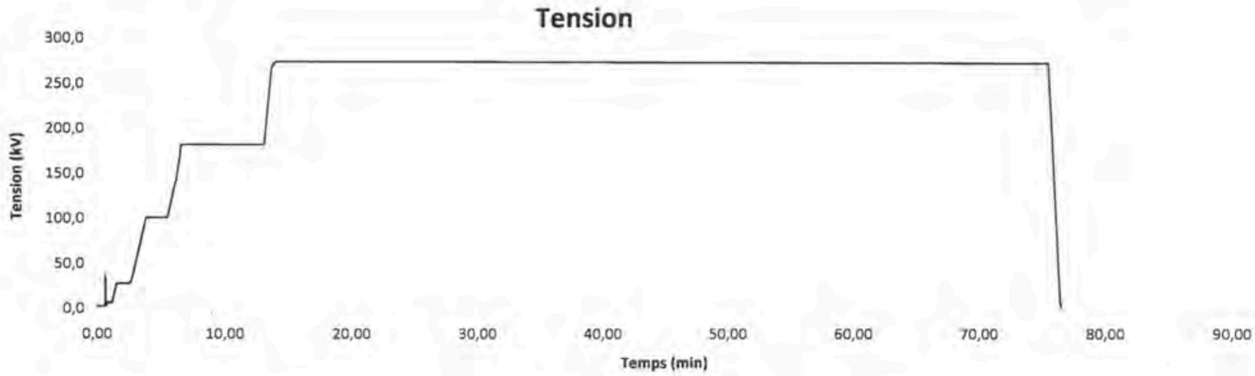
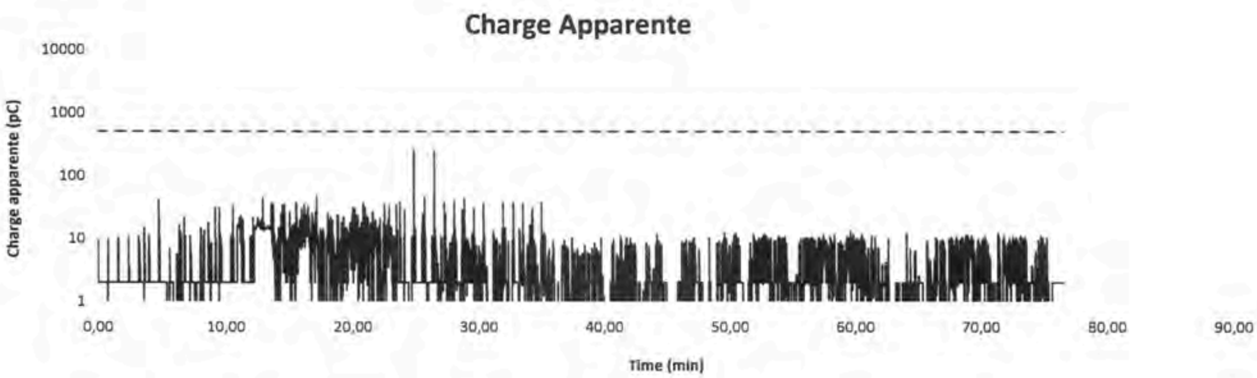
Hydro Québec
LABORATOIRE HAUTE TENSION

Type d'essai	Tension induite 3 phases
Objet d'essais	Inductance shunt 3-ph. 140 MVARS
N° Série	15079-01
N° Contrat	J794315045
Client	ABB Inc.

Terminal: H3





Essais par: RB, RM	Date : 2015-10-27

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Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Tension induite 3 phases
Objet d'essais	Inductance shunt 3-ph. 140 MVARS
N° Série	15079-01
N° Contrat	J794315045
Client	ABB Inc.

Temps d'essai (min)	Tension H2 (kV)	D.P.H1 (pC)	D.P.H2 (pC)	D.P.H3 (pC)
00:00:03	2,3	<10	<10	<10
00:01:34	27,1	10	10	<10
00:02:35	27,6	<10	<10	<10
00:03:58	100,2	<10	<10	<10
00:05:03	100,4	<10	<10	<10
00:05:32	100,6	<10	<10	<10
00:06:40	181,0	<10	<10	<10
00:10:03	181,2	<10	<10	<10
00:15:05	273,3	<10	<10	<10
00:20:05	273,3	<10	<10	<10
00:25:05	273,2	<10	<10	<10
00:30:05	273,1	<10	<10	<10
00:35:05	273,0	<10	<10	<10
00:40:05	272,9	<10	<10	<10
00:45:05	272,7	<10	<10	<10
00:50:05	272,5	<10	<10	<10
00:55:05	272,4	<10	<10	<10
01:00:05	272,3	10	<10	<10
01:05:05	272,2	13	13	<10
01:05:20	272,2	11	<10	<10
01:10:05	272,0	13	<10	<10
01:15:05	271,9	12	<10	<10
01:15:34	271,5	18	<10	<10

Essais par: RB, RM   Date : 2015-10-27

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai :	Résistance à froid	No de contrat :	J794315045
Client :	ABB	No d'essai :	001
Objet d'essai :	Inductance shunt 3-ph. 140 MVARs	No de série :	15079-01

Résistance à Froid

1/1

T° huile bas : 21.2 °C
T°moy. huile : 20.5 °C
T° huile haut : 19.8 °C

Borne	Pos. changeur de prise [Shunt]	Résistance à froid	Résistance corrigée à 75.0°C
H1-H01	na [1990674]	6.58896E-1	7.99719E-1
H2-H02	na [1990674]	6.58418E-1	7.99139E-1
H3-H03	na [1990674]	6.57280E-1	7.97757E-1

Essai réalisé par R.B.   Date : 2015-10-15   Heure : 09:09:50   Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : Résistance à froid Résistance Aluminium
Client : ABB
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 002
No de série : 15079-01

Résistance à Froid

1/1

T° huile bas : 21.1 °C
T°moy. huile : 21.1 °C
T° huile haut : 21.1 °C

Borne	Pos. changeur de prise [Shunt]	Résistance à froid	Résistance corrigée à 75.0°C
R. Alum.	na [1990674]	8.94781E-1	1.09075E+0

Essai réalisé par R.B.   Date : 2015-10-15   Heure : 09:38:19   Page :

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai :	Pertes	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
N° Série	15079-01	
N° Contrat	J794315045	
Client	ABB Inc.	

CONDITION D'ESSAI:

		Température (°C)	
Base (MVA) =	140	Haut	21,3
Tension nominale (kV) =	315	Bas	20,5
Fréquence f1 (Hz) =	60	Moyenne	20,9

DÉTAILS DES CONSTANTES DE MESURE :

Facteurs d'échelle

U1: 2001,82
U2: 1954,08
U3: 1975,52
I1,2,3: 1000

Détails des calculs

Z (Ω) = V/ I
L (H) ≅ Z / (2 π * f1)
P@Vref (kW) = Vref * Vref / Z * cos ϕ
P(kW) = cos(ϕ) * S

		MESURES					CALCULS						Z = R + jX	
	Heure	Fréquence	V ϕ-n	I	Cos ϕ	S	P	V/Vref	Z	L	Vref	P@Vref	R-equ	X -L
		Hz	(kV)	(A)		(kVA)	(kW)		(Ω)	(H)	(kV)	(kV)	(Ω)	(Ω)
											181,9			
H1	10:00	60,0	190,87	268,6	0,0017	51266,0	88,2	105,0%	710,7	1,884	191,0	88,3	1,22	710,7
H2	10:00	60,0	191,89	269,2	0,0014	51660,0	74,4	105,5%	712,8	1,890	191,0	73,7	1,03	712,8
H3	10:00	60,0	190,59	267,5	0,0017	50987,0	87,2	104,8%	712,4	1,889	191,0	87,5	1,22	712,4
			191,12	268,44			249,8			1,888		249,5	1,16	711,9
												105%		
H1	10:00	60,0	181,61	255,3	0,0017	46367,0	77,9	99,9%	711,3	1,886	181,9	78,1	1,19	711,3
H2	10:00	60,0	182,18	255,4	0,0015	46520,0	67,5	100,2%	713,4	1,892	181,9	67,2	1,03	713,4
H3	10:00	60,0	181,49	254,5	0,0017	46198,0	78,5	99,8%	713,0	1,891	181,9	78,9	1,21	713,0
			181,76	255,07			223,9			1,889		224,2	1,15	712,6
												100%		
H1														
H2														
H3														
H1	10:00	60,0	145,50	204,2	0,0016	29715,0	47,8	80,0%	712,4	1,890	145,5	47,8	1,15	712,4
H2	10:00	60,0	146,34	204,8	0,0015	29974,0	44,4	80,5%	714,5	1,895	145,5	43,8	1,06	714,5
H3	10:00	60,0	145,33	203,5	0,0017	29576,0	50,3	79,9%	714,1	1,894	145,5	50,4	1,21	714,1
			145,72	204,19			142,5			1,893			1,14	713,7
												80%		
H1	10:01	60,0	108,39	152,0	0,0016	16477,2	26,7	59,6%	713,0	1,892	109,1	27,1	1,16	713,0
H2	10:01	60,0	109,84	153,6	0,0015	16869,9	25,6	60,4%	715,1	1,897	109,1	25,3	1,09	715,1
H3	10:01	60,0	109,08	152,6	0,0017	16650,4	27,8	60,0%	714,7	1,896	109,1	27,8	1,19	714,7
			109,10	152,74			80,1			1,895		80,2	1,15	714,3
												60%		

COMMENTAIRES :

Essais par: RB BC

Date: 2015-10-18

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai :	Pertes	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

CONDITION D'ESSAI:

Base (MVA) = 140
Tension nominale (kV) = 315
Fréquence f1 (Hz) = 60

Température (ºC)	
Haut	21,3
Bas	20,5
Moyenne	20,9

DÉTAILS DES CONSTANTES DE MESURE :

Facteurs d'échelle
U1: 2001,82
U2: 1975,50
U3: 1954,10
I1,2,3: 1000

Détails des calculs
Z (Ω) = V/ I
L (H) ≅ Z / (2 π * f1)
P@Vref (kW) = Vref * Vref / Z * cos φ
P(kW) = cos(φ) * S

		MESURES					CALCULS						Z = R + jX	
	Heure	Fréquence	V φ-n	I	Cos φ	S	P	V/Vref	Z	L	Vref	P@Vref	R-equ	X -L
		Hz	(kV)	(A)		(kVA)	(kW)		(Ω)	(H)	(kV)	(kV)	(Ω)	(Ω)
											181,9			
H1	9:08	60,0	17,91	25,1	0,0019	449,4	0,9	9,8%	713,7	1,892	18,2	0,9	1,36	713,7
H2	9:08	60,0	18,48	25,8	0,0018	477,1	0,8	10,2%	715,6	1,897	18,2	0,8	1,25	715,6
H3	9:08	60,0	18,41	25,7	0,0018	474,2	0,8	10,1%	715,2	1,896	18,2	0,8	1,25	715,2
			18,26	25,55			2,5			1,895		2,5	1,29	714,8
												10%		
H1	9:08	60,0	36,32	50,9	0,0018	1848,7	3,2	20,0%	713,6	1,892	36,4	3,2	1,25	713,5
H2	9:08	60,0	36,92	51,6	0,0017	1904,4	3,2	20,3%	715,6	1,898	36,4	3,1	1,20	715,6
H3	9:08	60,0	36,73	51,4	0,0017	1886,7	3,2	20,2%	715,1	1,896	36,4	3,1	1,22	715,1
			36,66	51,28			9,6			1,895		9,5	1,22	714,7
												20%		
H1	9:08	60,0	54,15	76,0	0,0017	4113,6	7,0	29,8%	713,0	1,892	54,6	7,1	1,22	713,0
H2	9:08	60,0	54,94	76,8	0,0016	4221,0	6,9	30,2%	715,1	1,898	54,6	6,8	1,17	715,1
H3	9:08	60,0	54,74	76,6	0,0017	4193,8	7,1	30,1%	714,6	1,896	54,6	7,0	1,21	714,6
			54,61	76,46			21,0			1,896		21,0	1,20	714,2
												30%		
H1	9:09	60,0	72,26	101,3	0,0016	7325,8	11,9	39,7%	713,1	1,892	72,7	12,1	1,16	713,1
H2	9:09	60,0	73,13	102,3	0,0016	7480,2	11,6	40,2%	715,2	1,898	72,7	11,5	1,11	715,2
H3	9:09	60,0	72,76	101,8	0,0016	7410,3	12,2	40,0%	714,7	1,897	72,7	12,1	1,17	714,7
			72,72	101,80			35,7			1,896			1,15	714,3
												40%		
H1	9:09	60,0	90,23	126,5	0,0016	11417,8	18,5	49,6%	713,0	1,892	90,9	18,8	1,16	713,0
H2	9:09	60,0	90,94	127,2	0,0016	11565,2	17,9	50,0%	715,1	1,898	90,9	17,9	1,11	715,1
H3	9:09	60,0	90,46	126,6	0,0017	11451,2	18,9	49,7%	714,6	1,896	90,9	19,1	1,18	714,6
			90,54	126,77			55,3			1,895		55,8	1,15	714,3
												50%		

COMMENTAIRES :

Essais par: RB BC

Date: 2015-10-18

Hydro Québec
LABORATOIRE HAUTE TENSION

Type d'essai :	Pertes	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
N° Série	15079-01	
N° Contrat	J794315045	
Client	ABB Inc.	

IDENTIFICATION DES INSTRUMENTS UTILISÉS

		N° IREQ
Yokogawa Wattmeter		2070121
C.T. Weston	ph. A	38A0412
C.T. Weston	ph. B	32A054
C.T. Weston	ph. C	32A039
Cap.	ph. A	10A077
Cap.	ph. B	10A066
Cap.	ph. C	10A065
B.B.T.A. MIL	ph. A	2060342
B.B.T.A. MIL	ph. B	2060343
B.B.T.A. MIL	ph. C	2060344

Essais par: RB BC   Date: 2015-10-18

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Pertes corrigées	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

Mesure des pertes à froid

Voltage nominale ph-t (kV)	315.0
Température de correction (°C)	75

Température moyenne des enroulement	20.90

		Tension (kV)	Pertes (kW)	Pertes @ Vref
H1	100%	314.54	77.90	78.13
H2	100%	315.54	67.50	67.27
H3	100%	314.34	78.50	78.83
			Pertes totale	224.23

		Tension (kV)	Pertes (kW)	Pertes @ Vref
H1	105%	330.60	88.20	88.28
H2	105%	332.36	74.40	73.68
H3	105%	330.11	87.20	87.54
			Pertes totale	249.5

Facteur de correction

Choisir entre l'alternative A ou l'alternative B

A Inductance shunt de même conception

Numérode dossier	
Numéro de l'inductance	
Facteur de correction à 100%	
Facteur de correction à 105%	

B Résultats suite à un essai d'échauffement

Température moyenne des enroulements	73.60

		Tension (kV)	Pertes (kW)	Pertes @ Vref
H1	100%	315.49	83.70	83.44
H2	100%	317.83	74.60	73.28
H3	100%	316.22	86.20	85.54
			Pertes totale	242.25

		Tension (kV)	Pertes (kW)	Pertes @ Vref
H1	105%	330.06	89.10	89.5
H2	105%	332.60	79.60	78.7
H3	105%	331.09	94.00	93.8
			Pertes totale	262.0

Calcul du facteur de correction (K)

100%	0.3421
105%	0.2371

Calculs des pertes corrigées

$$P_c(75°C) = P_c(V_{nominale}) + K^*(T_{correction} - T_{moy(froid)})$$

$T_{correction}$ = 75 °C

Pc(75°C) à 100% = 242.73 kW

Pc(75°C) à 105% = 262.33 kW

Essais par : NP	Date : 2015-10-19

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Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai :	Échauffement	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

CONDITION D'ESSAI:

Base (MVA) = 140
Tension nominale (kV) = 315

DÉTAILS DES CONSTANTES DE MESURE :

Facteurs d'échelle
U1: 2001.82
U2: 1975.50
U3: 1954.10
I1,I2,I3: 1000

Heure	MESURES								CALCULS				
	Huile haut (°C)	Hydran (ppm)		Moyenne U ϕ–ϕ (kV)	I1 (A)	I2 (A)	I3 (A)	Moyenne I (A)	P1 (kW)	P2 (kW)	P3 (kW)	Σ P (kW)	COMMENTAIRES :
10:49				314.6840	254.44	255.57	255.28	255.1	78.4	67.1	77.8	223.4	
10:50				331.1600	267.90	269.04	268.89	268.61	85.9	73.2	87.3	246.5	105%
11:15	23.7	11.0		331.2320	268.18	269.28	269.12	268.86	86.5	74.4	87.4	248.4	
11:30	29.1	11.0		328.8930	266.01	267.31	267.11	266.81	86.7	74.3	87.2	248.2	
11:45	34.9	11.0		331.8900	268.64	269.77	269.39	269.27	89.4	76.7	90.2	256.4	
12:00	38.3	11.0		330.8550	267.65	268.97	268.30	268.31	88.3	75.8	88.5	252.6	
12:15	41	11.0		331.3400	267.84	268.87	268.86	268.52	89.0	76.3	89.9	255.2	
12:30	43.2	10.0		330.2150	267.00	268.01	268.07	267.69	88.4	75.8	89.4	253.5	
12:51	45.8			327.1810	264.50	265.77	265.43	265.23	87.7	74.5	88.1	250.4	
13:00	46.7			330.3020	267.31	268.02	268.40	267.91	88.6	76.8	90.6	255.9	
13:15	48.3			330.0750	266.77	267.94	267.84	267.51	89.3	76.3	90.3	255.8	
13:30	49.8	10.0		329.7390	266.72	267.60	267.43	267.25	88.2	75.1	89.5	252.8	
13:45	51.1			331.0170	267.65	268.82	268.62	268.37	89.8	77.3	91.3	258.4	
14:00	52.4	10.0		331.2790	268.04	268.49	269.07	268.53	89.6	76.1	91.1	256.8	
15:00	56.3			329.1390	265.92	267.54	267.05	266.84	88.2	77.1	91.8	257.0	
16:00	59.3	10.0		331.6390	268.19	269.15	269.40	268.91	90.7	78.0	93.4	262.0	
17:00	61.8	10.0		330.7590	267.45	268.67	268.39	268.17	90.2	78.8	93.2	262.2	
18:00	64	10.0		330.6090	267.29	268.45	267.98	267.91	90.7	78.1	93.0	261.7	
19:53	67.3	10.0		331.3150	267.90	269.11	268.57	268.52	91.1	80.1	95.4	266.5	
20:30	67.9	10.0		331.2710	267.69	268.99	268.12	268.27	90.5	79.0	93.1	262.6	
21:00	68.5	10.0		331.8090	268.11	269.55	269.26	268.97	92.7	79.8	96.4	268.8	
21:59	69.5	10		331.8690	268.33	269.68	269.33	269.11	92.4	80.4	96.4	269.2	

COMMENTAIRES :

Essais par: R.B. R.P. Date: 2015-10-19

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai :	Échauffement	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

CONDITION D'ESSAI:

Base (MVA) = 140
Tension nominale (kV) = 315

DÉTAILS DES CONSTANTES DE MESURE :

Facteurs d'échelle
U1: 2001.82
U2: 1975.50
U3: 1954.10
I1,I2,I3: 1000.00

Heure	MESURES								CALCULS				
	Huile haut (°C)	Hydran (ppm)		Moyenne U ϕ–ϕ (kV)	I1 (A)	I2 (A)	I3 (A)	Moyenne I (A)	P1 (kW)	P2 (kW)	P3 (kW)	Σ P (kW)	COMMENTAIRES :
23:00	70.2	10		331.768	267.37	269.52	268.96	268.61	89.8	80.4	94.7	264.8	
0:00	70.8	10.0		331.497	267.59	269.27	269.07	268.64	91.4	80.7	95.2	267.3	
1:00	71.3	10.0		331.638	268.30	269.23	268.84	268.79	90.3	80.1	94.6	265.0	
2:00	71.7	10.0		331.687	268.45	269.07	269.06	268.86	92.0	80.6	96.3	268.8	
3:00	72	10.0		331.518	268.18	269.17	268.77	268.71	91.3	80.1	95.5	266.9	
4:00	72.2	10.0		331.619	268.41	269.08	268.96	268.82	91.9	80.0	96.2	268.2	
5:00	72.5	10.0		331.298	268.16	269.33	268.48	268.66	91.2	80.2	95.8	267.2	
6:00	72.7	10.0		331.142	267.51	268.99	268.02	268.17	90.3	80.5	95.0	265.9	
7:00	72.9	10.0		331.268	267.63	269.09	268.50	268.41	90.9	80.6	95.9	267.4	
8:00	73	10.0		331.281	267.56	269.14	268.52	268.41	89.8	79.1	94.4	263.3	
8:08	73	10.0		315.080	254.48	255.77	255.47	255.24	82.7	72.4	84.5	239.6	100%
8:28	73.2	10.0		316.426	255.36	257.21	256.60	256.39	83.7	74.6	86.2	244.5	100%
8:27	73.2	10.0		331.129	267.26	269.18	268.80	268.41	89.1	79.6	94.0	262.8	105%
													Coupure

COMMENTAIRES :

Essais par: R.B. R.P. Date: 2015-10-19

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai :	Échauffement	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

IDENTIFICATION DES INSTRUMENTS UTILISÉS

INSTRUMENT	PHASE	
Yokogawa Wattmeter		2070121
C.T. Weston	ph. A	38A0412
C.T. Weston	ph. B	32A054
C.T. Weston	ph. C	32A039
Cap.	ph. A	10A077
Cap.	ph. B	10A066
Cap.	ph. C	10A065
B.B.T.A. MIL	ph. A	2060342
B.B.T.A. MIL	ph. B	2060343
B.B.T.A. MIL	ph. C	2060344

Essais par: R.B. R.P. Date: 2015-10-19

Hydro Québec

LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : Echauffement 105% Un
Client : ABB
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données d'échauffement

1/6

Type d'échauffement : Echauffement 105% Un
Position du changeur de prise : na

Date heure	HuileH 1	Amb 1	Amb 2	Amb 3	Amb moy	Delta T	RH 1	RB 1	RH 2	RB 2	RH 3
2015-10-18 10:35	22.2	20.5	20.3	20.8	20.5	1.7	22.5	20.9	22.7	20.9	22.6
2015-10-18 10:50	22.4	20.6	20.4	20.9	20.6	1.8	22.7	21.0	22.9	20.9	22.7
2015-10-18 11:05	23.5	20.6	20.4	20.9	20.6	2.9	24.0	21.1	24.1	21.1	23.9
2015-10-18 11:20	25.5	20.7	20.5	21.1	20.8	4.7	25.8	21.2	26.3	21.2	26.3
2015-10-18 11:35	31.2	20.7	20.6	21.0	20.8	10.4	32.4	21.8	33.6	22.0	32.9
2015-10-18 11:50	36.0	20.6	20.5	21.0	20.7	15.3	37.6	23.3	38.3	23.7	37.9
2015-10-18 12:05	39.2	20.7	20.6	21.0	20.8	18.4	40.9	25.6	41.6	26.0	41.2
2015-10-18 12:20	41.6	20.8	20.6	21.1	20.8	20.8	43.5	27.7	43.8	28.1	43.7
2015-10-18 12:35	43.7	20.9	20.7	21.2	20.9	22.8	45.4	29.4	45.9	29.6	45.5
2015-10-18 12:50	45.6	21.0	20.8	21.2	21.0	24.6	47.5	30.7	47.9	31.0	47.5
2015-10-18 13:05	47.2	21.0	20.9	21.3	21.1	26.1	49.1	31.8	49.5	32.0	49.2
2015-10-18 13:20	48.9	21.1	20.9	21.4	21.1	27.8	50.7	32.7	51.1	33.0	50.7
2015-10-18 13:35	50.3	21.2	21.0	21.8	21.3	29.0	52.2	33.7	52.5	33.9	52.2
2015-10-18 13:50	51.5	21.3	21.1	21.9	21.4	30.1	53.4	34.6	53.8	34.8	53.5
2015-10-18 14:05	52.7	21.3	21.2	21.8	21.4	31.3	54.6	35.3	55.0	35.9	54.6
2015-10-18 14:20	53.8	21.4	21.3	21.7	21.5	32.3	55.7	36.2	56.1	36.8	55.8
2015-10-18 14:35	54.8	21.5	21.4	21.8	21.6	33.2	56.8	37.2	57.1	37.8	56.9
2015-10-18 14:50	55.7	21.6	21.6	21.9	21.7	34.0	57.9	38.1	58.1	38.8	57.9
2015-10-18 15:05	56.6	21.7	21.7	22.0	21.8	34.8	58.8	38.8	59.0	39.5	58.8
2015-10-18 15:20	57.4	21.7	21.7	22.0	21.8	35.6	59.6	39.5	59.9	40.3	59.7
2015-10-18 15:35	58.1	21.8	21.8	22.1	21.9	36.2	60.4	40.2	60.7	41.1	60.5
2015-10-18 15:50	58.8	21.9	21.9	22.7	22.2	36.6	61.1	40.7	61.5	41.7	61.2
2015-10-18 16:05	59.4	22.0	21.9	23.0	22.3	37.1	61.8	41.6	62.1	42.4	61.9
2015-10-18 16:20	60.3	22.1	22.1	22.5	22.2	38.1	62.6	42.0	62.9	43.1	62.6
2015-10-18 16:35	60.8	22.2	22.2	22.8	22.4	38.4	63.2	42.8	63.5	44.0	63.2
2015-10-18 16:50	61.5	22.3	22.2	22.5	22.3	39.2	63.9	43.2	64.2	44.4	64.0
2015-10-18 17:05	62.1	22.3	22.3	22.6	22.4	39.7	64.4	43.9	64.8	45.0	64.5
2015-10-18 17:20	62.5	22.3	22.3	22.6	22.4	40.1	65.0	44.3	65.4	45.5	65.2
2015-10-18 17:35	63.1	22.4	22.4	22.7	22.5	40.6	65.6	44.9	65.9	46.1	65.7
2015-10-18 17:50	63.7	22.5	22.4	22.8	22.6	41.1	66.1	45.3	66.5	46.6	66.2
2015-10-18 18:05	64.1	22.6	22.5	22.8	22.6	41.5	66.6	45.8	67.0	47.1	66.7
2015-10-18 18:20	64.6	22.7	22.6	22.9	22.7	41.9	67.0	46.3	67.5	47.5	67.1
2015-10-18 18:35	65.3	22.8	22.6	25.1	23.5	41.8	67.7	46.6	68.1	48.2	68.0
2015-10-18 18:50	65.7	22.8	22.7	23.0	22.8	42.9	68.3	47.2	68.7	48.5	68.3
2015-10-18 19:05	66.2	22.9	22.7	23.1	22.9	43.3	68.6	47.3	69.1	48.9	68.7
2015-10-18 19:20	66.5	23.0	22.8	23.1	23.0	43.5	69.0	47.9	69.4	49.4	69.1
2015-10-18 19:35	66.9	23.0	22.8	23.2	23.0	43.9	69.3	48.1	69.8	49.5	69.4
2015-10-18 19:50	67.2	23.1	22.9	23.3	23.1	44.1	69.7	48.6	70.1	50.0	69.8
2015-10-18 20:05	67.4	23.1	22.8	23.2	23.0	44.4	70.0	48.6	70.4	50.1	70.1
2015-10-18 20:20	67.8	23.2	22.9	23.3	23.1	44.7	70.3	49.1	70.7	50.5	70.3

Essai réalisé par R.B., B.C., G.P., P.C.   Date : 2015-10-18   Heure : 10:35:00   Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : Échauffement 105% Un
Client : ABB
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données d'échauffement

2/6

Type d'échauffement : Échauffement 105% Un
Position du changeur de prise : na

Date heure	RB 3	RH 4	RB 4	RH moy	RB moy	HuileB 1
2015-10-18 10:35	21.1	22.5	19.2	22.6	20.5	20.5
2015-10-18 10:50	21.2	22.8	21.3	22.8	21.1	20.6
2015-10-18 11:05	21.3	23.7	21.4	23.9	21.2	20.6
2015-10-18 11:20	21.4	26.2	21.5	26.2	21.3	20.7
2015-10-18 11:35	21.9	32.6	22.0	32.9	21.9	20.8
2015-10-18 11:50	23.5	37.9	23.8	37.9	23.6	20.9
2015-10-18 12:05	25.6	41.2	26.3	41.2	25.9	21.1
2015-10-18 12:20	27.5	43.8	28.4	43.7	27.9	21.3
2015-10-18 12:35	29.0	45.8	30.1	45.7	29.5	21.6
2015-10-18 12:50	30.3	47.7	31.4	47.7	30.8	22.0
2015-10-18 13:05	31.3	49.3	32.5	49.3	31.9	22.7
2015-10-18 13:20	32.3	51.0	33.6	50.9	32.9	23.7
2015-10-18 13:35	33.2	52.3	34.6	52.3	33.8	24.7
2015-10-18 13:50	34.0	53.6	35.5	53.6	34.7	26.0
2015-10-18 14:05	34.8	54.9	36.5	54.8	35.6	27.3
2015-10-18 14:20	35.8	56.0	37.5	55.9	36.6	28.4
2015-10-18 14:35	36.7	57.1	38.5	57.0	37.6	29.5
2015-10-18 14:50	37.5	58.1	39.4	58.0	38.4	30.4
2015-10-18 15:05	38.2	59.0	40.2	58.9	39.2	31.4
2015-10-18 15:20	38.8	59.9	41.0	59.8	39.9	32.4
2015-10-18 15:35	39.6	60.7	41.7	60.6	40.7	33.3
2015-10-18 15:50	40.1	61.4	42.4	61.3	41.2	34.2
2015-10-18 16:05	40.7	62.1	43.1	62.0	42.0	35.3
2015-10-18 16:20	41.4	63.0	43.7	62.8	42.6	36.0
2015-10-18 16:35	42.0	63.4	44.3	63.3	43.3	36.8
2015-10-18 16:50	42.5	64.1	45.0	64.0	43.8	37.6
2015-10-18 17:05	43.1	64.7	45.6	64.6	44.4	38.3
2015-10-18 17:20	43.6	65.3	46.2	65.2	44.9	39.0
2015-10-18 17:35	44.1	65.8	46.6	65.8	45.4	39.6
2015-10-18 17:50	44.5	66.4	47.2	66.3	45.9	40.3
2015-10-18 18:05	44.9	66.9	47.7	66.8	46.4	41.0
2015-10-18 18:20	45.4	67.3	48.2	67.2	46.8	41.6
2015-10-18 18:35	46.0	67.9	48.8	67.9	47.4	42.1
2015-10-18 18:50	46.2	68.5	49.2	68.4	47.8	42.7
2015-10-18 19:05	46.6	68.9	49.7	68.8	48.1	43.2
2015-10-18 19:20	47.0	69.3	50.1	69.2	48.6	43.7
2015-10-18 19:35	47.3	69.6	50.4	69.5	48.8	44.2
2015-10-18 19:50	47.5	70.1	50.7	69.9	49.2	44.7
2015-10-18 20:05	47.8	70.3	51.1	70.2	49.4	45.0
2015-10-18 20:20	48.0	70.6	51.3	70.5	49.7	45.4

Essai réalisé par R.B., B.C., G.P., P.C.   Date : 2015-10-18   Heure : 10:35:00   Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : Échauffement 105% Un
Client : ABB
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données d'échauffement

3/6

Type d'échauffement : Échauffement 105% Un
Position du changeur de prise : na

Date heure	HuileH 1	Amb 1	Amb 2	Amb 3	Amb moy	Delta T	RH 1	RB 1	RH 2	RB 2	RH 3
2015-10-18 20:35	68.0	23.2	23.0	23.3	23.2	44.8	70.6	49.4	71.1	50.7	70.7
2015-10-18 20:50	68.4	23.3	23.1	23.4	23.3	45.1	70.9	49.7	71.4	51.0	71.0
2015-10-18 21:05	68.6	23.4	23.1	23.4	23.3	45.3	71.1	50.0	71.6	51.4	71.2
2015-10-18 21:20	68.8	23.3	23.1	23.5	23.3	45.5	71.4	49.9	71.9	51.4	71.5
2015-10-18 21:35	69.0	23.4	23.1	23.5	23.3	45.7	71.7	50.4	72.2	51.9	71.8
2015-10-18 21:50	69.3	23.4	23.2	23.5	23.4	45.9	71.9	50.4	72.4	51.9	72.0
2015-10-18 22:05	69.6	23.5	23.2	23.6	23.4	46.2	72.2	50.8	72.7	52.3	72.3
2015-10-18 22:20	69.8	23.6	23.3	23.6	23.5	46.3	72.5	51.1	73.0	52.6	72.5
2015-10-18 22:35	70.0	23.6	23.2	23.7	23.5	46.5	72.7	51.3	73.2	52.7	72.8
2015-10-18 22:50	70.1	23.6	23.2	23.6	23.5	46.6	72.8	51.1	73.3	52.7	73.0
2015-10-18 23:05	70.4	23.7	23.3	23.7	23.6	46.8	73.0	51.4	73.5	53.0	73.1
2015-10-18 23:20	70.5	23.7	23.3	23.7	23.6	46.9	73.1	51.5	73.6	53.1	73.1
2015-10-18 23:35	70.6	23.7	23.4	23.8	23.6	47.0	73.3	51.8	73.8	53.3	73.3
2015-10-18 23:50	70.7	23.7	23.4	23.8	23.6	47.1	73.4	51.6	73.9	53.3	73.4
2015-10-19 00:05	70.8	23.7	23.4	23.8	23.6	47.2	73.5	52.0	74.0	53.5	73.6
2015-10-19 00:20	71.0	23.8	23.4	23.8	23.7	47.3	73.7	52.0	74.2	53.6	73.8
2015-10-19 00:35	71.2	23.8	23.4	23.9	23.7	47.5	73.8	51.9	74.3	53.6	73.9
2015-10-19 00:50	71.2	23.8	23.4	23.8	23.7	47.5	73.9	52.2	74.4	53.8	74.0
2015-10-19 01:05	71.3	23.9	23.5	23.9	23.8	47.5	74.0	52.1	74.4	53.8	74.1
2015-10-19 01:20	71.4	23.9	23.4	23.9	23.7	47.7	74.1	52.4	74.6	54.0	74.2
2015-10-19 01:35	71.6	23.9	23.5	23.9	23.8	47.8	74.3	52.4	74.7	54.0	74.3
2015-10-19 01:50	71.6	23.9	23.5	23.9	23.8	47.8	74.3	52.3	74.8	54.1	74.3
2015-10-19 02:05	71.7	24.0	23.5	24.0	23.8	47.9	74.3	52.6	74.9	54.2	74.4
2015-10-19 02:20	71.8	23.9	23.5	23.9	23.8	48.0	74.5	52.4	74.9	54.3	74.6
2015-10-19 02:35	71.9	24.0	23.5	23.9	23.8	48.1	74.5	52.7	75.1	54.5	74.6
2015-10-19 02:50	72.0	24.0	23.5	24.0	23.8	48.2	74.7	52.6	75.2	54.4	74.7
2015-10-19 03:05	72.0	24.0	23.6	24.0	23.9	48.1	74.7	52.8	75.2	54.5	74.8
2015-10-19 03:20	72.1	24.0	23.6	24.0	23.9	48.2	74.8	52.9	75.3	54.6	74.9
2015-10-19 03:35	72.1	24.0	23.6	24.0	23.9	48.2	74.9	53.0	75.3	54.6	74.9
2015-10-19 03:50	72.2	24.1	23.6	24.0	23.9	48.3	74.9	53.0	75.3	54.7	74.9
2015-10-19 04:05	72.3	24.1	23.7	24.1	24.0	48.3	75.0	53.1	75.4	54.8	75.0
2015-10-19 04:20	72.4	24.1	23.7	24.0	23.9	48.5	75.1	53.1	75.5	54.7	75.2
2015-10-19 04:35	72.4	24.1	23.7	24.0	23.9	48.5	75.1	53.2	75.6	54.8	75.1
2015-10-19 04:50	72.5	24.1	23.7	24.1	24.0	48.5	75.2	53.3	75.7	54.9	75.2
2015-10-19 05:05	72.5	24.1	23.6	24.0	23.9	48.6	75.2	53.3	75.7	54.9	75.2
2015-10-19 05:20	72.6	24.2	23.7	24.1	24.0	48.6	75.3	53.2	75.8	55.0	75.3
2015-10-19 05:35	72.6	24.2	23.7	24.1	24.0	48.6	75.3	53.3	75.7	55.0	75.4
2015-10-19 05:50	72.6	24.2	23.7	24.1	24.0	48.6	75.4	53.4	75.7	55.0	75.3
2015-10-19 06:05	72.7	24.2	23.7	24.1	24.0	48.7	75.4	53.5	75.9	55.2	75.5
2015-10-19 06:20	72.7	24.2	23.7	24.1	24.0	48.7	75.4	53.4	75.9	55.1	75.5

Essai réalisé par R.B., B.C., G.P., P.C.   Date : 2015-10-18   Heure : 10:35:00   Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : Échauffement 105% Un
Client : ABB
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données d'échauffement

4/6

Type d'échauffement : Échauffement 105% Un
Position du changeur de prise : na

Date heure	RB 3	RH 4	RB 4	RH moy	RB moy	HuileB 1
2015-10-18 20:35	48.4	70.9	51.6	70.8	50.0	45.8
2015-10-18 20:50	48.6	71.2	51.9	71.1	50.3	46.1
2015-10-18 21:05	48.9	71.5	52.1	71.4	50.6	46.4
2015-10-18 21:20	49.1	71.8	52.4	71.6	50.7	46.7
2015-10-18 21:35	49.4	72.0	52.6	71.9	51.1	47.1
2015-10-18 21:50	49.6	72.3	52.9	72.2	51.2	47.3
2015-10-18 22:05	49.9	72.6	53.1	72.4	51.5	47.6
2015-10-18 22:20	50.1	72.8	53.4	72.7	51.8	47.9
2015-10-18 22:35	50.2	73.0	53.6	72.9	52.0	48.1
2015-10-18 22:50	50.3	73.1	53.7	73.0	52.0	48.3
2015-10-18 23:05	50.5	73.3	53.9	73.2	52.2	48.5
2015-10-18 23:20	50.7	73.4	54.0	73.3	52.3	48.7
2015-10-18 23:35	50.8	73.6	54.2	73.5	52.5	48.9
2015-10-18 23:50	50.9	73.7	54.2	73.6	52.5	49.1
2015-10-19 00:05	51.0	73.9	54.4	73.8	52.7	49.3
2015-10-19 00:20	51.2	74.1	54.6	73.9	52.8	49.4
2015-10-19 00:35	51.3	74.2	54.7	74.0	52.9	49.6
2015-10-19 00:50	51.3	74.2	54.8	74.1	53.0	49.7
2015-10-19 01:05	51.3	74.3	54.8	74.2	53.0	49.7
2015-10-19 01:20	51.5	74.4	55.0	74.3	53.2	49.8
2015-10-19 01:35	51.5	74.6	55.1	74.5	53.2	49.9
2015-10-19 01:50	51.7	74.6	55.1	74.5	53.3	50.0
2015-10-19 02:05	51.7	74.7	55.2	74.6	53.4	50.1
2015-10-19 02:20	51.8	74.8	55.4	74.7	53.5	50.2
2015-10-19 02:35	52.0	74.9	55.4	74.8	53.6	50.3
2015-10-19 02:50	51.9	75.0	55.5	74.9	53.6	50.3
2015-10-19 03:05	52.0	75.1	55.5	74.9	53.7	50.4
2015-10-19 03:20	52.1	75.2	55.7	75.0	53.8	50.5
2015-10-19 03:35	52.1	75.2	55.6	75.1	53.8	50.5
2015-10-19 03:50	52.2	75.2	55.7	75.1	53.9	50.6
2015-10-19 04:05	52.3	75.3	55.8	75.2	54.0	50.7
2015-10-19 04:20	52.3	75.4	55.8	75.3	54.0	50.7
2015-10-19 04:35	52.3	75.4	55.9	75.3	54.0	50.8
2015-10-19 04:50	52.4	75.5	55.9	75.4	54.1	50.9
2015-10-19 05:05	52.5	75.5	56.0	75.4	54.2	50.9
2015-10-19 05:20	52.5	75.6	56.2	75.5	54.2	51.0
2015-10-19 05:35	52.5	75.6	56.1	75.5	54.2	51.0
2015-10-19 05:50	52.6	75.6	56.2	75.5	54.3	51.1
2015-10-19 06:05	52.7	75.7	56.2	75.6	54.4	51.2
2015-10-19 06:20	52.7	75.8	56.2	75.6	54.4	51.2

Essai réalisé par R.B., B.C., G.P., P.C.   Date : 2015-10-18   Heure : 10:35:00   Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : Échauffement 105% Un
Client : ABB
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données d'échauffement

5/6

Type d'échauffement : Échauffement 105% Un
Position du changeur de prise : na

Date heure	HuileH 1	Amb 1	Amb 2	Amb 3	Amb moy	Delta T	RH 1	RB 1	RH 2	RB 2	RH 3
2015-10-19 06:35	72.8	24.3	23.7	24.2	24.1	48.7	75.5	53.6	76.0	55.3	75.6
2015-10-19 06:50	73.0	24.3	23.8	24.2	24.1	48.9	75.6	53.7	76.0	55.4	75.6
2015-10-19 07:05	72.9	24.2	23.7	24.1	24.0	48.9	75.6	53.5	76.1	55.3	75.7
2015-10-19 07:20	73.0	24.3	23.8	24.2	24.1	48.9	75.7	53.9	76.2	55.6	75.8
2015-10-19 07:35	73.1	24.3	23.8	24.2	24.1	49.0	75.7	53.7	76.2	55.4	75.8
2015-10-19 07:50	73.1	24.3	23.8	24.2	24.1	49.0	75.8	54.0	76.2	55.6	75.9
2015-10-19 08:05	73.0	24.3	23.8	24.2	24.1	48.9	75.7	53.7	76.2	55.5	75.7
2015-10-19 08:20	73.1	24.3	23.8	24.2	24.1	49.0	75.8	54.0	76.2	55.6	75.9
2015-10-19 08:28	73.2	24.3	23.9	24.2	24.1	49.1	75.9	54.0	76.4	55.6	75.9

Essai réalisé par R.B., B.C., G.P., P.C. Date : 2015-10-18 Heure : 10:35:00 Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : Échauffement 105% Un
Client : ABB
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données d'échauffement

6/6

Type d'échauffement : Échauffement 105% Un
Position du changeur de prise : na

Date heure	RB 3	RH 4	RB 4	RH moy	RB moy	HuileB 1					
2015-10-19 06:35	52.8	75.8	56.3	75.7	54.5	51.2					
2015-10-19 06:50	52.9	75.9	56.4	75.8	54.6	51.3					
2015-10-19 07:05	52.9	76.0	56.4	75.8	54.5	51.4					
2015-10-19 07:20	53.0	76.0	56.5	75.9	54.8	51.5					
2015-10-19 07:35	53.0	76.0	56.5	75.9	54.6	51.5					
2015-10-19 07:50	53.0	76.1	56.6	76.0	54.8	51.6					
2015-10-19 08:05	53.0	76.0	56.5	75.9	54.7	51.6					
2015-10-19 08:20	53.1	76.1	56.5	76.0	54.8	51.6					
2015-10-19 08:28	53.1	76.2	56.6	76.1	54.8	51.7					

Essai réalisé par R.B., B.C., G.P., P.C.

Date : 2015-10-18 Heure : 10:35:00

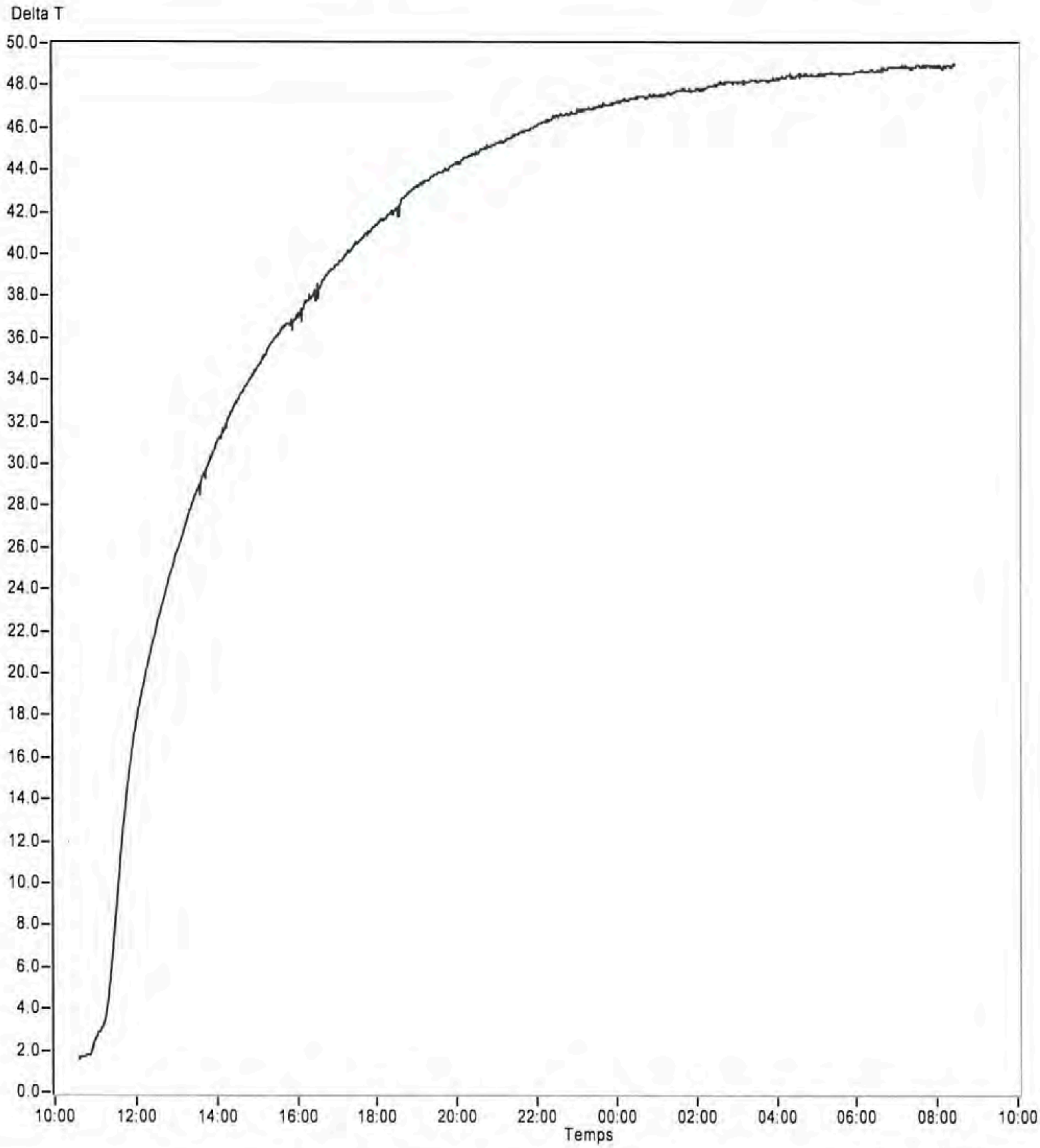
Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai :	Échauffement 105% Un	No de contrat :	J794315045
Client :	ABB	No d'essai :	001
Objet d'essai :	Inductance shunt 3-ph. 140 MVARs	No de série :	15079-01

Delta T vs Temps

Type d'échauffement : Échauffement 105% Un
Position du changeur de prise : na
Début de stabilité : 2015-10-18 22:27



Essai réalisé par R.B., B.C., G.P., P.C. Date : 2015-10-18 Heure : 10:35:00 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : Échauffement 105% Un
Client : ABB
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données de Résistance à Chaud

1/2

Type d'échauffement : Échauffement 105% Un
Position du changeur de prise : na

Temps (sec)	H1-H01	H2-H02	H3-H03		
(Shunts)	1990674	1990674	1990674		
210	7.86460E-1	7.87234E-1	7.85115E-1		
220	7.86108E-1	7.86874E-1	7.84772E-1		
230	7.85738E-1	7.86514E-1	7.84419E-1		
240	7.85489E-1	7.86255E-1	7.84170E-1		
250	7.85161E-1	7.85926E-1	7.83847E-1		
260	7.84753E-1	7.85522E-1	7.83444E-1		
270	7.84485E-1	7.85250E-1	7.83195E-1		
280	7.84228E-1	7.84980E-1	7.82937E-1		
290	7.83887E-1	7.84625E-1	7.82599E-1		
300	7.83716E-1	7.84452E-1	7.82434E-1		
310	7.83380E-1	7.84110E-1	7.82100E-1		
320	7.83118E-1	7.83850E-1	7.81853E-1		
330	7.82779E-1	7.83486E-1	7.81506E-1		
340	7.82484E-1	7.83192E-1	7.81228E-1		
350	7.82218E-1	7.82931E-1	7.80968E-1		
360	7.81919E-1	7.82625E-1	7.80666E-1		
370	7.81675E-1	7.82376E-1	7.80424E-1		
380	7.81424E-1	7.82109E-1	7.80180E-1		
390	7.81153E-1	7.81835E-1	7.79918E-1		
400	7.80901E-1	7.81582E-1	7.79673E-1		
410	7.80820E-1	7.81481E-1	7.79583E-1		
420	7.80474E-1	7.81143E-1	7.79256E-1		
430	7.80280E-1	7.80935E-1	7.79054E-1		
440	7.80006E-1	7.80652E-1	7.78780E-1		
450	7.79819E-1	7.80448E-1	7.78588E-1		
460	7.79618E-1	7.80238E-1	7.78397E-1		
470	7.79399E-1	7.80024E-1	7.78188E-1		
480	7.79235E-1	7.79842E-1	7.78022E-1		
490	7.78994E-1	7.79596E-1	7.77789E-1		
500	7.78795E-1	7.79389E-1	7.77582E-1		
510	7.78598E-1	7.79193E-1	7.77406E-1		
520	7.78392E-1	7.78978E-1	7.77196E-1		
530	7.78252E-1	7.78827E-1	7.77045E-1		
540	7.78062E-1	7.78619E-1	7.76853E-1		
550	7.77925E-1	7.78479E-1	7.76707E-1		
560	7.77724E-1	7.78270E-1	7.76520E-1		
570	7.77546E-1	7.78077E-1	7.76342E-1		
580	7.77392E-1	7.77925E-1	7.76194E-1		
590	7.77184E-1	7.77713E-1	7.75985E-1		

Essai réalisé par R.B., B.C., G.P., P.C. Date : 2015-10-19 Heure : 08:32:22 Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : Échauffement 105% Un
Client : ABB
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données de Résistance à Chaud

2/2

Type d'échauffement : Échauffement 105% Un
Position du changeur de prise : na

Temps (sec)	H1-H01	H2-H02	H3-H03		
600	7.77036E-1	7.77551E-1	7.75825E-1		

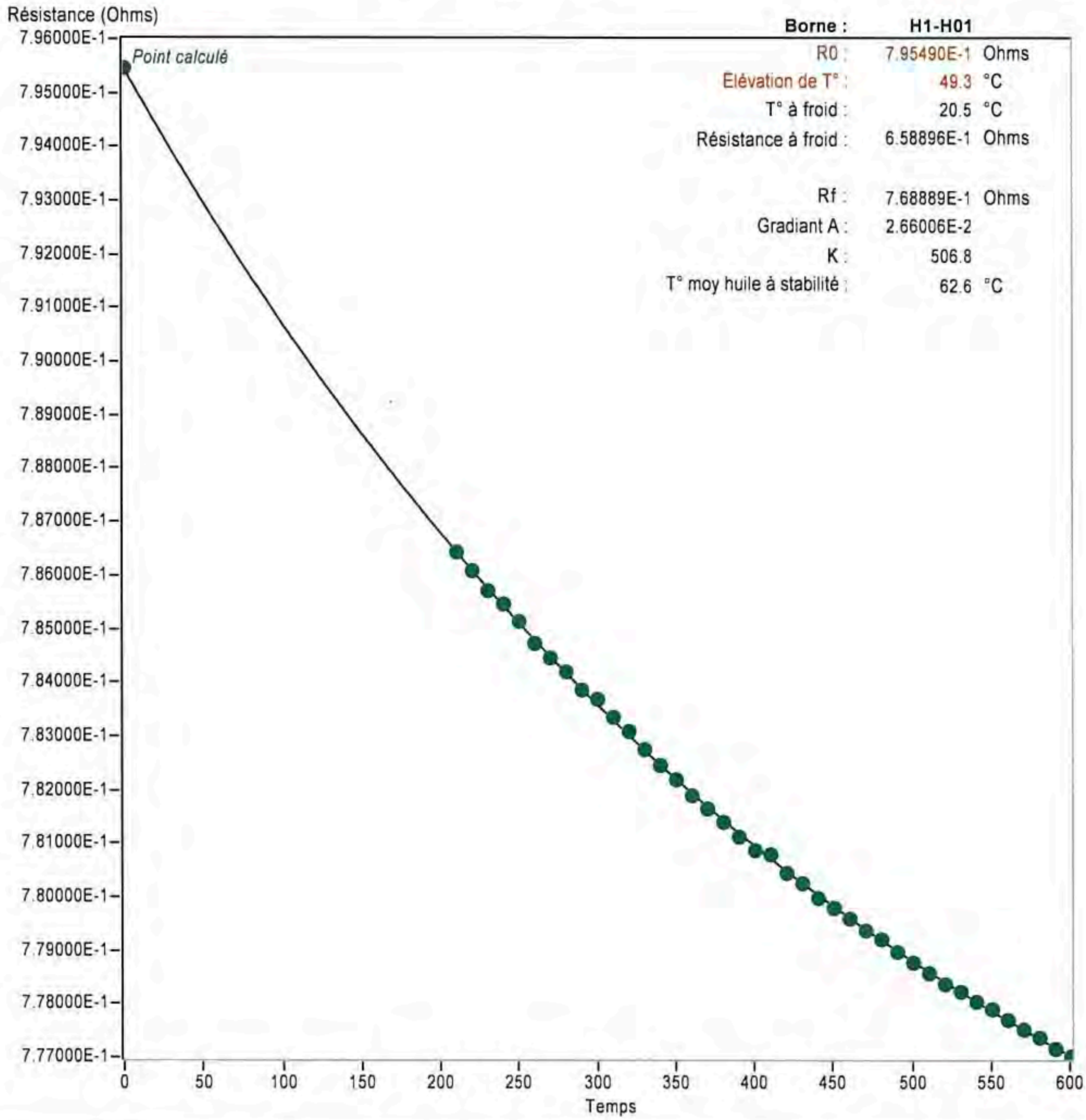
Essai réalisé par R.B., B.C., G.P., P.C. Date : 2015-10-19 Heure : 08:32:22 Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai :	Echauffement 105% Un	No de contrat :	J794315045
Client :	ABB	No d'essai :	001
Objet d'essai :	Inductance shunt 3-ph. 140 MVARs	No de série :	15079-01

Élévation de Température

T° ambiante à stabilité :	24.1 °C	T° ambiante à coupure :	24.1 °C	Type d'échauffement :	Échauffement 105% Un
T° radiateur haut à stabilité :	76.1 °C	T° radiateur haut à coupure :	76.1 °C	Position du changeur de prise :	na
T° radiateur bas à stabilité :	54.8 °C	T° radiateur bas à coupure :	54.8 °C	Nombre de ventilateurs :	0
T° huile haut à stabilité :	73.2 °C	T° huile haut à coupure :	73.2 °C	Nombre de radiateurs :	17
dT° à stabilité :	49.1 °C	dT° à coupure :	49.1 °C		



Essai réalisé par R.B., B.C., G.P., P.C. Date : 2015-10-18 Heure : 10:35:00 Page :

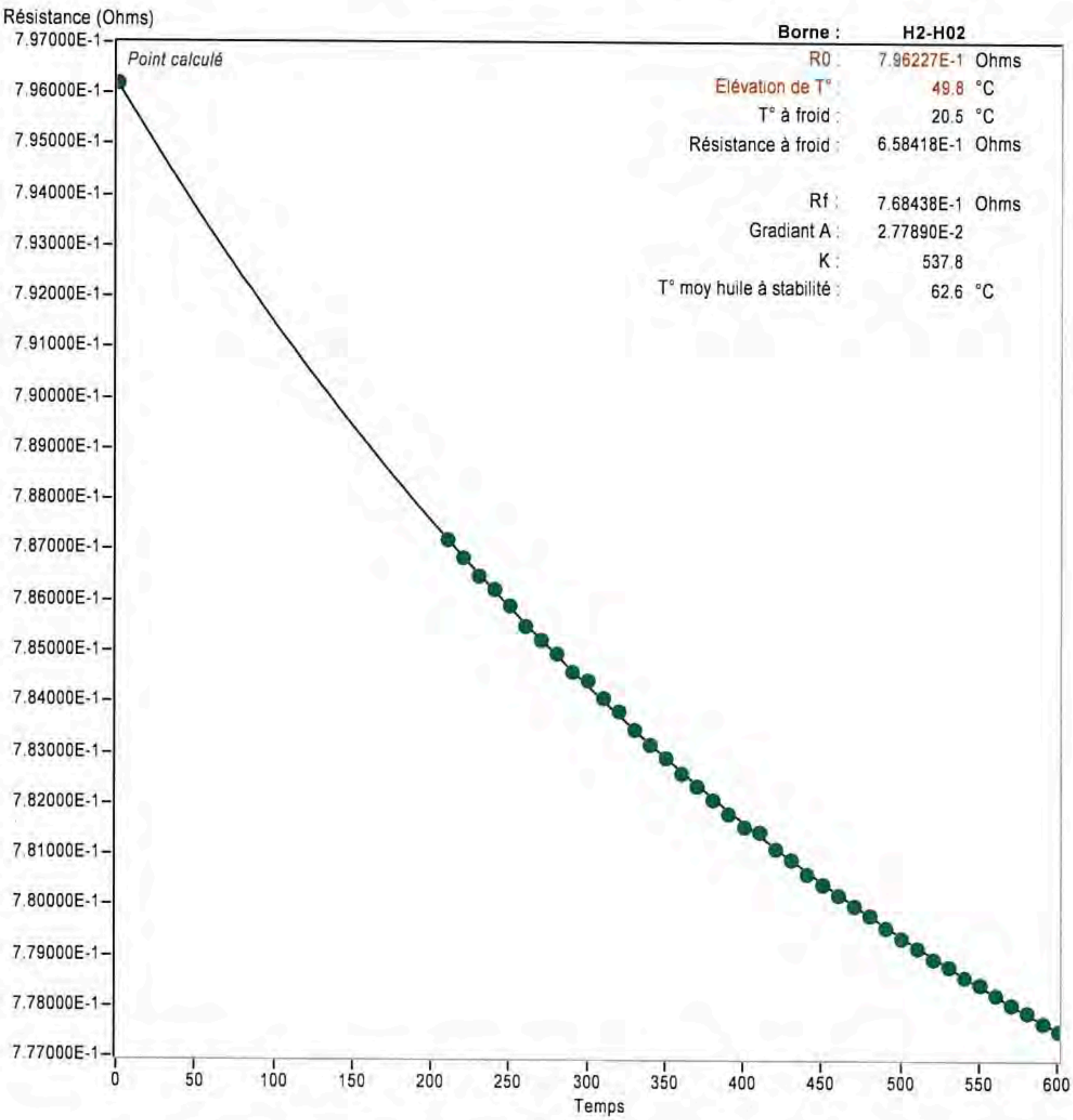
Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai :	Échauffement 105% Un	No de contrat :	J794315045
Client :	ABB	No d'essai :	001
Objet d'essai :	Inductance shunt 3-ph. 140 MVARs	No de série :	15079-01

Élévation de Température

T° ambiante à stabilité :	24.1 °C	T° ambiante à coupure :	24.1 °C	Type d'échauffement :	Échauffement 105% Un
T° radiateur haut à stabilité :	76.1 °C	T° radiateur haut à coupure :	76.1 °C	Position du changeur de prise :	na
T° radiateur bas à stabilité :	54.8 °C	T° radiateur bas à coupure :	54.8 °C	Nombre de ventilateurs :	0
T° huile haut à stabilité :	73.2 °C	T° huile haut à coupure :	73.2 °C	Nombre de radiateurs :	17
dT° à stabilité :	49.1 °C	dT° à coupure :	49.1 °C		

Borne :	H2-H02	
R0 :	7.96227E-1	Ohms
Elévation de T° :	49.8	°C
T° à froid :	20.5	°C
Résistance à froid :	6.58418E-1	Ohms
Rf :	7.68438E-1	Ohms
Gradiant A :	2.77890E-2	
K :	537.8	
T° moy huile à stabilité :	62.6	°C



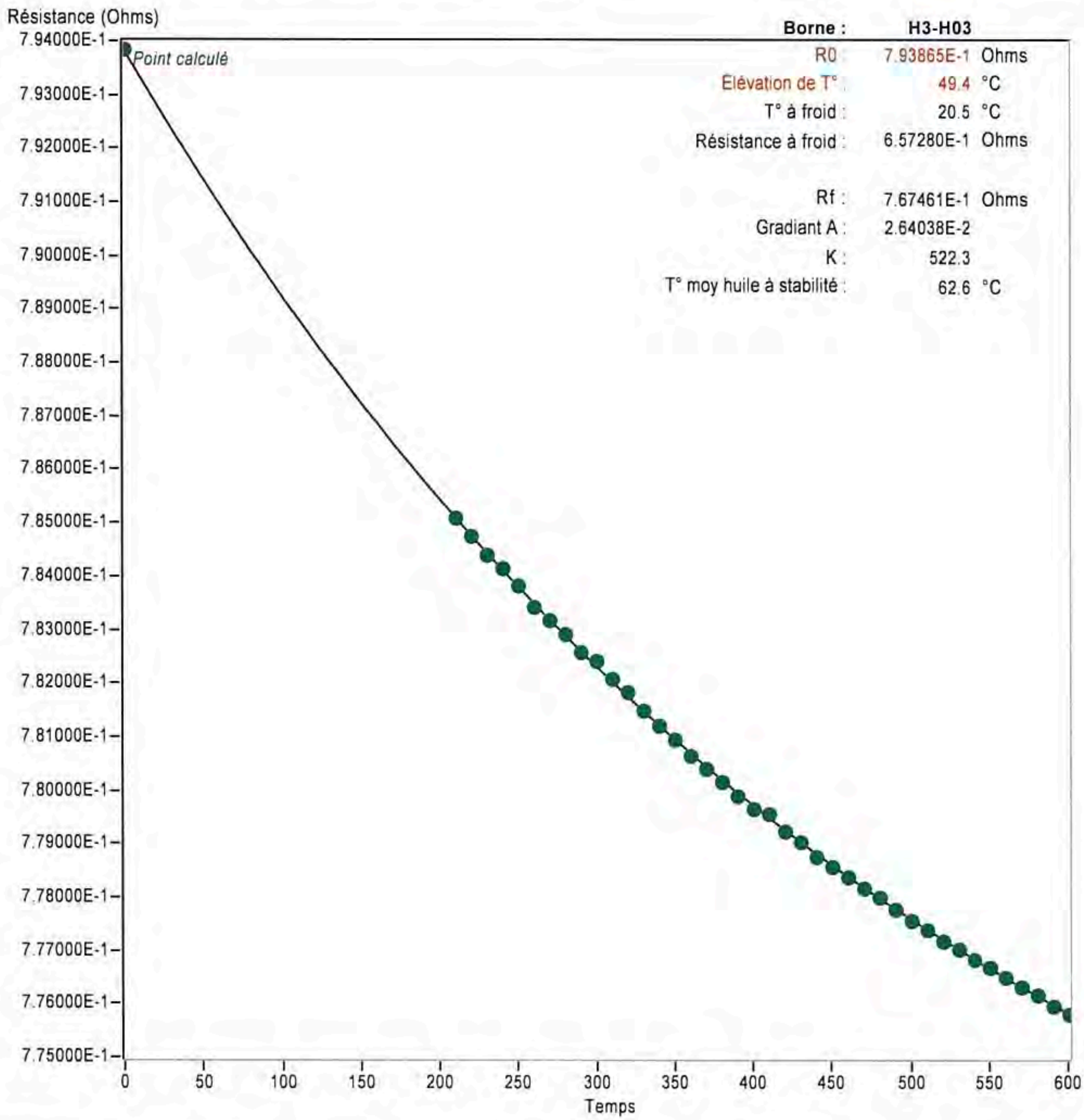
Essai réalisé par R.B., B.C., G.P., P.C.   Date : 2015-10-18   Heure : 10:35:00   Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai :	Échauffement 105% Un	No de contrat :	J794315045
Client :	ABB	No d'essai :	001
Objet d'essai :	Inductance shunt 3-ph. 140 MVARs	No de série :	15079-01

Élévation de Température

T° ambiante à stabilité :	24.1 °C	T° ambiante à coupure :	24.1 °C	Type d'échauffement :	Échauffement 105% Un
T° radiateur haut à stabilité :	76.1 °C	T° radiateur haut à coupure :	76.1 °C	Position du changeur de prise :	na
T° radiateur bas à stabilité :	54.8 °C	T° radiateur bas à coupure :	54.8 °C	Nombre de ventilateurs :	0
T° huile haut à stabilité :	73.2 °C	T° huile haut à coupure :	73.2 °C	Nombre de radiateurs :	17
dT° à stabilité :	49.1 °C	dT° à coupure :	49.1 °C		



Essai réalisé par R.B., B.C., G.P., P.C. Date : 2015-10-18 Heure : 10:35:00 Page :

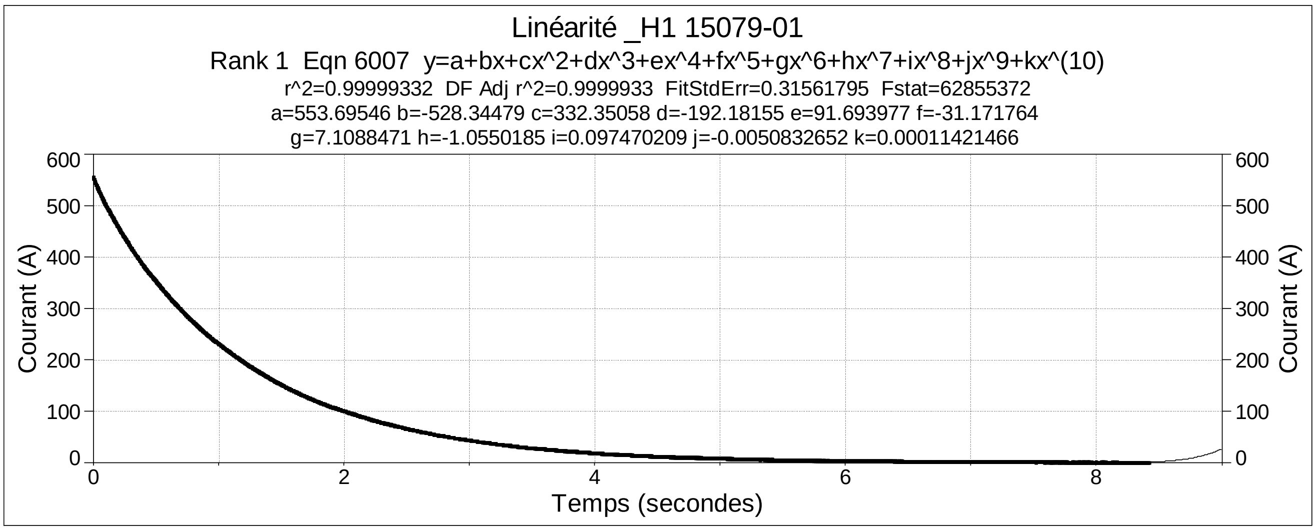
Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Mesure de la linéarité
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.
Tension	315 kV

Courant nominal (RMS)	256.60	A	**Instruments utilisés**	**# IREQ**
Tension nominale (phase-terre)	181865	V		
Valeur de la résistance à froid de l'inductance	0.658896	ohms	Pince ampèremétrique	2060430
Valeur de la résistance à chaud de l'inductance	0.687886	ohms	Oscillo. TDS5104B	2050019
Valeur de la résistance de décharge	0.894781	ohms		
Valeur de la résistance totale	1.568172	ohms		

Essai	p.u.	Courant décharge
	%	Ic
562.48	2.19	8.0



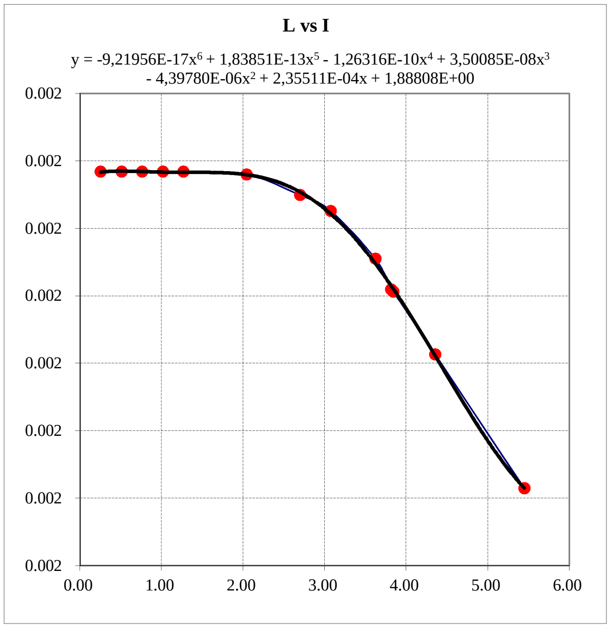
	I	p.u.	R total	Temps	d(i)/d(t)	L
	(A)		(ohm)	(sec)		(H)
Mesure AC Essai pertes	25.10	0.10				1.892
	50.90	0.20				1.892
	76.00	0.30				1.892
	101.30	0.39				1.892
	126.50	0.49				1.892
	204.20	0.80				1.890
Mesure DC	269.52	1.05	1.56817	0.82	-225.4438	1.875
	307.34	1.20	1.56817	0.67	-258.7110	1.863
	362.06	1.41	1.56817	0.47	-310.6786	1.828
	381.41	1.49	1.56817	0.41	-331.3995	1.805
	384.19	1.50	1.56817	0.40	-334.1318	1.803
	435.44	1.70	1.56817	0.26	-388.7142	1.757
	544.61	2.12	1.56817	0.02	-515.2785	1.657

Essais par : NP Date : 2015-10-20

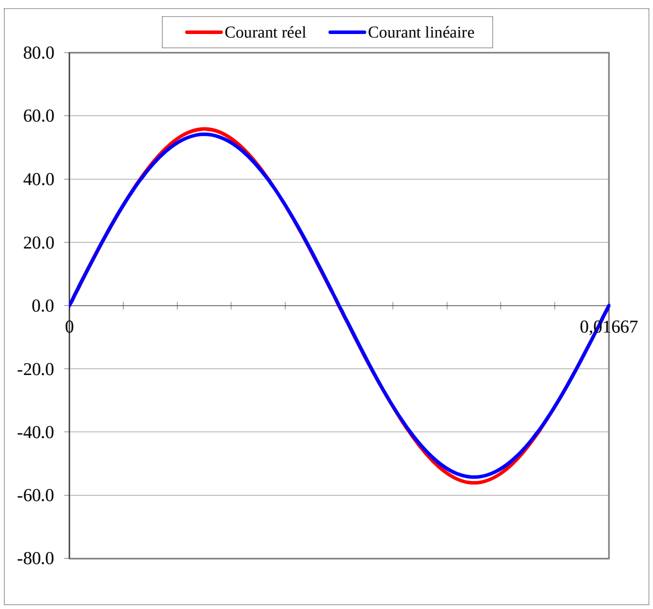
Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Mesure de la linéarité
N° Série	15079-01
N° Contrat	J794315045
Client	ABB Inc.
Tension	315 kV



Différence entre courant idéal et réel à 1,5 pu



p.u.	Impédance RMS (ohms)	Erreur (%)
1.00	710.8	0.00
1.05	710.1	-0.10
1.20	707.2	-0.52
1.50	697.8	-1.83

Essais par : NP Date : 2015-10-20

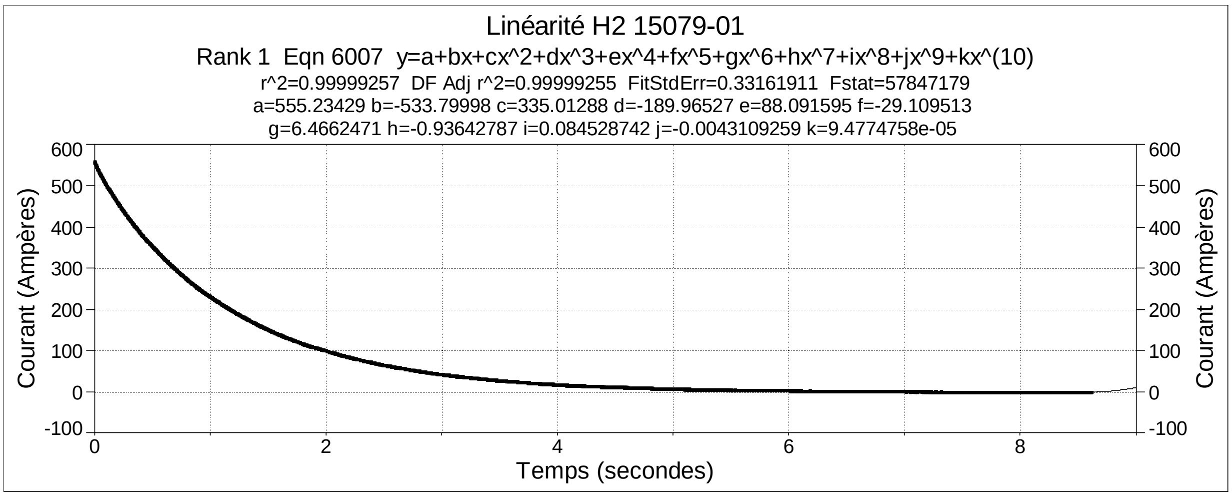
Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Mesure de la linéarité
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.
Tension	315 kV

Courant nominal (RMS)	256.60	A	**Instruments utilisés**	**# IREQ**
Tension nominale (phase-terre)	181865	V		
Valeur de la résistance à froid de l'inductance	0.658418	ohms	Pince ampèremétrique	2060430
Valeur de la résistance à chaud de l'inductance	0.691832	ohms	Oscillocope Tektronik	2050019
Valeur de la résistance de décharge	0.894781	ohms		
Valeur de la résistance totale	1.569906	ohms		

Essai	p.u.	Courant décharge
	%	Ic
562.48	2.19	8.0



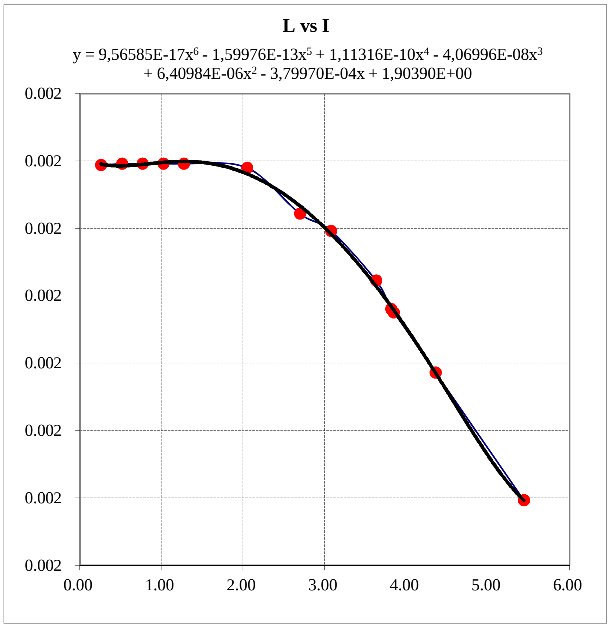
	I	p.u.	R total	Temps	d(i)/d(t)	L
	(A)		(ohm)	(sec)		(H)
Mesure AC Essai pertes	25.80	0.10				1.897
	51.60	0.20				1.898
	76.80	0.30				1.898
	102.30	0.40				1.898
	127.20	0.50				1.898
	204.80	0.80				1.895
Mesure DC	269.50	1.05	1.56991	0.816	-227.3472	1.861
	307.64	1.20	1.56991	0.662	-261.3049	1.848
	362.84	1.41	1.56991	0.470	-314.4739	1.811
	381.22	1.49	1.56991	0.410	-334.2966	1.790
	384.66	1.50	1.56991	0.400	-337.7761	1.788
	435.86	1.70	1.56991	0.260	-392.5460	1.743
	543.94	2.12	1.56991	0.024	-518.0428	1.648

Essais par : NP   Date : 2015-10-20

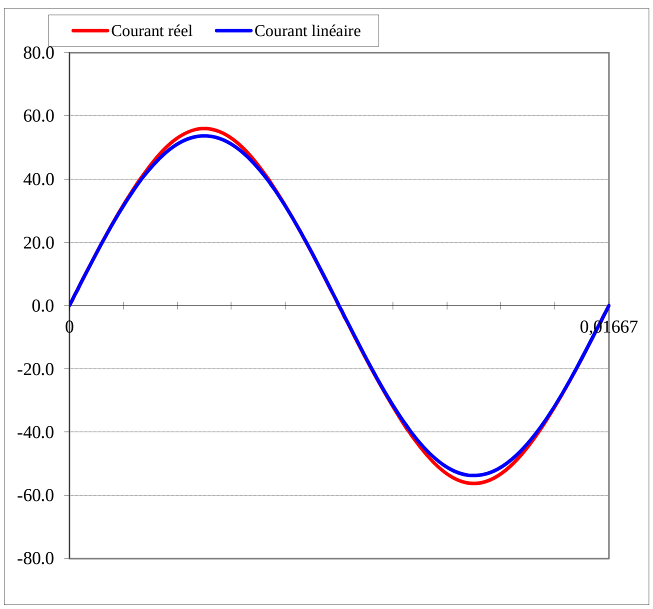
Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Mesure de la linéarité
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.
Tension	315 kV



Différence entre courant idéal et réel à 1,5 pu



p.u.	Impédance RMS (ohms)	Erreur (%)
1.00	711.4	0.00
1.05	710.4	-0.14
1.20	706.7	-0.65
1.50	696.5	-2.10

Essais par : NP   Date : 2015-10-20

Hydro Québec

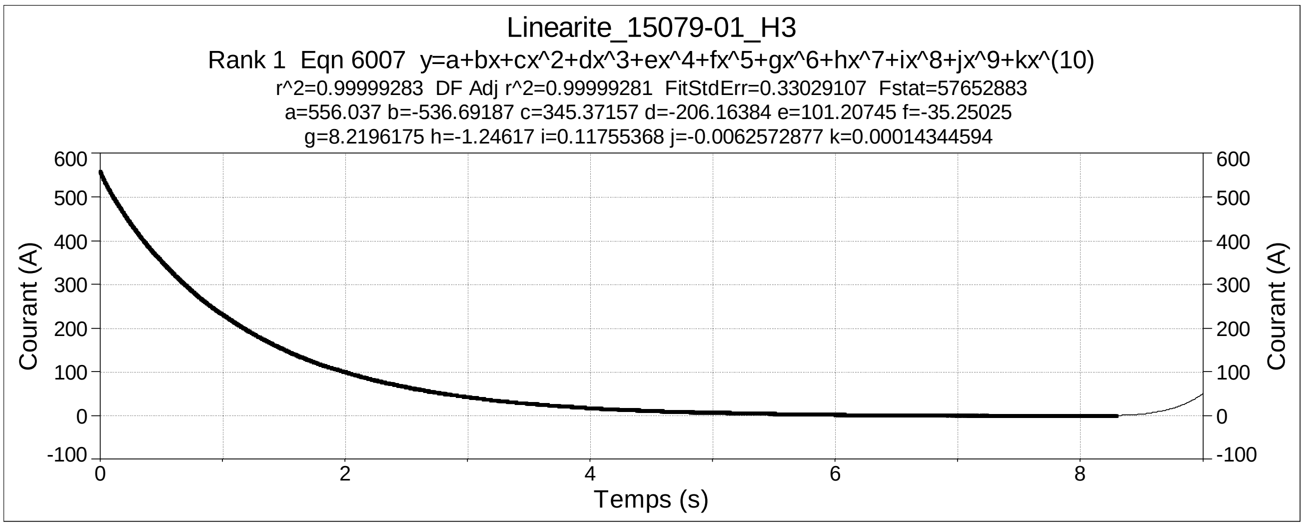
LABORATOIRE HAUTE TENSION

Type d'essai	Mesure de la linéarité
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.
Tension	315 kV

Courant nominal (RMS)	256.60	A
Tension nominale (phase-terre)	181865	V
Valeur de la résistance à froid de l'inductance	0.657280	ohms
Valeur de la résistance à chaud de l'inductance	0.690082	ohms
Valeur de la résistance de décharge	0.894781	ohms
Valeur de la résistance totale	1.568462	ohms

Instruments utilisés	# IREQ
Pince ampèremétrique	2060430
Oscillocope Tektronik	2050019

Essai	p.u.	Courant décharge
	%	Ic
562.48	2.19	8.0



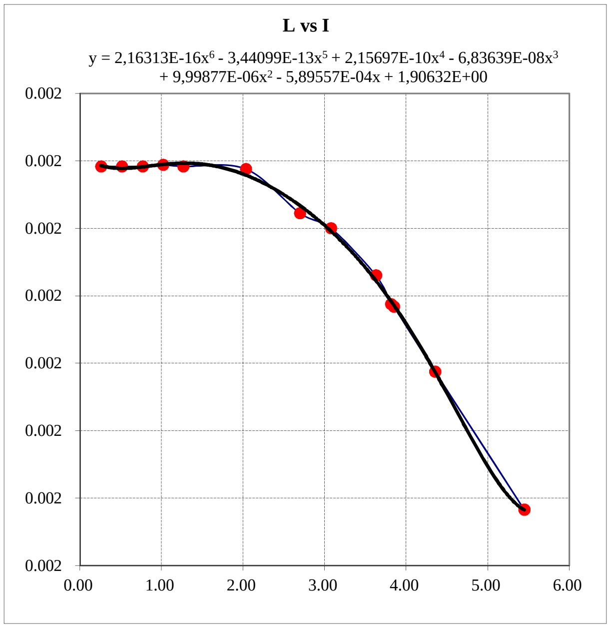
	I	p.u.	R total	Temps	d(i)/d(t)	L
	(A)		(ohm)	(sec)		(H)
Mesure AC Essai pertes	25.70	0.10				1.896
	51.40	0.20				1.896
	76.60	0.30				1.896
	101.80	0.40				1.897
	126.60	0.49				1.896
	203.50	0.79				1.894
Mesure DC	269.59	1.05	1.56846	0.82	-227.1748	1.861
	307.64	1.20	1.56846	0.66	-260.8048	1.850
	362.88	1.41	1.56846	0.47	-313.5658	1.815
	381.22	1.49	1.56846	0.41	-333.3130	1.794
	384.78	1.50	1.56846	0.40	-336.7846	1.792
	435.44	1.70	1.56846	0.26	-391.6645	1.744
	544.67	2.12	1.56846	0.02	-520.4648	1.641

Essais par : NP Date : 2015-10-20

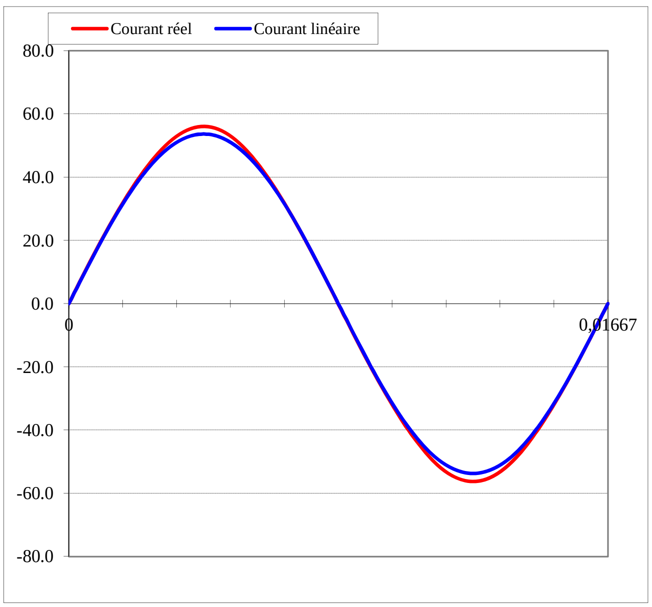
Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Mesure de la linéarité
N° Série	15079-01
N° Contrat	J794315045
Client	ABB Inc.
Tension	315 kV



Différence entre courant idéal et réel à 1,5 pu



p.u.	Impédance RMS (ohms)	Erreur (%)
1.00	711.1	0.00
1.05	710.2	-0.13
1.20	706.7	-0.62
1.50	696.2	-2.09

Essais par : NP Date : 2015-10-20

Hydro Québec

LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : linéaritée H1
Client : abb
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données de Résistance à Chaud

1/2

Type d'échauffement : linéaritée H1
Position du changeur de prise : na

Temps (sec)	H1-H01				
(Shunts)	1990674				
120	6.86501E-1				
130	6.86512E-1				
140	6.86448E-1				
150	6.86369E-1				
160	6.86298E-1				
170	6.86212E-1				
180	6.86134E-1				
190	6.86047E-1				
200	6.85941E-1				
210	6.85860E-1				
220	6.85766E-1				
230	6.85692E-1				
240	6.85594E-1				
250	6.85508E-1				
260	6.85418E-1				
270	6.85341E-1				
280	6.85246E-1				
290	6.85174E-1				
300	6.85077E-1				
310	6.84991E-1				
320	6.84917E-1				
330	6.84841E-1				
340	6.84763E-1				
350	6.84676E-1				
360	6.84595E-1				
370	6.84521E-1				
380	6.84435E-1				
390	6.84361E-1				
400	6.84272E-1				
410	6.84199E-1				
420	6.84131E-1				
430	6.84052E-1				
440	6.83983E-1				
450	6.83899E-1				
460	6.83835E-1				
470	6.83769E-1				
480	6.83686E-1				
490	6.83619E-1				
500	6.83547E-1				

Essai réalisé par R.B., R.P. Date : 2015-10-20 Heure : 13:55:26 Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : linéaritée H1
Client : abb
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 001
No de série : 15079-01

Données de Résistance à Chaud

2/2

Type d'échauffement : linéaritée H1
Position du changeur de prise : na

Temps (sec)	H1-H01				
510	6.83475E-1				
520	6.83404E-1				
530	6.83320E-1				
540	6.83257E-1				
550	6.83191E-1				
560	6.83120E-1				
570	6.83055E-1				
580	6.82991E-1				
590	6.82930E-1				
600	6.82856E-1				

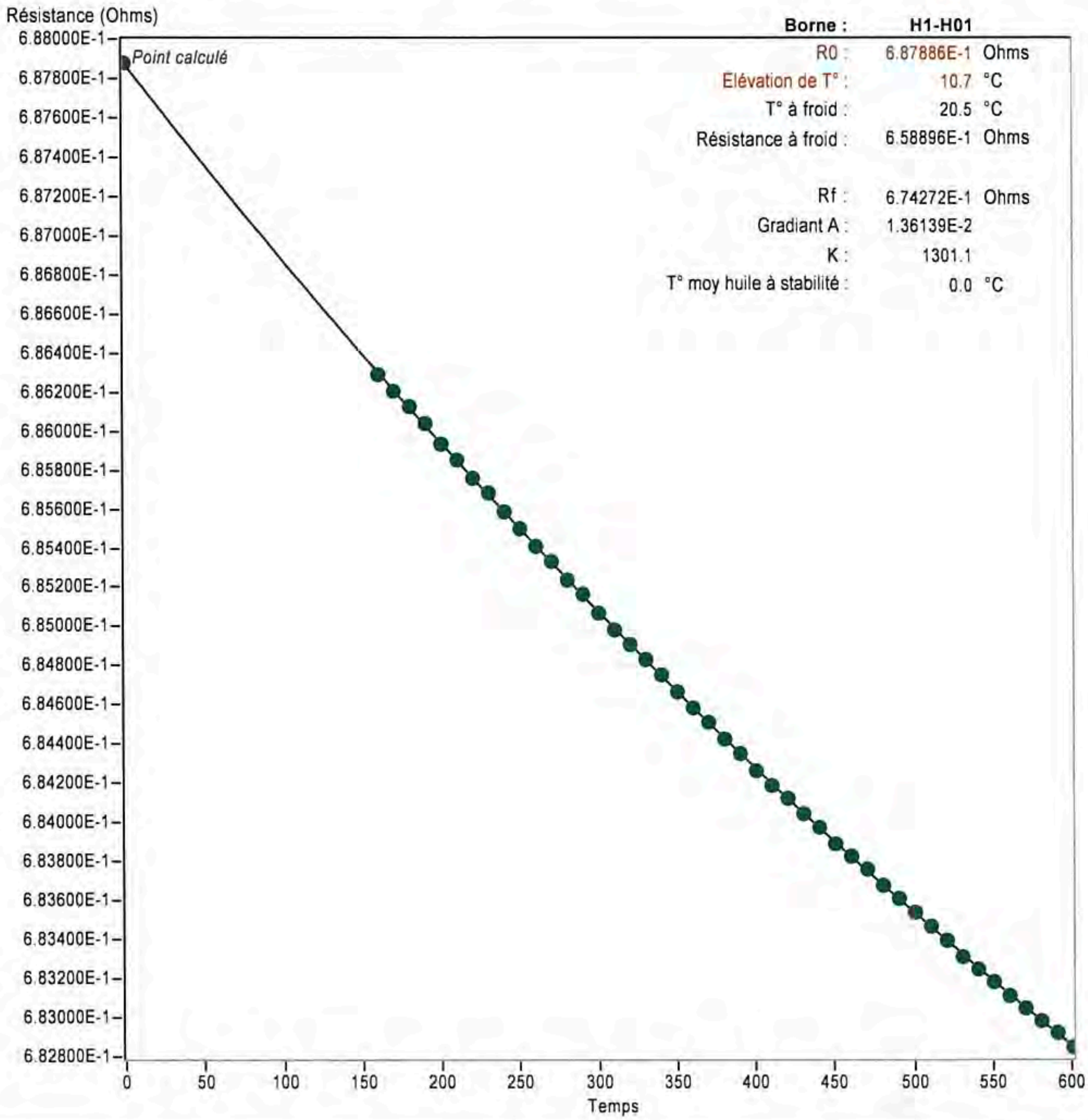
Essai réalisé par R.B., R.P. Date : 2015-10-20 Heure : 13:55:26 Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai :	linéaritée H1	No de contrat :	J794315045
Client :	abb	No d'essai :	001
Objet d'essai :	Inductance shunt 3-ph. 140 MVARs	No de série :	15079-01

Élévation de Température

T° ambiante à stabilité :	21.0 °C	T° ambiante à coupure :	21.0 °C	Type d'échauffement :	linéaritée H1
T° radiateur haut à stabilité :	0.0 °C	T° radiateur haut à coupure :	0.0 °C	Position du changeur de prise :	na
T° radiateur bas à stabilité :	0.0 °C	T° radiateur bas à coupure :	0.0 °C	Nombre de ventilateurs :	0
T° huile haut à stabilité :	0.0 °C	T° huile haut à coupure :	0.0 °C	Nombre de radiateurs :	0
dT° à stabilité :	0.0 °C	dT° à coupure :	0.0 °C		



Borne :	H1-H01	
R0 :	6.87886E-1	Ohms
Elévation de T° :	10.7	°C
T° à froid :	20.5	°C
Résistance à froid :	6.58896E-1	Ohms
Rf :	6.74272E-1	Ohms
Gradiant A :	1.36139E-2	
K :	1301.1	
T° moy huile à stabilité :	0.0	°C

Essai réalisé par R.B., R.P. Date : 2015-10-20 Heure : 13:50:00 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : linéaritée H2
Client : abb
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 002
No de série : 15079-01

Données de Résistance à Chaud

1/2

Type d'échauffement : linéaritée H2
Position du changeur de prise : na

Temps (sec)	H2-H02				
(Shunts)	1990674				
130	6.89977E-1				
140	6.89895E-1				
150	6.89804E-1				
160	6.89705E-1				
170	6.89580E-1				
180	6.89463E-1				
190	6.89340E-1				
200	6.89217E-1				
210	6.89104E-1				
220	6.88982E-1				
230	6.88860E-1				
240	6.88754E-1				
250	6.88636E-1				
260	6.88522E-1				
270	6.88401E-1				
280	6.88293E-1				
290	6.88182E-1				
300	6.88078E-1				
310	6.87961E-1				
320	6.87850E-1				
330	6.87742E-1				
340	6.87641E-1				
350	6.87527E-1				
360	6.87422E-1				
370	6.87316E-1				
380	6.87211E-1				
390	6.87114E-1				
400	6.87007E-1				
410	6.86910E-1				
420	6.86816E-1				
430	6.86712E-1				
440	6.86609E-1				
450	6.86506E-1				
460	6.86412E-1				
470	6.86319E-1				
480	6.86231E-1				
490	6.86145E-1				
500	6.86039E-1				
510	6.85947E-1				

Essai réalisé par R.B., R.P.   Date : 2015-10-20   Heure : 14:52:23   Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : linéaritée H2
Client : abb
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 002
No de série : 15079-01

Données de Résistance à Chaud

2/2

Type d'échauffement : linéaritée H2
Position du changeur de prise : na

Temps (sec)	H2-H02				
520	6.85855E-1				
530	6.85757E-1				
540	6.85663E-1				
550	6.85559E-1				
560	6.85474E-1				
570	6.85408E-1				
580	6.85309E-1				
590	6.85227E-1				
600	6.85143E-1				

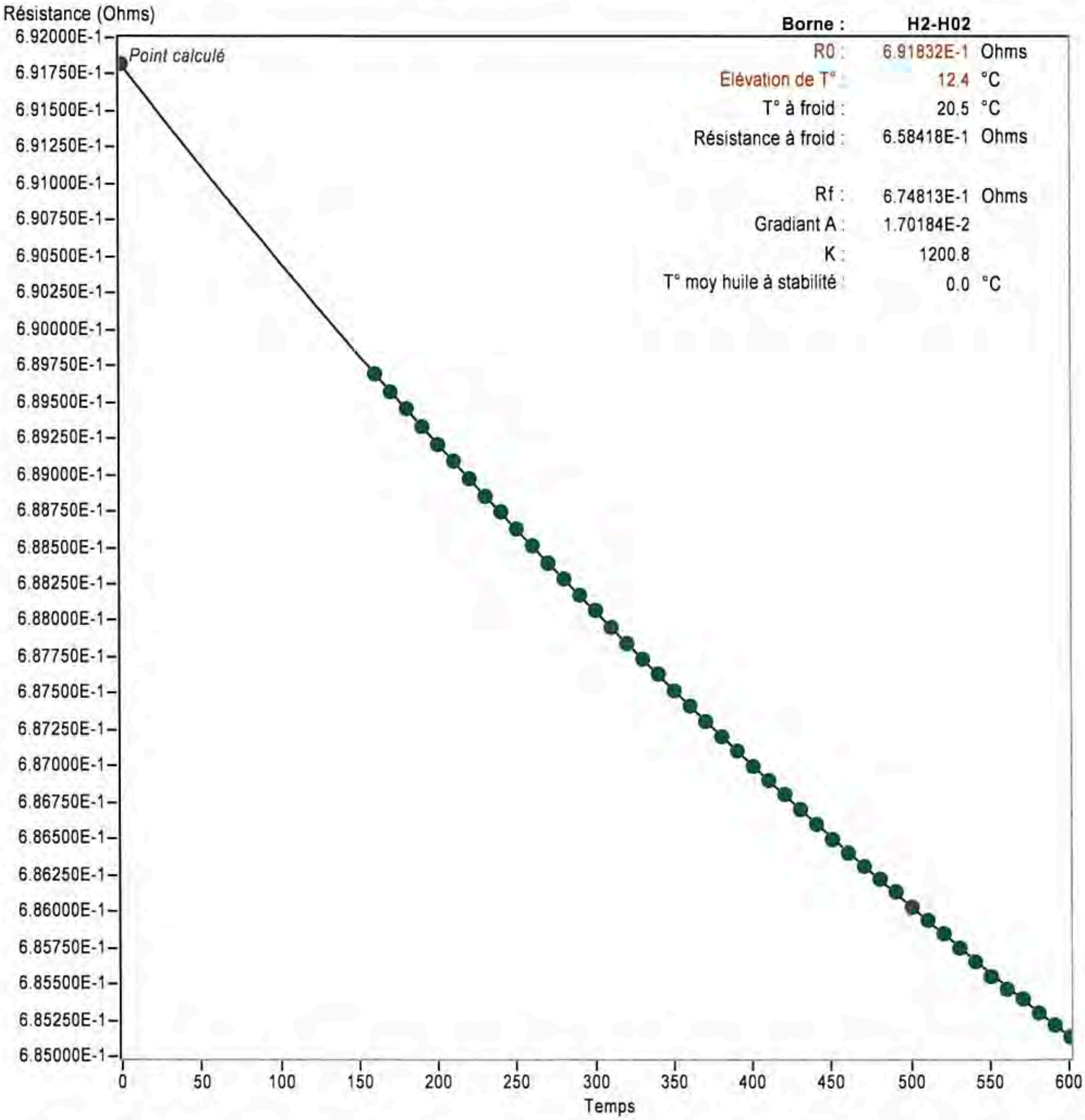
Essai réalisé par R.B., R.P.   Date : 2015-10-20   Heure : 14:52:23   Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai :	linéaritée H2	No de contrat :	J794315045
Client :	abb	No d'essai :	002
Objet d'essai :	Inductance shunt 3-ph. 140 MVARs	No de série :	15079-01

Élévation de Température

T° ambiante à stabilité :	21.0 °C	T° ambiante à coupure :	21.0 °C	Type d'échauffement :	linéaritée H2
T° radiateur haut à stabilité :	0.0 °C	T° radiateur haut à coupure :	0.0 °C	Position du changeur de prise :	na
T° radiateur bas à stabilité :	0.0 °C	T° radiateur bas à coupure :	0.0 °C	Nombre de ventilateurs :	0
T° huile haut à stabilité :	0.0 °C	T° huile haut à coupure :	0.0 °C	Nombre de radiateurs :	0
dT° à stabilité :	0.0 °C	dT° à coupure :	0.0 °C		



Borne :	H2-H02	
R0 :	6.91832E-1	Ohms
Élévation de T° :	12.4	°C
T° à froid :	20.5	°C
Résistance à froid :	6.58418E-1	Ohms
Rf :	6.74813E-1	Ohms
Gradiant A :	1.70184E-2	
K :	1200.8	
T° moy huile à stabilité :	0.0	°C

Essai réalisé par R.B., R.P. Date : 2015-10-20 Heure : 14:13:00 Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : linéaritée H3
Client : abb
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 003
No de série : 15079-01

Données de Résistance à Chaud

1/2

Type d'échauffement : linéaritée H3
Position du changeur de prise : na

Temps (sec)	H3-H03				
(Shunts)	1990674				
140	6.88141E-1				
150	6.88057E-1				
160	6.87950E-1				
170	6.87853E-1				
180	6.87751E-1				
190	6.87618E-1				
200	6.87503E-1				
210	6.87394E-1				
220	6.87272E-1				
230	6.87140E-1				
240	6.87057E-1				
250	6.86801E-1				
260	6.86822E-1				
270	6.86657E-1				
280	6.86589E-1				
290	6.86458E-1				
300	6.86352E-1				
310	6.86255E-1				
320	6.86126E-1				
330	6.86015E-1				
340	6.85918E-1				
350	6.85808E-1				
360	6.85709E-1				
370	6.85605E-1				
380	6.85493E-1				
390	6.85399E-1				
400	6.85282E-1				
410	6.85187E-1				
420	6.85093E-1				
430	6.84985E-1				
440	6.84884E-1				
450	6.84780E-1				
460	6.84688E-1				
470	6.84599E-1				
480	6.84503E-1				
490	6.84409E-1				
500	6.84322E-1				
510	6.84233E-1				
520	6.84139E-1				

Essai réalisé par R.B., R.P. Date : 2015-10-20 Heure : 16:01:51 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai : linéaritée H3
Client : abb
Objet d'essai : Inductance shunt 3-ph. 140 MVARs

No de contrat : J794315045
No d'essai : 003
No de série : 15079-01

Données de Résistance à Chaud

2/2

Type d'échauffement : linéaritée H3
Position du changeur de prise : na

Temps (sec)	H3-H03				
530	6.84048E-1				
540	6.83954E-1				
550	6.83853E-1				
560	6.83767E-1				
570	6.83682E-1				
580	6.83599E-1				
590	6.83506E-1				
600	6.83420E-1				

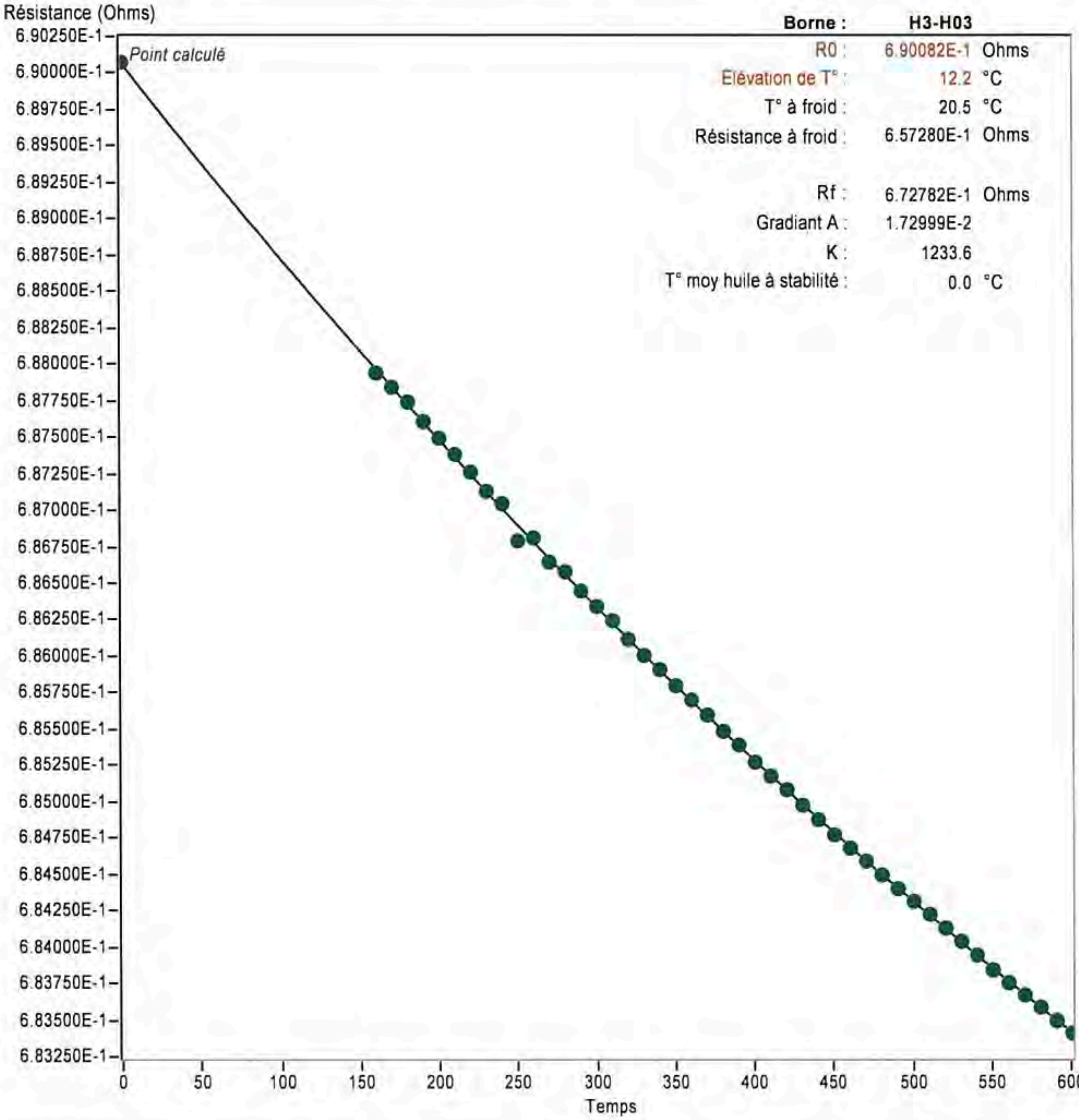
Essai réalisé par R.B., R.P. Date : 2015-10-20 Heure : 16:01:51 Page :

Hydro Québec
LABORATOIRE HAUTE TENSION
SMTR 4.0.0

Type d'essai :	linéaritée H3	No de contrat :	J794315045
Client :	abb	No d'essai :	003
Objet d'essai :	Inductance shunt 3-ph. 140 MVARs	No de série :	15079-01

Élévation de Température

T° ambiante à stabilité : 21.0 °C	T° ambiante à coupure :	21.0 °C	Type d'échauffement :	linéaritée H3
T° radiateur haut à stabilité : 0.0 °C	T° radiateur haut à coupure :	0.0 °C	Position du changeur de prise :	na
T° radiateur bas à stabilité : 0.0 °C	T° radiateur bas à coupure :	0.0 °C	Nombre de ventilateurs :	0
T° huile haut à stabilité : 0.0 °C	T° huile haut à coupure :	0.0 °C	Nombre de radiateurs :	0
dT° à stabilité : 0.0 °C	dT° à coupure :	0.0 °C		



Essai réalisé par R.B., R.P. Date : 2015-10-20 Heure : 15:45:00 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Version 1.0

Test type	Détermination du niveau acoustique
Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

PROGRAMME D'ESSAI ABB									
	ABB Inc.	15079-01		À vide	En charge	Fréquence	Distance du	Puissance dB(A)	
Test #	Régime	Ventilateurs	CP	V-appl.(kV)	I-appl.(A)	(Hz)	contour (m)	Garantie	Mesurée
1	ONAN	na	na	331		60	0.3	91	85.1

Rapport de la détermination du niveau acoustique			
Site:	LHT IREQ	Lieu de fabrication:	Varennes/Québec/Canada
Détails relatifs à la méthode de mesure			
Norme de mesure:	CEI 60076-10 2001-05		
Garantie	Puissance dB(A)		
Pondérée A / 1/3 d'octave			
Détails relatifs à l'appareil de mesure			
Produit:	Brüel & Kjaer	Type de compteur:	3050-A-6/0
Numéro de série:	3050-108860		
Type de microphone:	4197	Numéro de série:	2731221 Part 1
			2731221 Part 2
			2751819 Part 1
			2751819 Part 2

Information sur l'étalonnage

NOM DU SIGNAL	AJUSTEMENT GAIN DÉBUT	AJUSTEMENT GAIN FIN
S1-P1	1.03	1.03
S1-P2	1.00	1.00
S2-P1	1.03	1.03
S2-P2	1.00	1.00

TYPE DE MESURE	AAAA/MM/JJ	HH/MM	dB(A)
Moyenne bruit ambiant avant essais	N/A	N/A	N/A
Moyenne bruit ambiant après essais	N/A	N/A	N/A
Mesure intensité 0°125 Hz	2015/10/19	9:51	53.3
Mesure intensité 180°125Hz	2015/10/19	9:52	-53.6

Conditions d'essais

Température de l'huile (Haut)	65.7	℃
Température de l'huile (Bas)	50.1	℃
Température ambiante	24.0	℃
Pression atmosphérique	1025	mbar
Longueur du ou des contours prescrits, lm	28.80	m
Hauteur de l'objet d'essai, h	4.10	m
Zone de surface de mesure, S	147.5	m2
10*log(S/S0)	21.7	

Note:

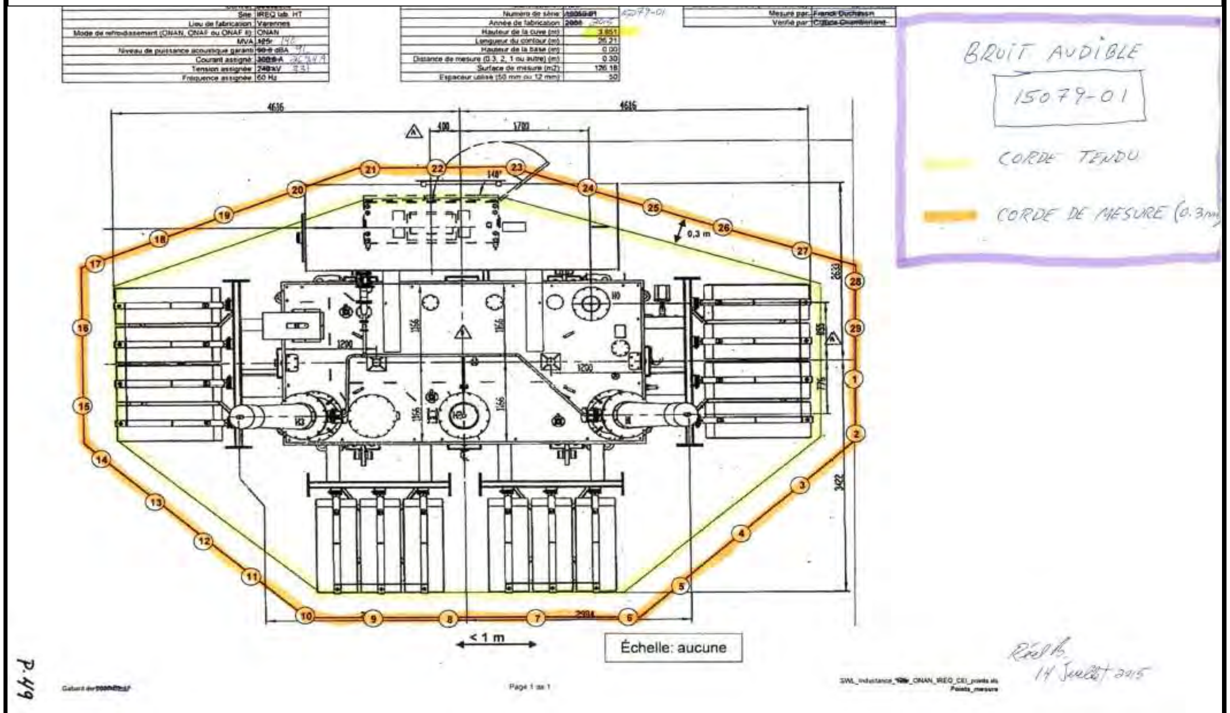
Essais par : R.B., R.P. Date : 2015-10-19 Page :

Version : 2006-04 Bruit Audible 1.xls

Hydro Québec	Test type	Détermination du niveau acoustique
	Objet d'essais	Inductance shunt 3-ph.
	Nº Série	15079-01
LABORATOIRE HAUTE TENSION	Nº Contrat	J794315045
Version 1.0	Client	ABB Inc.

Plan de l'objet d'essai

Y compris des positions de mesure, la position des traversées HT, la proximité de surfaces réfléchissantes acoustiques avoisinantes, par exemple matériels, murs, et positions pour les mesures de bruits de fond



Nombre de mesures	29		
Hauteurs des microphones au-dessus du sol	Hauteur 1/3	1.37	m
	Hauteur 2/3	2.73	m

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Hydro Québec

LABORATOIRE HAUTE TENSION
Version 1.0

Test type	Détermination du niveau acoustique
Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Méthode d'intensité acoustique

Mesures de l'intensité acoustique et de la pression acoustique pondérée A									
Position en plan	Hauteur 1/3		Hauteur 2/3		Position en plan	Hauteur 1/3		Hauteur 2/3	
	L_{IAi}	L_{pAi}	L_{IAi}	L_{pAi}		L_{IAi}	L_{pAi}	L_{IAi}	L_{pAi}
1	56.2	62.1	63.4	68.0	41				
2	57.1	61.2	61.6	66.7	42				
3	57.0	62.6	66.3	69.0	43				
4	55.5	61.2	69.6	71.2	44				
5	55.5	59.9	68.5	70.6	45				
6	44.3	65.5	67.1	70.9	46				
7	49.7	65.0	62.5	68.9	47				
8	54.1	60.3	70.0	71.3	48				
9	57.2	63.3	67.1	73.1	49				
10	57.7	62.0	67.2	69.1	50				
11	57.2	62.6	65.9	68.9	51				
12	58.3	63.8	66.8	69.6	52				
13	58.5	63.9	61.2	66.1	53				
14	60.1	65.5	-50.6	64.9	54				
15	43.2	59.5	58.8	64.6	55				
16	61.0	66.8	64.8	68.9	56				
17	60.6	65.6	65.1	65.0	57				
18	59.5	64.5	66.7	69.4	58				
19	57.8	63.4	62.0	68.0	59				
20	57.1	63.5	65.4	67.6	60				
21	56.7	63.9	61.2	66.2	61				
22	41.0	64.5	67.3	70.5	62				
23	55.3	65.4	61.8	67.3	63				
24	42.5	63.3	59.8	64.4	64				
25	54.6	62.4	63.3	65.0	65				
26	58.6	63.8	69.7	73.1	66				
27	58.6	63.1	65.6	68.2	67				
28	58.5	64.0	64.6	68.3	68				
29	57.5	62.8	67.5	71.0	69				
30					70				
31					71				
32					72				
33					73				
34					74				
35					75				
36					76				
37					77				
38					78				
39					79				
40					80				

Moyenne arithmétique / d'énergie, LpA0	67.2	dB(A)		
Moyenne arithmétique / d'énergie, LIA	63.4	dB(A)		
pA0 L – IA L (doit être ≤8 dB(A))	3.8	dB(A)	CONFORME	
Niveau de puissance acoustique pondérée A calculé, LWA	85.1	dB(A)		

Bruit ambiant	1	2	3	4
Avant essais (moyenne 2 micros)	N/A	N/A	N/A	N/A
Après essais (moyenne 2 micros)	N/A	N/A	N/A	N/A

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LABORATOIRE HAUTE TENSION	Test type	Détermination du niveau acoustique
Version 1.0	Objet d'essais	Inductance shunt 3-ph.
	N° Série	15079-01
	N° Contrat	J794315045
	Client	ABB Inc.




Essais par : R.B., R.P. Date : 2015-10-19 Page :

LABORATOIRE HAUTE TENSION

Test type: Détermination du niveau acoustique
Objet d'essais: Inductance shunt 3-ph.
Nº Série: 15079-01
Nº Contrat: J794315045
Pression acoustique mesuré: ABB Inc.

Pression acoustique mesurée

Fréquence 1/3 octave (Hz)	Lp 1/3 hauteur Point # 1 dB(A)	Lp 1/3 hauteur Point # 2 dB(A)	Lp 1/3 hauteur Point # 3 dB(A)	Lp 1/3 hauteur Point # 4 dB(A)	Lp 1/3 hauteur Point # 5 dB(A)	Lp 1/3 hauteur Point # 6 dB(A)	Lp 1/3 hauteur Point # 7 dB(A)	Lp 1/3 hauteur Point # 8 dB(A)	Lp 1/3 hauteur Point # 9 dB(A)
63	17.7	19.6	19.8	20.4	18.5	17.5	16.5	14.8	17.4
80	17.3	19.8	17.1	15.6	14.2	18.3	21.9	15.7	15.9
100	19.5	32.9	40.2	41.2	41.1	47.1	44.1	35.9	34.2
125	31.2	47.5	54.8	55.9	55.8	61.8	58.9	50.5	48.9
160	21.9	23.7	28.7	29.3	29.3	34.9	32.2	25.2	24.2
200	45.7	43.1	40.5	38.4	39.9	45.4	44.6	36.2	46.8
250	61.1	58.5	55.8	53.7	55.2	60.7	60.0	51.5	62.2
315	45.8	43.5	51.7	48.1	45.8	45.0	54.1	51.1	45.6
400	50.2	48.4	56.2	52.7	50.2	49.9	58.7	55.6	49.8
500	49.9	55.9	55.7	52.1	43.8	57.5	53.4	49.2	51.7
630	39.8	46.4	50.9	53.4	44.0	42.2	45.3	53.2	34.2
800	46.2	41.4	47.4	46.1	44.9	44.3	47.2	39.3	45.3
1000	38.5	33.9	37.9	38.2	41.5	41.5	43.3	43.6	40.2
1250	36.3	35.8	36.4	40.1	41.2	41.4	32.9	36.5	35.3

Fréquence 1/3 octave (Hz)	Lp 2/3 hauteur Point # 1 dB(A)	Lp 2/3 hauteur Point # 2 dB(A)	Lp 2/3 hauteur Point # 3 dB(A)	Lp 2/3 hauteur Point # 4 dB(A)	Lp 2/3 hauteur Point # 5 dB(A)	Lp 2/3 hauteur Point # 6 dB(A)	Lp 2/3 hauteur Point # 7 dB(A)	Lp 2/3 hauteur Point # 8 dB(A)	Lp 2/3 hauteur Point # 9 dB(A)
63	22.4	22.6	20.6	20.6	22.5	23.1	22.0	20.6	21.2
80	22.6	22.9	20.8	19.6	18.5	20.7	24.4	19.6	19.1
100	49.2	48.4	50.5	55.1	53.6	43.9	49.9	47.3	47.5
125	64.0	63.1	65.2	69.9	68.3	58.6	64.7	62.0	62.2
160	37.1	36.2	38.2	42.7	41.2	32.7	37.7	35.1	35.4
200	49.5	46.5	49.1	47.0	42.2	51.4	46.7	54.3	56.2
250	64.9	61.8	64.4	62.4	57.4	66.7	62.1	69.7	71.7
315	45.1	52.0	46.8	45.4	52.1	61.5	49.9	56.4	58.2
400	49.2	56.4	51.8	50.7	57.2	65.9	55.1	60.6	62.5
500	55.6	51.9	60.9	59.8	63.8	58.9	62.9	45.9	59.4
630	45.5	50.4	47.8	50.9	58.3	51.5	52.4	53.8	50.2
800	46.7	49.4	52.1	51.5	44.4	53.9	55.7	54.8	49.1
1000	40.2	42.7	42.6	45.2	48.2	46.3	49.9	50.3	44.7
1250	35.3	36.9	39.5	40.3	48.0	51.4	38.0	38.1	38.0

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Hydro Québec

LABORATOIRE HAUTE TENSION

Test type	Détermination du niveau acoustique
Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Pression acoustique mesurée

Fréquence 1/3 octave (Hz)	Lp 1/3 hauteur Point # 10 dB(A)	Lp 1/3 hauteur Point # 11 dB(A)	Lp 1/3 hauteur Point # 12 dB(A)	Lp 1/3 hauteur Point # 13 dB(A)	Lp 1/3 hauteur Point # 14 dB(A)	Lp 1/3 hauteur Point # 15 dB(A)	Lp 1/3 hauteur Point # 16 dB(A)	Lp 1/3 hauteur Point # 17 dB(A)	Lp 1/3 hauteur Point # 18 dB(A)
63	14.7	14.4	16.4	19.6	16.6	17.1	16.3	18.1	14.3
80	15.5	15.8	17.4	16.4	19.1	16.2	19.8	16.6	15.8
100	37.7	42.3	38.6	39.3	45.9	32.5	47.4	48.2	44.5
125	52.4	56.9	53.3	54.0	60.5	47.1	62.1	63.0	59.1
160	26.5	30.5	28.1	28.3	33.5	22.8	34.9	35.9	32.2
200	44.3	40.7	44.9	33.7	45.5	40.8	36.0	38.9	40.1
250	59.7	56.0	60.3	48.7	60.9	56.1	51.1	54.3	55.4
315	46.0	51.7	49.2	49.8	53.4	49.2	57.5	52.4	55.6
400	50.5	56.1	53.9	55.0	57.8	53.6	62.0	57.1	60.0
500	53.4	54.3	57.2	62.2	53.7	39.0	58.7	57.6	51.8
630	45.5	46.1	53.3	44.6	48.7	48.0	51.3	41.0	46.5
800	45.9	44.2	41.9	39.9	37.7	44.8	41.1	43.7	42.8
1000	37.9	39.5	38.7	39.0	37.0	38.4	37.4	40.0	39.2
1250	37.1	35.8	37.2	37.0	33.3	36.3	35.8	38.3	35.1

Fréquence 1/3 octave (Hz)	Lp 2/3 hauteur Point # 10 dB(A)	Lp 2/3 hauteur Point # 11 dB(A)	Lp 2/3 hauteur Point # 12 dB(A)	Lp 2/3 hauteur Point # 13 dB(A)	Lp 2/3 hauteur Point # 14 dB(A)	Lp 2/3 hauteur Point # 15 dB(A)	Lp 2/3 hauteur Point # 16 dB(A)	Lp 2/3 hauteur Point # 17 dB(A)	Lp 2/3 hauteur Point # 18 dB(A)
63	19.9	20.3	22.6	27.6	24.1	20.5	20.2	23.0	21.2
80	18.7	19.6	21.8	20.9	23.8	19.6	25.9	21.3	19.5
100	48.8	46.6	40.0	45.5	43.1	42.0	45.0	44.9	51.1
125	63.6	61.3	54.7	60.2	57.7	56.7	59.7	59.7	65.7
160	36.7	34.5	29.7	33.8	32.0	30.8	33.0	33.2	38.6
200	51.0	46.4	50.8	47.2	45.3	45.9	42.4	40.7	50.0
250	66.4	61.8	66.2	62.6	60.6	61.3	57.7	56.1	65.3
315	52.8	59.3	60.5	49.5	46.7	48.5	60.5	53.5	55.2
400	57.1	63.7	65.0	54.0	51.7	53.0	64.9	58.2	59.5
500	50.3	61.6	50.7	56.3	59.4	55.8	62.3	59.0	47.1
630	52.3	49.0	42.2	55.0	52.3	55.1	49.1	48.7	46.9
800	52.7	48.4	41.4	44.1	44.5	47.1	46.0	44.7	44.7
1000	48.1	43.9	45.3	40.1	41.5	40.2	46.6	44.4	46.2
1250	41.0	37.4	43.2	42.3	34.8	39.3	35.9	40.2	36.7

Essais par : R.B., R.P. Date : 2015-10-19 Page:

Hydro Québec

LABORATOIRE HAUTE TENSION

Test type	Détermination du niveau acoustique
Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Pression acoustique mesurée

Fréquence 1/3 octave (Hz)	Lp 1/3 hauteur Point # 19 dB(A)	Lp 1/3 hauteur Point # 20 dB(A)	Lp 1/3 hauteur Point # 21 dB(A)	Lp 1/3 hauteur Point # 22 dB(A)	Lp 1/3 hauteur Point # 23 dB(A)	Lp 1/3 hauteur Point # 24 dB(A)	Lp 1/3 hauteur Point # 25 dB(A)	Lp 1/3 hauteur Point # 26 dB(A)	Lp 1/3 hauteur Point # 27 dB(A)
63	16.2	17.8	19.1	19.9	17.6	17.0	17.6	15.5	14.9
80	17.2	16.4	16.6	16.5	15.3	13.9	15.6	17.2	16.4
100	47.1	45.6	44.0	32.5	37.2	33.3	43.0	37.1	37.8
125	61.7	60.2	58.5	46.9	51.9	47.8	57.6	51.8	52.4
160	34.6	33.1	31.7	25.1	27.0	23.6	30.8	26.3	27.2
200	37.3	30.4	40.5	47.8	46.2	46.8	43.4	46.9	45.1
250	52.4	44.9	55.7	63.1	61.6	62.1	58.6	62.3	60.4
315	50.1	51.0	37.8	51.7	52.6	49.9	35.5	49.9	51.5
400	54.3	55.5	46.9	55.9	57.3	54.0	41.8	54.3	55.8
500	44.9	57.4	60.8	50.7	60.1	39.5	55.6	48.5	51.9
630	43.9	49.9	44.5	39.7	46.7	43.4	38.7	44.6	43.0
800	43.0	40.6	46.4	42.3	43.0	44.4	40.9	43.8	39.0
1000	39.9	38.9	35.6	38.4	36.9	37.7	39.3	38.1	37.6
1250	39.8	34.8	37.9	37.3	34.2	33.7	33.4	33.7	34.3

Fréquence 1/3 octave (Hz)	Lp 2/3 hauteur Point # 19 dB(A)	Lp 2/3 hauteur Point # 20 dB(A)	Lp 2/3 hauteur Point # 21 dB(A)	Lp 2/3 hauteur Point # 22 dB(A)	Lp 2/3 hauteur Point # 23 dB(A)	Lp 2/3 hauteur Point # 24 dB(A)	Lp 2/3 hauteur Point # 25 dB(A)	Lp 2/3 hauteur Point # 26 dB(A)	Lp 2/3 hauteur Point # 27 dB(A)
63	22.1	23.9	27.1	28.1	25.2	24.2	22.6	20.0	21.0
80	20.0	20.0	20.7	21.2	20.0	18.2	19.3	21.1	21.1
100	45.0	43.9	47.6	49.0	50.9	30.2	46.9	51.2	51.9
125	59.6	58.5	62.2	63.6	65.6	44.3	61.5	65.9	66.5
160	33.2	32.4	35.5	36.9	38.7	25.4	34.5	38.8	39.4
200	46.4	50.6	34.4	53.5	34.4	47.5	41.7	56.2	45.8
250	61.7	65.9	48.5	68.8	48.7	62.8	56.9	71.6	61.1
315	52.3	53.3	56.5	52.7	52.7	49.5	54.4	46.7	48.3
400	57.2	57.5	60.8	56.7	57.4	53.8	58.6	48.8	52.6
500	64.6	50.8	55.7	55.0	58.1	54.6	48.8	60.5	54.7
630	52.0	43.9	54.4	46.7	48.9	47.9	46.4	47.4	46.7
800	43.0	46.6	43.0	43.8	49.2	47.1	45.1	50.8	43.9
1000	41.5	43.3	41.3	41.1	40.0	43.1	41.1	42.7	39.7
1250	37.0	35.3	40.5	39.4	35.5	39.1	37.3	38.1	37.5

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LABORATOIRE HAUTE TENSION

Test type	Détermination du niveau acoustique
Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Pression acoustique mesurée

Fréquence 1/3 octave (Hz)	Lp 1/3 hauteur Point # 28 dB(A)	Lp 1/3 hauteur Point # 29 dB(A)	Lp 1/3 hauteur Point # 30 dB(A)	Lp 1/3 hauteur Point # 31 dB(A)	Lp 1/3 hauteur Point # 32 dB(A)	Lp 1/3 hauteur Point # 33 dB(A)	Lp 1/3 hauteur Point # 34 dB(A)	Lp 1/3 hauteur Point # 35 dB(A)	Lp 1/3 hauteur Totaux dB(A)
63	14.5	15.2							17.4
80	17.0	16.3							17.2
100	44.0	38.1							42.7
125	58.7	52.7							57.3
160	31.8	26.7							30.7
200	43.6	44.8							43.6
250	58.9	60.1							59.0
315	53.2	50.2							51.1
400	57.6	54.6							55.6
500	48.3	53.0							55.5
630	47.8	45.8							47.7
800	40.9	43.8							43.9
1000	35.4	37.2							39.2
1250	34.9	33.8							36.9

Fréquence 1/3 octave (Hz)	Lp 2/3 hauteur Point # 28 dB(A)	Lp 2/3 hauteur Point # 29 dB(A)	Lp 2/3 hauteur Point # 30 dB(A)	Lp 2/3 hauteur Point # 31 dB(A)	Lp 2/3 hauteur Point # 32 dB(A)	Lp 2/3 hauteur Point # 33 dB(A)	Lp 2/3 hauteur Point # 34 dB(A)	Lp 2/3 hauteur Point # 35 dB(A)	Lp 2/3 hauteur Totaux dB(A)
63	21.8	22.5							23.2
80	22.7	22.2							21.3
100	50.0	53.4							49.2
125	64.6	68.0							63.9
160	37.7	40.9							37.0
200	48.4	50.2							49.8
250	63.8	65.5							65.2
315	50.8	57.9							55.1
400	55.2	62.2							59.6
500	58.3	47.9							58.7
630	47.9	42.6							51.2
800	45.8	38.7							49.2
1000	38.6	40.0							44.7
1250	40.3	33.2							41.4

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LABORATOIRE HAUTE TENSION

Test type	Détermination du niveau acoustique
Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Pression acoustique mesuré	ABB Inc.

Intensité mesurée

Fréquence 1/3 octave (Hz)	Lp 1/3 hauteur Point # 1 dB(A)	Lp 1/3 hauteur Point # 2 dB(A)	Lp 1/3 hauteur Point # 3 dB(A)	Lp 1/3 hauteur Point # 4 dB(A)	Lp 1/3 hauteur Point # 5 dB(A)	Lp 1/3 hauteur Point # 6 dB(A)	Lp 1/3 hauteur Point # 7 dB(A)	Lp 1/3 hauteur Point # 8 dB(A)	Lp 1/3 hauteur Point # 9 dB(A)
63	-22.9	-25.3	-24.4	23.2	16.5	20.3	19.9	-18.2	-15.9
80	16.4	-17.9	10.1	-7.3	-9.5	22.4	10.7	0.5	18.3
100	20.6	-30.5	21.8	30.1	34.1	39.2	31.9	29.9	-19.4
125	34.8	-45.6	35.6	45.3	49.1	54.3	47.4	45.0	-34.2
160	12.0	-21.1	-8.3	23.9	23.2	27.6	22.6	15.4	13.3
200	39.2	40.7	38.0	36.8	37.8	-40.0	-34.9	34.7	40.4
250	55.1	56.5	53.7	52.7	53.6	-55.8	-50.8	50.5	56.2
315	38.4	34.2	44.1	43.1	36.8	40.6	43.5	37.8	41.6
400	43.3	38.3	49.4	48.4	41.5	46.4	49.1	43.0	46.8
500	46.0	48.8	49.1	-39.4	-35.0	48.9	46.4	44.0	43.3
630	35.7	36.2	46.4	46.1	39.6	35.5	36.3	47.2	20.6
800	40.5	34.7	43.4	39.1	39.5	30.5	39.2	33.8	40.2
1000	33.1	24.9	27.8	29.0	34.0	34.4	30.0	35.0	33.9
1250	25.5	28.0	25.2	26.1	25.3	34.0	22.7	30.4	25.6

Fréquence 1/3 octave (Hz)	Lp 2/3 hauteur Point # 1 dB(A)	Lp 2/3 hauteur Point # 2 dB(A)	Lp 2/3 hauteur Point # 3 dB(A)	Lp 2/3 hauteur Point # 4 dB(A)	Lp 2/3 hauteur Point # 5 dB(A)	Lp 2/3 hauteur Point # 6 dB(A)	Lp 2/3 hauteur Point # 7 dB(A)	Lp 2/3 hauteur Point # 8 dB(A)	Lp 2/3 hauteur Point # 9 dB(A)
63	-11.3	-5.5	10.5	-19.0	-8.0	10.9	-16.5	-21.3	-10.2
80	-11.7	-14.6	-13.1	-13.3	-11.5	13.6	-15.1	-9.2	-5.5
100	47.7	47.8	47.7	53.1	51.6	41.2	45.5	42.4	41.4
125	62.9	62.9	62.8	68.3	66.7	56.3	60.7	57.5	56.6
160	36.4	36.4	36.4	41.8	40.3	28.3	34.3	31.2	30.5
200	40.5	-41.4	46.1	46.7	38.6	44.1	-38.5	52.8	48.3
250	56.3	-57.3	61.8	62.5	54.2	60.1	-54.3	68.6	64.2
315	-48.9	-47.3	-45.0	43.4	49.2	58.5	36.9	55.8	53.7
400	-54.4	-52.5	-50.0	48.1	55.0	63.9	45.0	60.9	59.1
500	46.4	48.5	58.8	51.1	61.1	53.9	56.7	50.9	59.1
630	46.3	50.2	45.7	48.0	53.4	49.9	52.0	49.6	47.2
800	43.5	46.0	46.4	50.4	37.4	50.2	51.6	48.3	42.0
1000	28.5	35.0	37.3	42.5	44.9	41.0	43.1	46.0	42.1
1250	25.1	34.6	38.3	35.7	45.6	42.5	32.0	36.9	30.7

Essais par : R.B., R.P. Date : 2015-10-19 Page:

Hydro Québec

LABORATOIRE HAUTE TENSION

Test type	Détermination du niveau acoustique
Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Intensité mesurée

Fréquence 1/3 octave (Hz)	Lp 1/3 hauteur Point # 10 dB(A)	Lp 1/3 hauteur Point # 11 dB(A)	Lp 1/3 hauteur Point # 12 dB(A)	Lp 1/3 hauteur Point # 13 dB(A)	Lp 1/3 hauteur Point # 14 dB(A)	Lp 1/3 hauteur Point # 15 dB(A)	Lp 1/3 hauteur Point # 16 dB(A)	Lp 1/3 hauteur Point # 17 dB(A)	Lp 1/3 hauteur Point # 18 dB(A)
63	19.3	-19.5	-25.8	-25.8	-19.7	22.9	-24.8	23.6	21.4
80	-10.8	22.0	-14.4	-8.6	-8.9	6.8	16.7	17.3	9.8
100	32.9	39.0	36.0	37.8	40.6	-25.9	40.9	42.2	40.3
125	47.9	54.1	51.2	52.9	55.7	-41.0	56.1	57.4	55.3
160	21.4	28.2	25.1	26.3	29.3	-18.5	30.0	30.9	28.8
200	39.1	-30.8	39.9	-27.9	39.7	-21.9	30.5	34.9	35.1
250	54.9	-46.6	55.7	-43.4	55.4	-37.6	46.1	50.7	50.7
315	43.3	45.7	36.4	45.4	47.1	33.5	51.4	46.5	49.8
400	48.7	51.1	41.7	51.2	52.4	38.9	56.7	52.1	55.0
500	49.7	50.8	50.2	55.4	48.2	37.3	51.3	54.0	-44.3
630	37.3	41.0	45.2	40.5	-36.4	43.2	45.9	34.7	42.2
800	39.4	36.0	36.5	33.5	-29.1	34.4	37.4	39.9	39.9
1000	30.5	34.2	33.5	35.2	30.6	25.4	30.9	34.2	32.2
1250	29.4	25.8	-23.0	23.7	23.7	21.4	23.8	30.8	19.8

Fréquence 1/3 octave (Hz)	Lp 2/3 hauteur Point # 10 dB(A)	Lp 2/3 hauteur Point # 11 dB(A)	Lp 2/3 hauteur Point # 12 dB(A)	Lp 2/3 hauteur Point # 13 dB(A)	Lp 2/3 hauteur Point # 14 dB(A)	Lp 2/3 hauteur Point # 15 dB(A)	Lp 2/3 hauteur Point # 16 dB(A)	Lp 2/3 hauteur Point # 17 dB(A)	Lp 2/3 hauteur Point # 18 dB(A)
63	-16.6	14.9	18.4	20.2	22.7	25.2	24.7	20.8	19.9
80	5.4	12.1	-5.3	-20.6	11.6	5.5	17.0	8.5	7.3
100	43.2	37.6	35.9	-31.3	-38.8	-43.3	-39.2	45.6	47.7
125	58.4	52.6	51.0	-46.4	-53.9	-58.4	-54.3	60.8	62.7
160	31.8	-25.6	23.3	-20.7	-28.1	-31.9	-28.4	34.3	36.2
200	49.2	43.4	45.4	42.9	-39.1	43.6	40.7	43.0	48.5
250	65.0	59.1	61.2	58.7	-54.9	59.4	56.6	58.8	64.2
315	53.1	55.9	58.6	48.7	49.1	47.5	57.1	53.0	39.2
400	58.3	61.2	64.1	54.1	54.5	52.7	62.4	58.5	37.4
500	49.8	59.9	46.8	49.0	-36.4	49.8	57.2	54.7	44.9
630	51.5	50.5	36.7	52.8	49.4	53.4	46.5	38.5	35.6
800	50.5	45.8	-38.5	31.6	38.8	41.1	40.4	38.9	43.4
1000	46.6	40.0	42.4	35.0	31.0	37.4	42.9	40.5	44.4
1250	37.5	31.0	-37.9	25.1	-20.4	23.5	32.2	33.2	-28.0

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Hydro Québec

LABORATOIRE HAUTE TENSION

Test type	Détermination du niveau acoustique
Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Intensité mesurée

Fréquence 1/3 octave (Hz)	Lp 1/3 hauteur Point # 19 dB(A)	Lp 1/3 hauteur Point # 20 dB(A)	Lp 1/3 hauteur Point # 21 dB(A)	Lp 1/3 hauteur Point # 22 dB(A)	Lp 1/3 hauteur Point # 23 dB(A)	Lp 1/3 hauteur Point # 24 dB(A)	Lp 1/3 hauteur Point # 25 dB(A)	Lp 1/3 hauteur Point # 26 dB(A)	Lp 1/3 hauteur Point # 27 dB(A)
63	20.9	23.0	24.3	26.5	26.4	27.4	29.1	-5.4	-23.5
80	17.0	-17.1	-6.1	-13.0	18.5	4.6	12.8	8.2	-16.8
100	41.5	34.1	-32.7	26.1	16.9	29.9	32.0	-19.7	33.9
125	56.5	49.3	-47.5	41.0	31.8	45.1	47.1	-34.2	48.8
160	29.9	22.1	-20.7	-15.9	13.9	20.3	21.9	11.0	20.0
200	24.9	28.4	37.8	-34.6	35.8	-33.5	35.4	40.5	41.4
250	41.2	44.3	53.4	-50.4	51.7	-49.1	51.1	56.4	57.1
315	44.4	44.3	35.7	43.6	45.2	41.4	-28.3	47.0	43.1
400	49.4	49.8	42.5	48.9	50.6	46.6	-27.0	52.4	48.1
500	-43.7	54.0	54.2	-37.2	44.5	-37.1	50.2	47.4	42.4
630	43.5	44.2	36.4	36.5	36.0	39.0	30.4	37.7	36.8
800	35.8	27.2	40.8	39.4	33.7	37.3	-26.0	33.4	35.2
1000	27.5	31.6	-26.0	33.4	27.2	27.4	33.2	31.2	28.9
1250	32.0	-7.6	28.3	23.4	21.7	19.1	23.1	23.7	19.9

Fréquence 1/3 octave (Hz)	Lp 2/3 hauteur Point # 19 dB(A)	Lp 2/3 hauteur Point # 20 dB(A)	Lp 2/3 hauteur Point # 21 dB(A)	Lp 2/3 hauteur Point # 22 dB(A)	Lp 2/3 hauteur Point # 23 dB(A)	Lp 2/3 hauteur Point # 24 dB(A)	Lp 2/3 hauteur Point # 25 dB(A)	Lp 2/3 hauteur Point # 26 dB(A)	Lp 2/3 hauteur Point # 27 dB(A)
63	14.3	-14.5	-16.0	0.2	-14.5	23.8	27.2	20.6	-19.3
80	-2.2	-6.5	2.0	-4.6	-7.3	-0.7	-11.2	-11.8	-11.3
100	40.2	-41.2	33.7	41.3	41.1	-36.2	44.8	48.9	50.6
125	55.2	-56.3	48.7	56.4	56.3	-51.2	59.8	64.1	65.6
160	28.6	-30.4	19.9	29.6	29.3	-24.8	33.2	37.6	39.1
200	-41.2	49.7	-29.0	50.4	34.6	43.9	45.5	51.8	-39.8
250	-56.9	65.5	-43.9	66.1	50.7	59.6	61.2	67.6	-55.6
315	47.2	49.9	53.4	51.3	51.4	-38.2	-47.0	44.3	45.1
400	53.3	54.7	58.6	56.2	56.9	-44.3	-52.4	47.8	50.5
500	61.6	-49.8	53.6	53.2	53.4	49.8	35.1	58.5	48.5
630	45.2	-39.5	50.2	42.2	48.1	48.0	38.1	-43.2	41.3
800	-24.7	-33.9	-34.5	-42.0	47.3	43.8	-35.2	48.6	40.2
1000	35.8	31.1	28.3	-33.2	32.1	38.4	39.0	37.7	32.8
1250	-28.3	20.4	-28.1	-30.1	-25.5	29.8	31.3	35.2	33.7

Essais par : R.B., R.P. Date : 2015-10-19 Page:

Hydro Québec

LABORATOIRE HAUTE TENSION

Test type	Détermination du niveau acoustique
Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Intensité mesurée

Fréquence 1/3 octave (Hz)	Lp 1/3 hauteur Point # 28 dB(A)	Lp 1/3 hauteur Point # 29 dB(A)	Lp 1/3 hauteur Point # 30 dB(A)	Lp 1/3 hauteur Point # 31 dB(A)	Lp 1/3 hauteur Point # 32 dB(A)	Lp 1/3 hauteur Point # 33 dB(A)	Lp 1/3 hauteur Point # 34 dB(A)	Lp 1/3 hauteur Point # 35 dB(A)	Lp 1/3 hauteur Totaux dB(A)
63	-26.8	-24.8							14.3
80	15.9	-1.6							12.5
100	37.2	32.5							35.9
125	52.4	47.6							50.9
160	25.8	20.8							24.6
200	39.2	39.6							36.2
250	55.0	55.3							52.0
315	46.6	42.8							44.4
400	51.9	47.9							49.8
500	41.1	48.7							48.8
630	-36.3	-31.6							41.1
800	31.6	37.4							37.6
1000	28.8	25.7							31.6
1250	26.8	-11.6							26.6

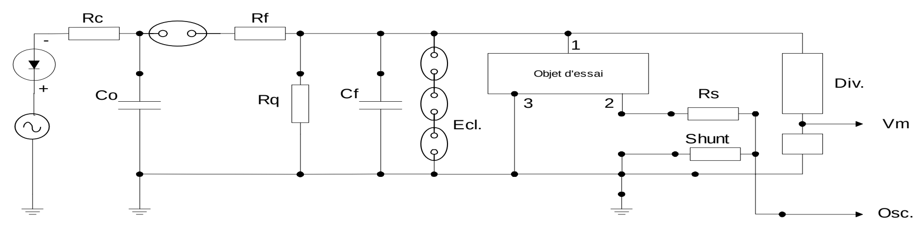
Fréquence 1/3 octave (Hz)	Lp 2/3 hauteur Point # 28 dB(A)	Lp 2/3 hauteur Point # 29 dB(A)	Lp 2/3 hauteur Point # 30 dB(A)	Lp 2/3 hauteur Point # 31 dB(A)	Lp 2/3 hauteur Point # 32 dB(A)	Lp 2/3 hauteur Point # 33 dB(A)	Lp 2/3 hauteur Point # 34 dB(A)	Lp 2/3 hauteur Point # 35 dB(A)	Lp 2/3 hauteur Totaux dB(A)
63	-14.3	-13.6							17.4
80	-13.1	-12.2							-5.9
100	48.4	51.7							46.0
125	63.5	66.7							61.1
160	37.1	40.2							34.6
200	38.8	35.9							45.6
250	54.5	51.4							61.4
315	35.8	51.6							51.7
400	41.8	56.8							57.0
500	52.4	42.9							55.0
630	48.1	-33.1							48.4
800	39.9	-32.2							44.9
1000	-32.0	33.9							40.4
1250	30.6	25.3							34.8

Essais par : R.B., R.P. Date : 2015-10-19 Page:

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Essai de Chocs sur H1, H2, H3	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	



BORNES

1 = H1
2 = H01,2,3
3 = H2,H3

PARAMÈTRES DU CIRCUIT D'ESSAI			DIVISEUR DE TENSION		FORME D'ONDE		
Rc =	51 k * 5	ohm	RC-4 Rd/1 :	2072,8	Forme d'onde	1,37/47,2	µs
Rf =	15 x 6	ohm			Lancée de tension	4,7	%
Rq =	(400//400) * 6	ohm			Lancée inverse	4	%
Cf =	---	nF	Shunt (ohm)	2,9942	U appliquée	1050	kV
Co =	312/6	nF			Tension sur H01,2,3	0	% BIL
Ecl=	12	éclateurs			Lancée inverse / coupée	0	%
Rs =	---	ohm			Correction	1,14	%

EFFICACITÉ DU CIRCUIT

$$\text{Efficacité} = \frac{\text{Vm} * 100}{\text{U charge} * \text{nombre d'étages}} = \frac{265 * 100}{50 * 6} \quad 88,3 \ \%$$

Séquence d'essai Nb	Forme	Pol.	Volt Appliq. kV	Gén. de chocs Charge kV	Pression en kV	kV	% Pleine	Pos. du C.P.	Système de mesure Balayage Tension, courant (µs)	Éclateurs Ecart. mm	Rq 1 Ratio / 1	Ligne à délai kV
2	RP	N	669,5	126,3	152	662	63,8	---	102			
1	P	N	1062,0	200,4	240	1050	101,1	---	102			
2	RC	N	736,3	138,9	167	728	70,1			24		
2	PC	N	1168,2	220,4	264	1155	111,3			38		
2	P	N	1062,0	200,4	240	1050	101,1					

Remarques :

Essais par : R.B. R.P. Date : 2015-10-23

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Essai de Chocs sur H1, H2, H3	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

IDENTIFICATION DES INSTRUMENTS UTILISÉS

	ENTRÉE #1	ENTRÉE #2
SHUNTS		36B0327
DIVISEURS	32A186	
BRAS BASSE TENSION	36C0458	
ATTÉNUATEUR DU DIVISEUR	2040217	
TERMINAISONS 50 OHMS		36A0422
DIGITALISATEUR (GAGE)	2040217	2040217
ATTÉNUATEUR DU DIGITALISATEUR	0327602	0327603
PONT DE RAPPORT DE DIVISEUR	32A049	

Essais par : R.B. R.P.

Date : 2015-10-23

Hydro Québec

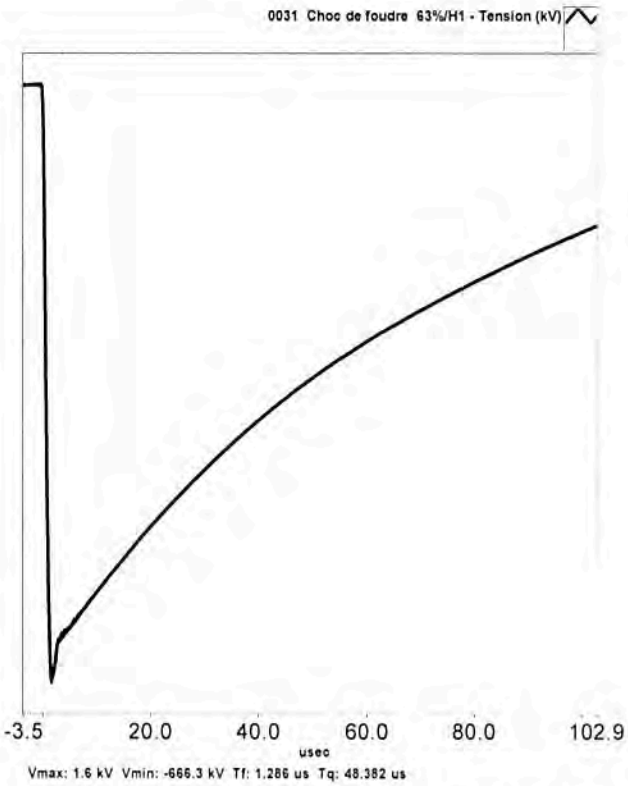
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

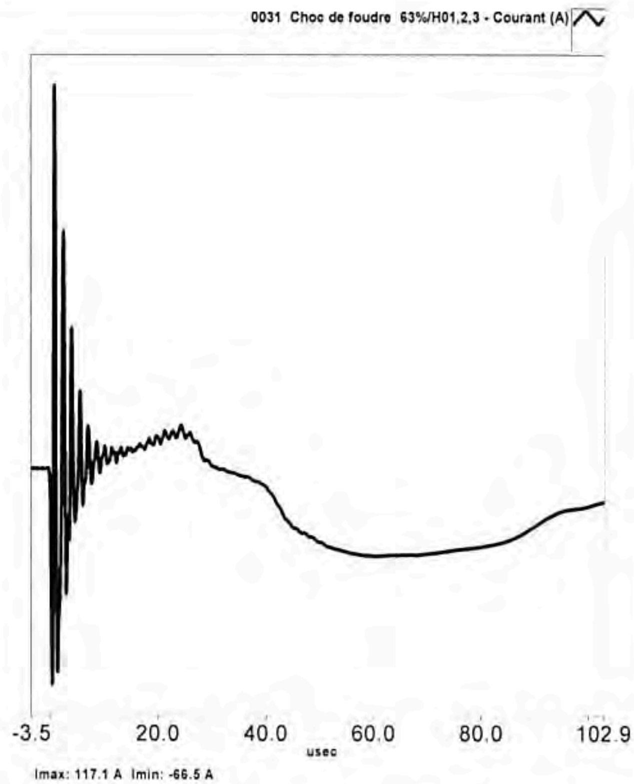
Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB

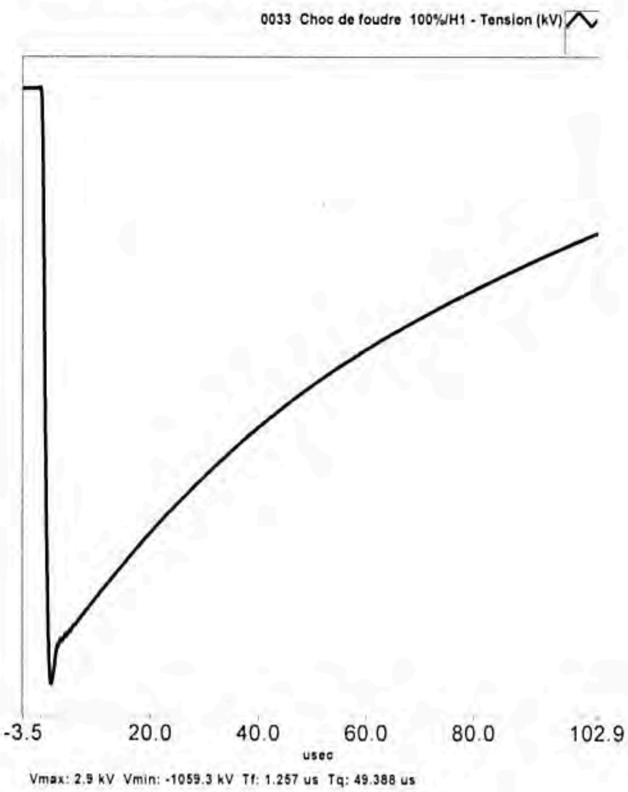
#	Type d'impulsion	Type de signal	Max		Min		
1	0031 Choc de foudre 63%	H1 - Tension (kV)	1.6 kV	-666.3 kV	Tf: 1.286 us	Tq: 48.382 us	
2	0031 Choc de foudre 63%	H01,2,3 - Courant (A)	117.1 A	-66.5 A			
3	0032 Choc de foudre 63%	H1 - Tension (kV)	3.0 kV	-669.3 kV	Tf: 1.276 us	Tq: 48.409 us	
4	0032 Choc de foudre 63%	H01,2,3 - Courant (A)	120.3 A	-72.1 A			
5	0033 Choc de foudre 100%	H1 - Tension (kV)	2.9 kV	-1059.3 kV	Tf: 1.257 us	Tq: 49.388 us	
6	0033 Choc de foudre 100%	H01,2,3 - Courant (A)	196.5 A	-116.6 A			
7	0034 Choc coupé 68%	H1 - Tension (kV)	19.2 kV	-734.4 kV	Tf: 1.287 us	Tc: 3.85 us	
8	0034 Choc coupé 68%	H01,2,3 - Courant (A)	254.4 A	-219.0 A			
9	0035 Choc coupé 68%	H1 - Tension (kV)	18.6 kV	-733.9 kV	Tf: 1.286 us	Tc: 3.82 us	
10	0035 Choc coupé 68%	H01,2,3 - Courant (A)	253.4 A	-220.8 A			
11	0036 Choc coupé 110%	H1 - Tension (kV)	31.6 kV	-1166.6 kV	Tf: 1.254 us	Tc: 3.54 us	
12	0036 Choc coupé 110%	H01,2,3 - Courant (A)	337.7 A	-337.3 A			
13	0037 Choc coupé 110%	H1 - Tension (kV)	31.1 kV	-1167.5 kV	Tf: 1.265 us	Tc: 3.65 us	
14	0037 Choc coupé 110%	H01,2,3 - Courant (A)	342.7 A	-340.0 A			
15	0038 Choc de foudre 100%	H1 - Tension (kV)	11.9 kV	-1063.2 kV	Tf: 1.259 us	Tq: 49.142 us	
16	0038 Choc de foudre 100%	H01,2,3 - Courant (A)	186.8 A	-109.7 A			
17	0039 Choc de foudre 100%	H1 - Tension (kV)	8.8 kV	-1069.9 kV	Tf: 1.293 us	Tq: 48.909 us	
18	0039 Choc de foudre 100%	H01,2,3 - Courant (A)	195.5 A	-112.6 A			

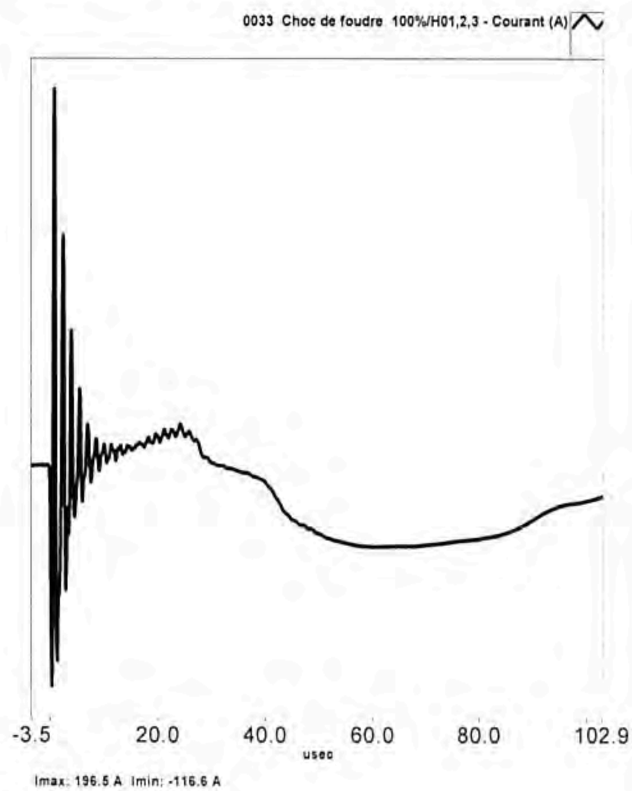
Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

Hydro Québec	Type d'essai	: CHOCS
	Objet d'essai	: INDUCTANCE SHUNT 3 PH., 140MVAR
	No de série	: 15079-01
LABORATOIRE HAUTE TENSION	No de contrat	: J794315045
Chocs V5.5.11	Client	: ABB







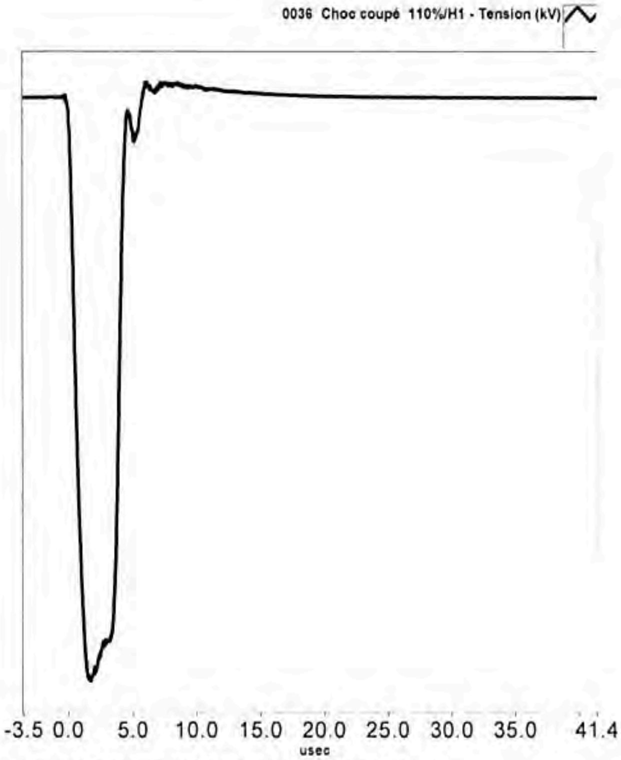


Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

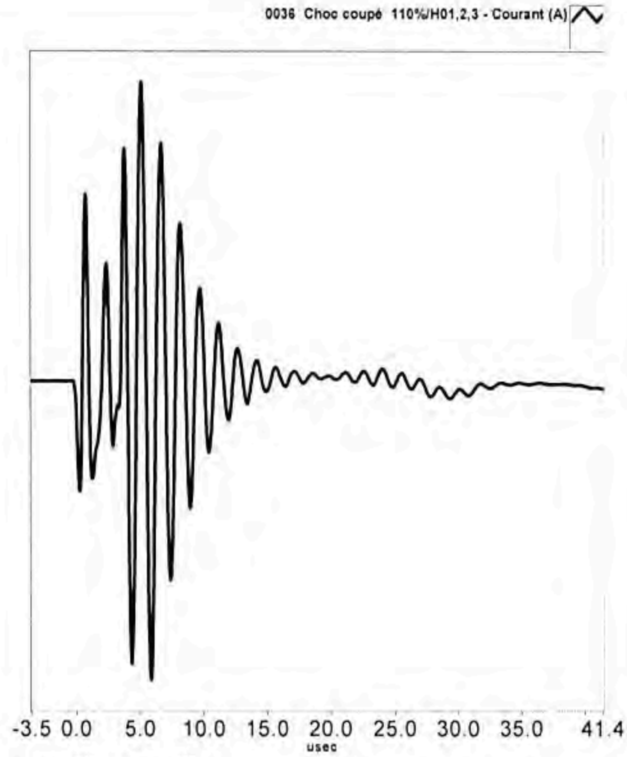
Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

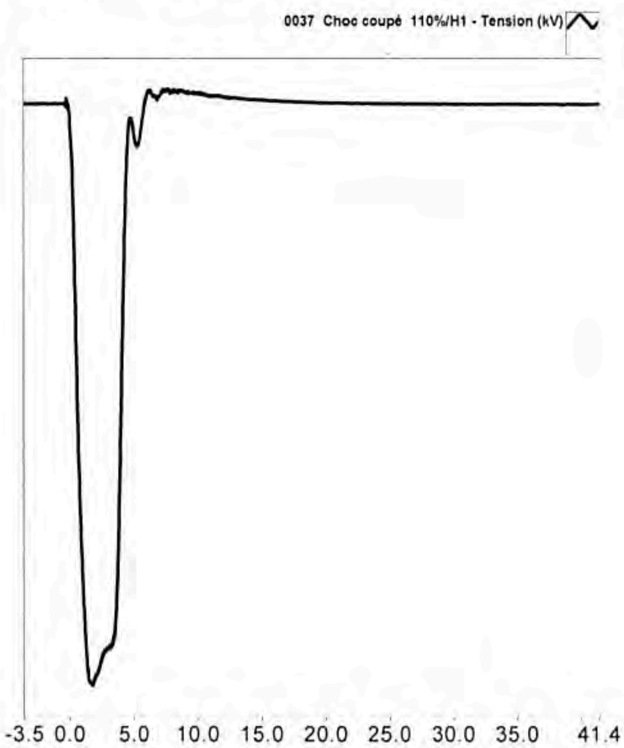
Type d'essai	: CHOCS
Objet d'essai	: INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	: 15079-01
No de contrat	: J794315045
Client	: ABB



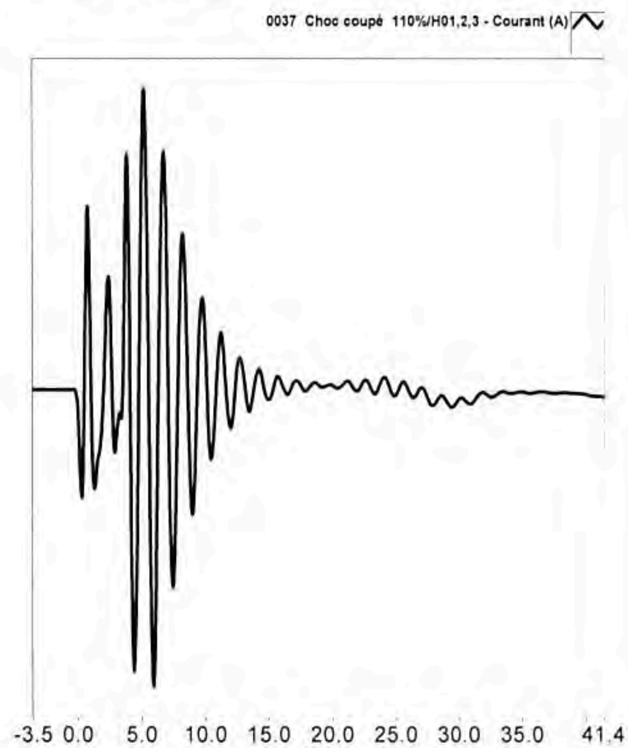
Vmax: 31.6 kV Vmin: -1166.6 kV Tf: 1.254 us Tc: 3.54 us



Imax: 337.7 A Imin: -337.3 A



Vmax: 31.1 kV Vmin: -1167.5 kV Tf: 1.265 us Tc: 3.65 us



Imax: 342.7 A Imin: -340.0 A

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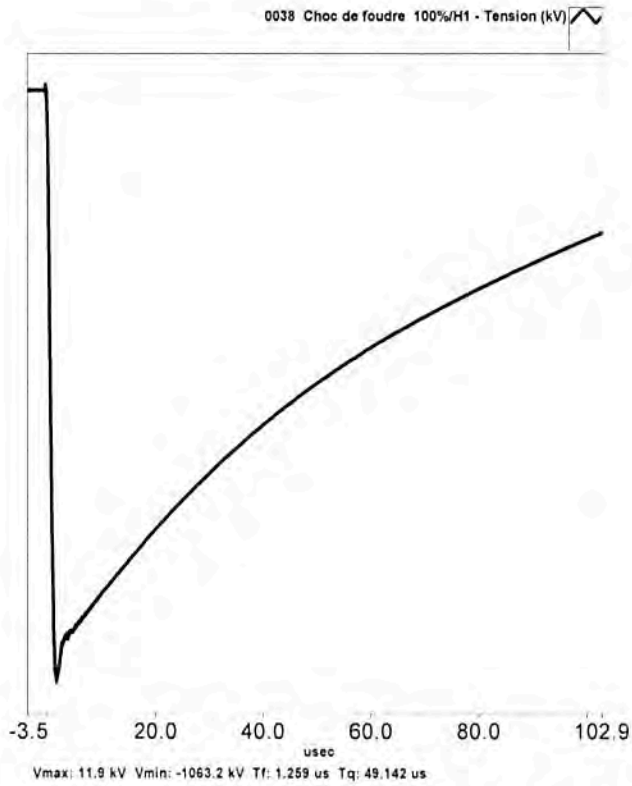
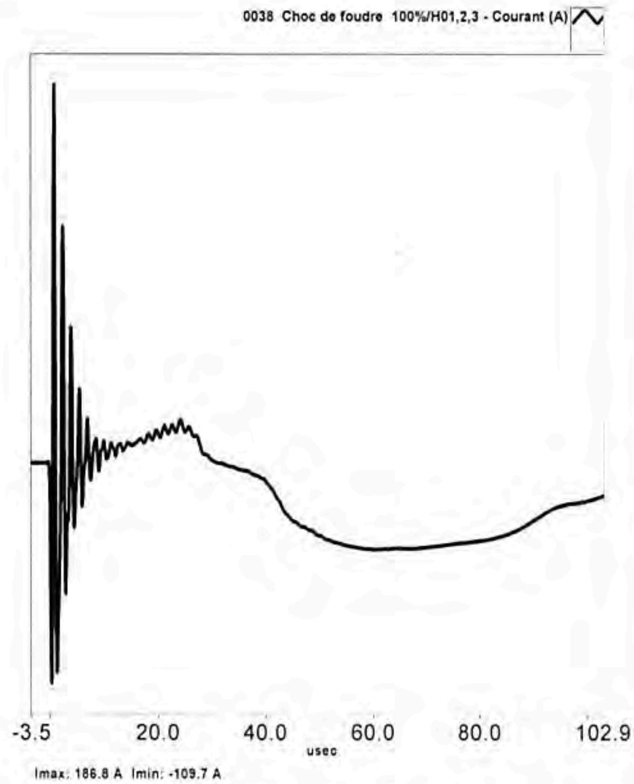
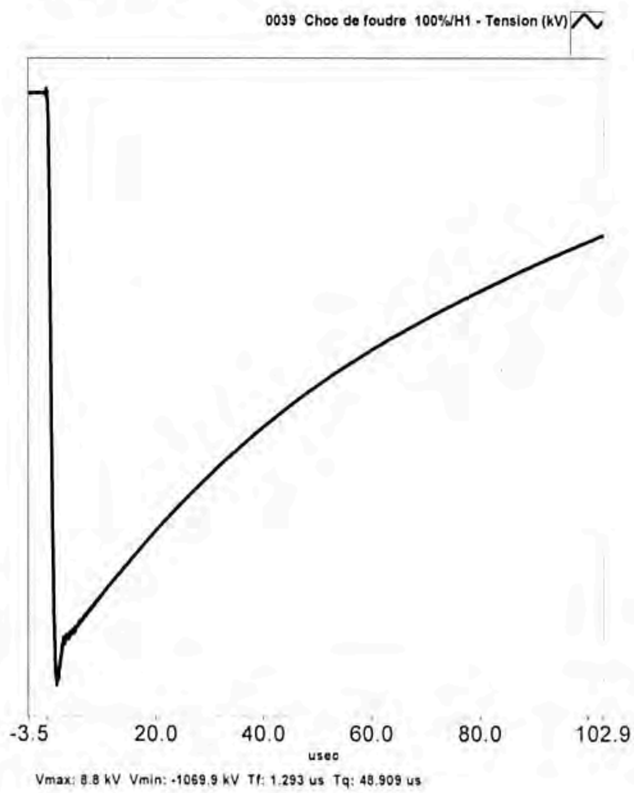
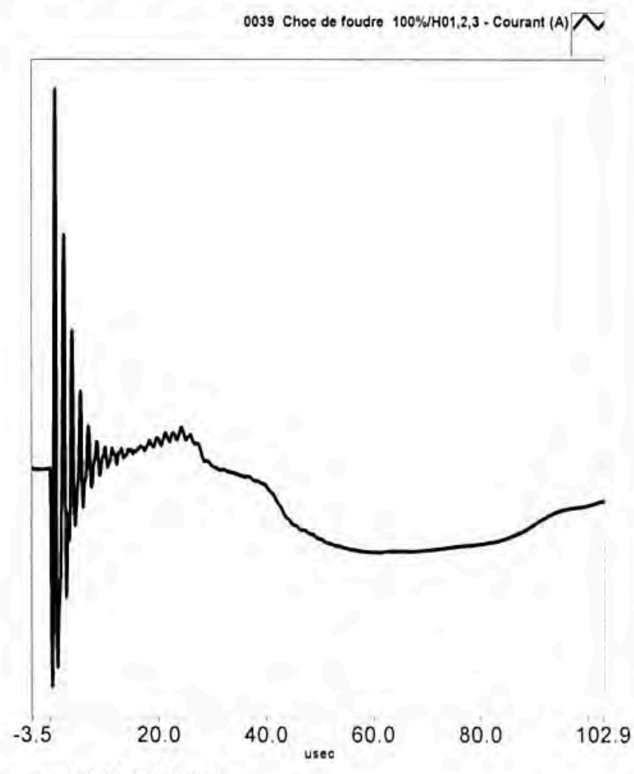
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB







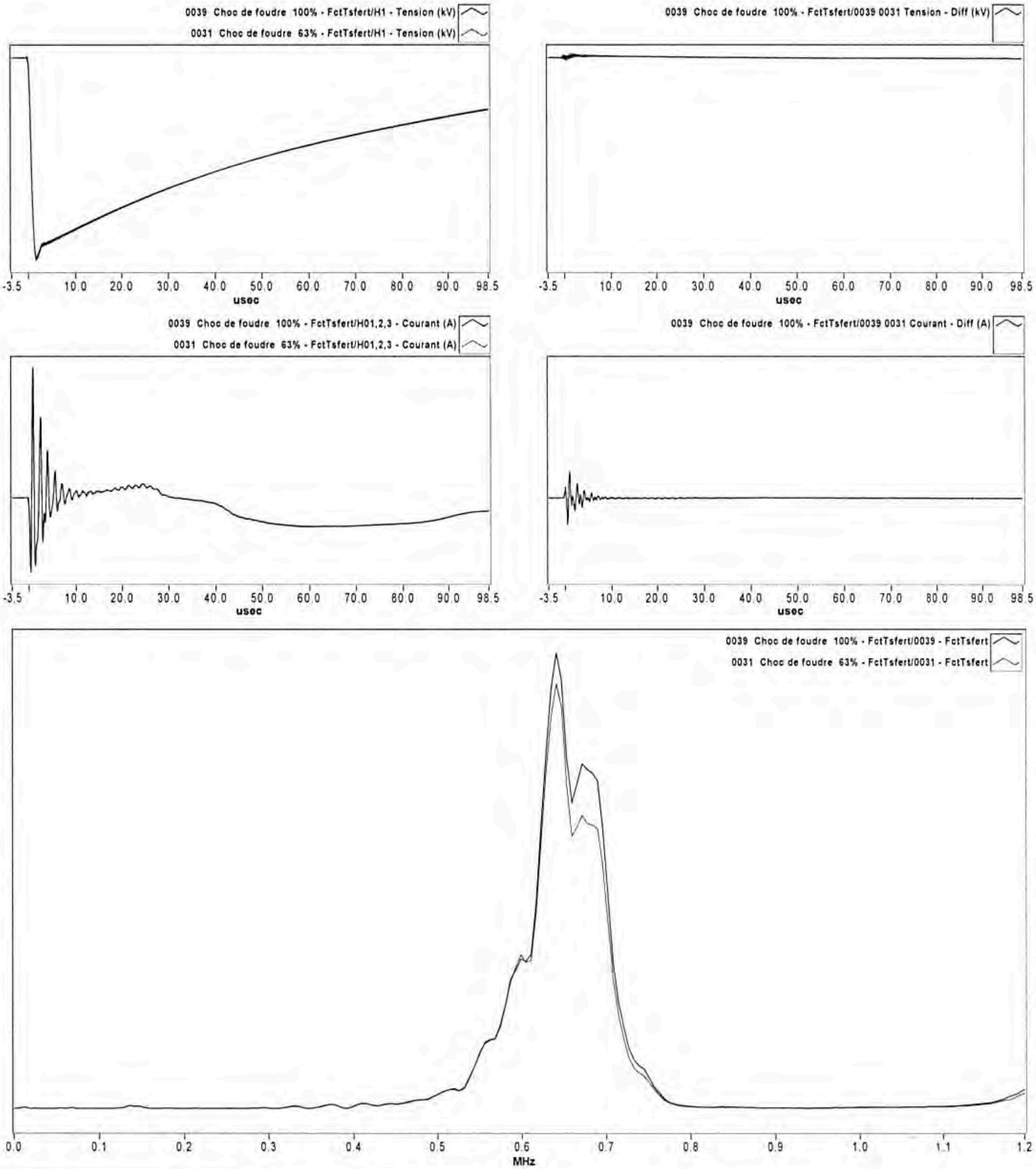


Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB



Essai réalisé par : R.B.,R.P.
Date : 2015-10-23
Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB

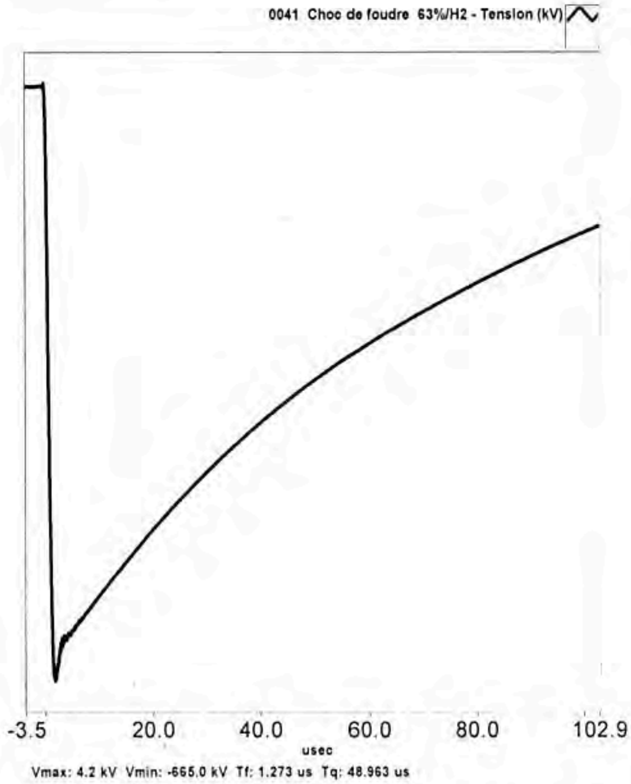
#	Type d'impulsion	Type de signal	Max		Min		
1	0041 Choc de foudre 63%	H2 - Tension (kV)	4.2 kV	-665.0 kV	Tf: 1.273 us	Tq: 48.963 us	
2	0041 Choc de foudre 63%	H01,2,3 - Courant (A)	121.1 A	-76.0 A			
3	0042 Choc de foudre 63%	H2 - Tension (kV)	1.4 kV	-670.2 kV	Tf: 1.280 us	Tq: 49.080 us	
4	0042 Choc de foudre 63%	H01,2,3 - Courant (A)	124.6 A	-74.8 A			
5	0043 Choc de foudre 100%	H2 - Tension (kV)	1.8 kV	-1067.7 kV	Tf: 1.278 us	Tq: 49.522 us	
6	0043 Choc de foudre 100%	H01,2,3 - Courant (A)	207.7 A	-137.2 A			
7	0044 Choc coupé 68%	H2 - Tension (kV)	22.2 kV	-736.3 kV	Tf: 1.269 us	Tc: 3.82 us	
8	0044 Choc coupé 68%	H01,2,3 - Courant (A)	223.0 A	-182.5 A			
9	0045 Choc coupé 68%	H2 - Tension (kV)	22.7 kV	-735.9 kV	Tf: 1.293 us	Tc: 3.79 us	
10	0045 Choc coupé 68%	H01,2,3 - Courant (A)	222.6 A	-184.5 A			
11	0046 Choc coupé 110%	H2 - Tension (kV)	36.6 kV	-1168.5 kV	Tf: 1.272 us	Tc: 3.52 us	
12	0046 Choc coupé 110%	H01,2,3 - Courant (A)	293.0 A	-292.0 A			
13	0047 Choc coupé 110%	H2 - Tension (kV)	37.0 kV	-1167.4 kV	Tf: 1.260 us	Tc: 3.48 us	
14	0047 Choc coupé 110%	H01,2,3 - Courant (A)	290.2 A	-291.7 A			
15	0048 Choc de foudre 100%	H2 - Tension (kV)	16.5 kV	-1060.4 kV	Tf: 1.285 us	Tq: 49.866 us	
16	0048 Choc de foudre 100%	H01,2,3 - Courant (A)	203.2 A	-124.1 A			
17	0049 Choc de foudre 100%	H2 - Tension (kV)	12.1 kV	-1060.4 kV	Tf: 1.266 us	Tq: 50.044 us	
18	0049 Choc de foudre 100%	H01,2,3 - Courant (A)	198.4 A	-126.1 A			

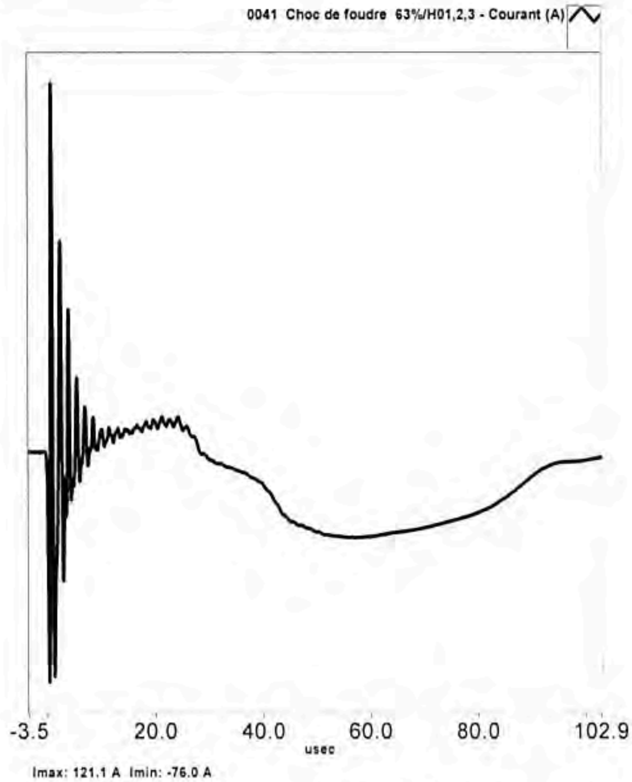
Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

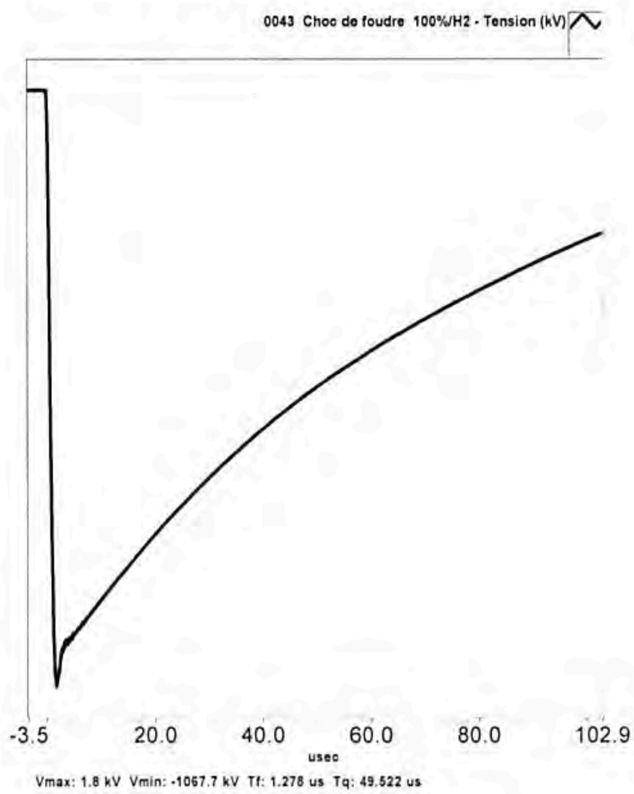
Hydro Québec

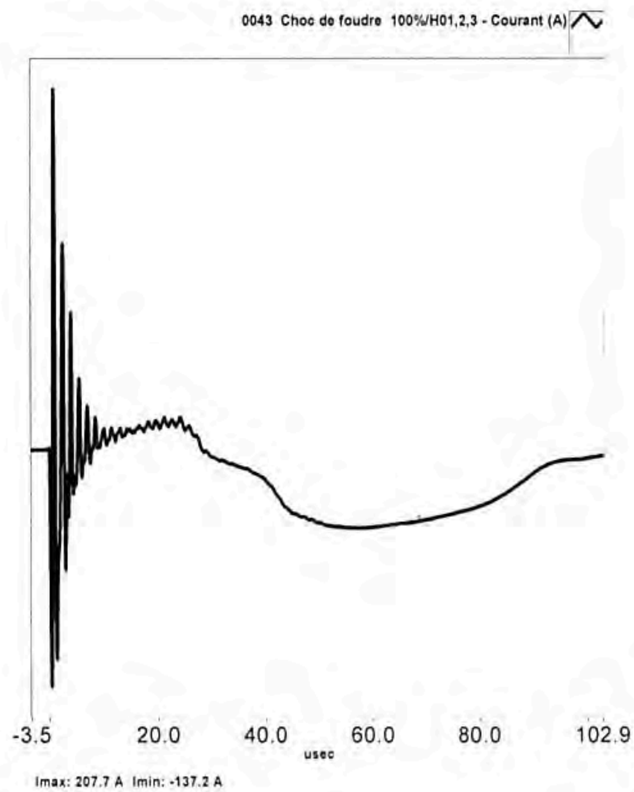
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai	: CHOCS
Objet d'essai	: INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	: 15079-01
No de contrat	: J794315045
Client	: ABB







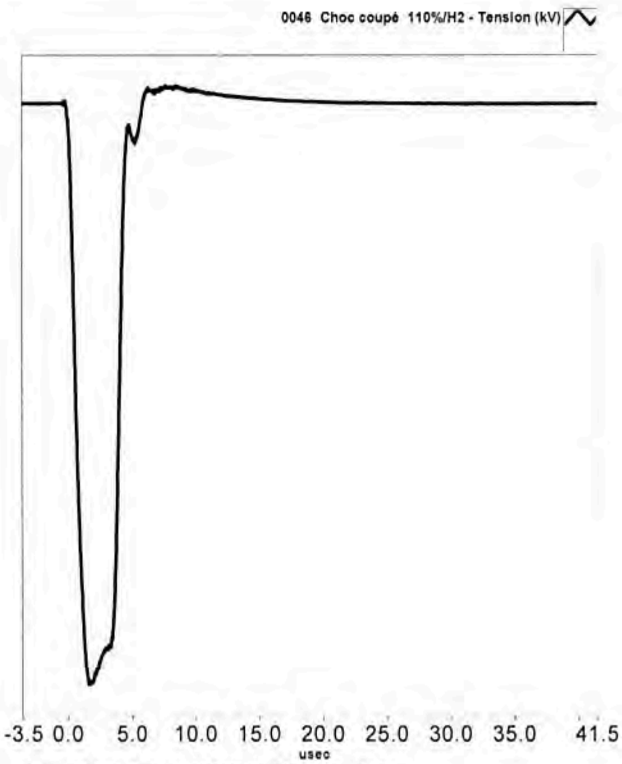


Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

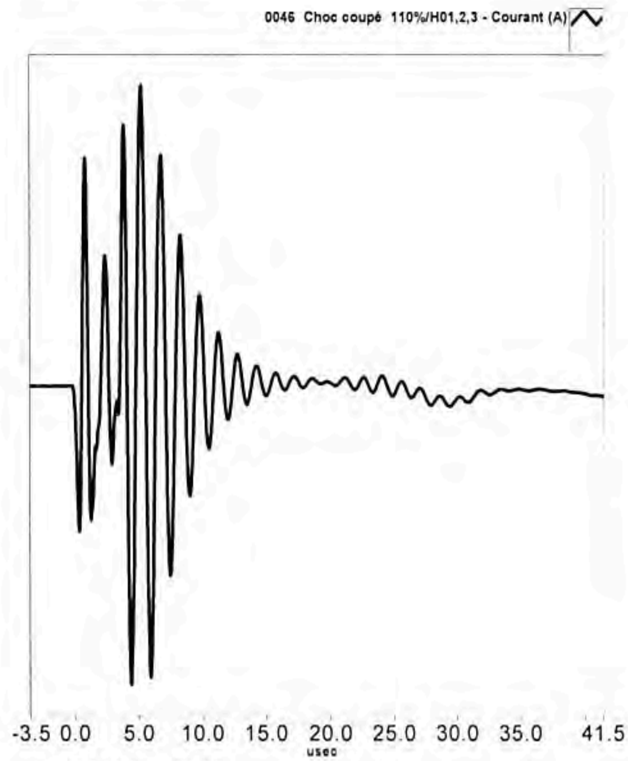
Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

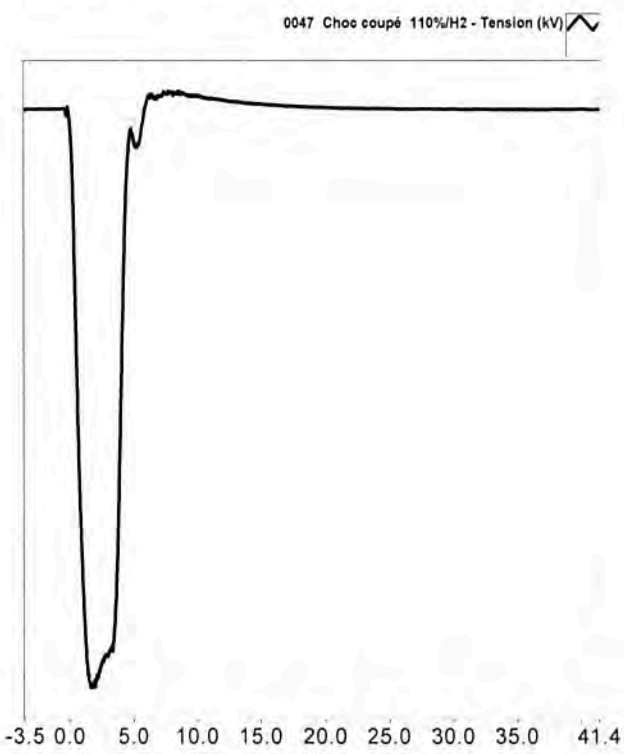
Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB



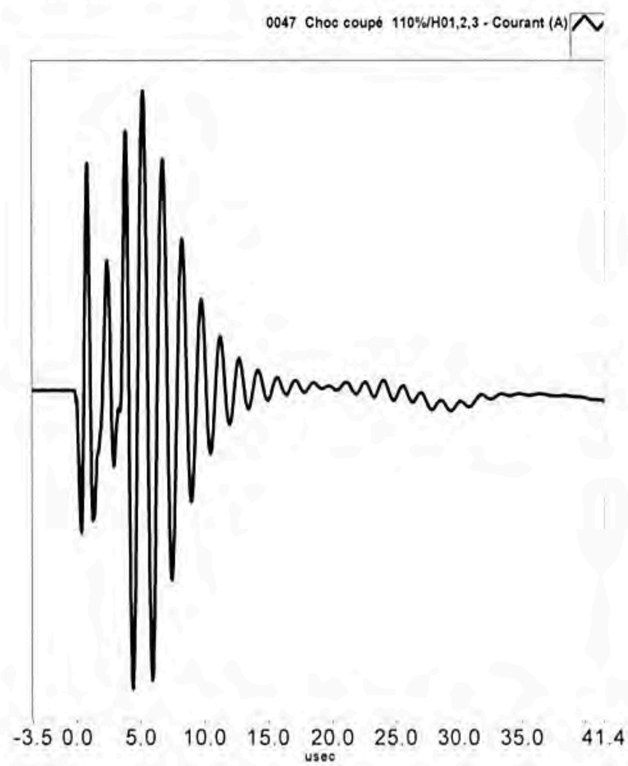
Vmax: 36.6 kV Vmin: -1168.5 kV Tf: 1.272 us Tc: 3.52 us



Imax: 293.0 A Imin: -292.0 A



Vmax: 37.0 kV Vmin: -1167.4 kV Tf: 1.260 us Tc: 3.48 us



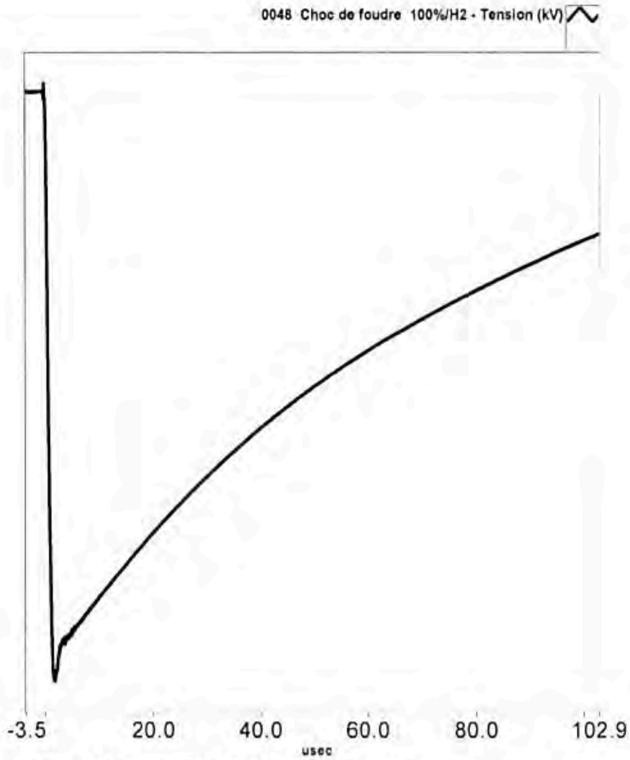
Imax: 290.2 A Imin: -291.7 A

Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

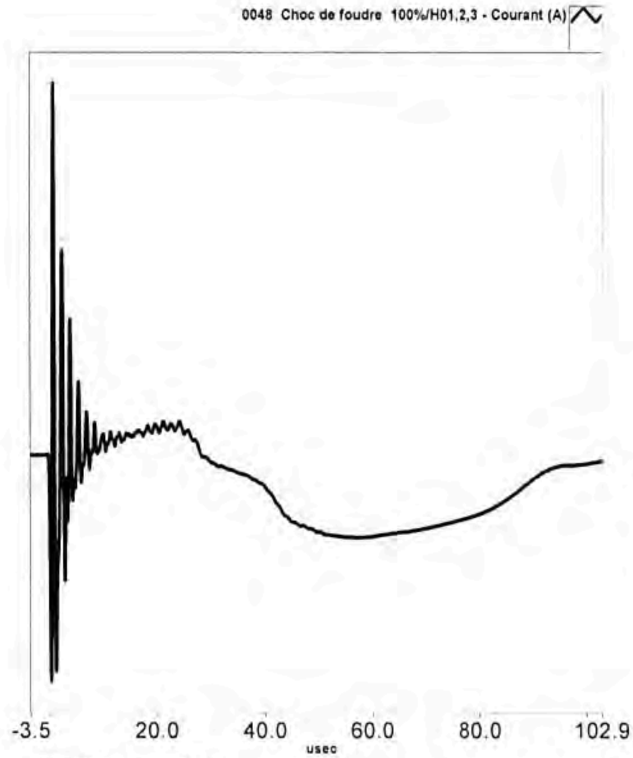
Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

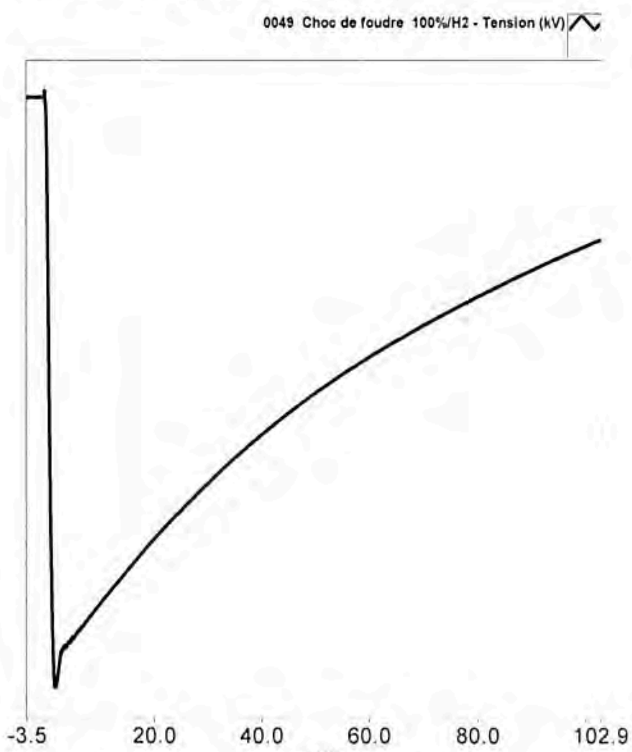
Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB



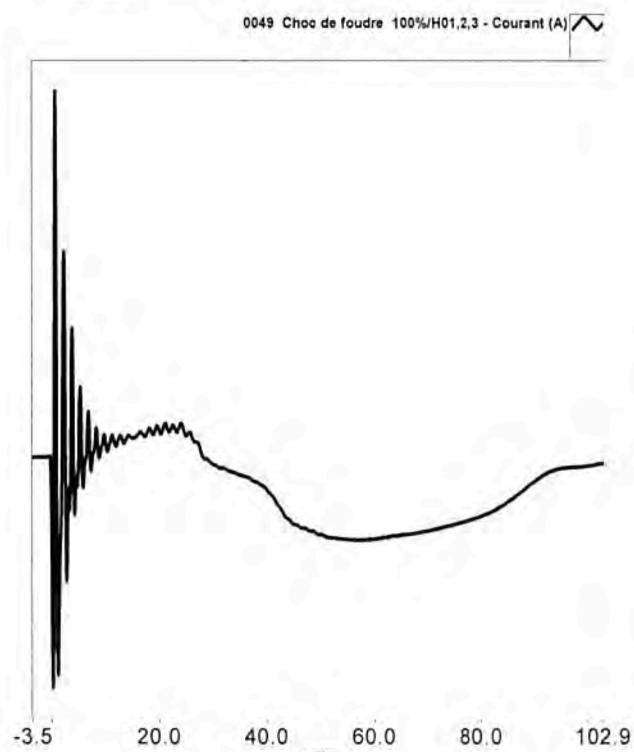
Vmax: 16.5 kV Vmin: -1060.4 kV Tf: 1.285 us Tq: 49.866 us



Imax: 203.2 A Imin: -124.1 A



Vmax: 12.1 kV Vmin: -1060.4 kV Tf: 1.266 us Tq: 50.044 us



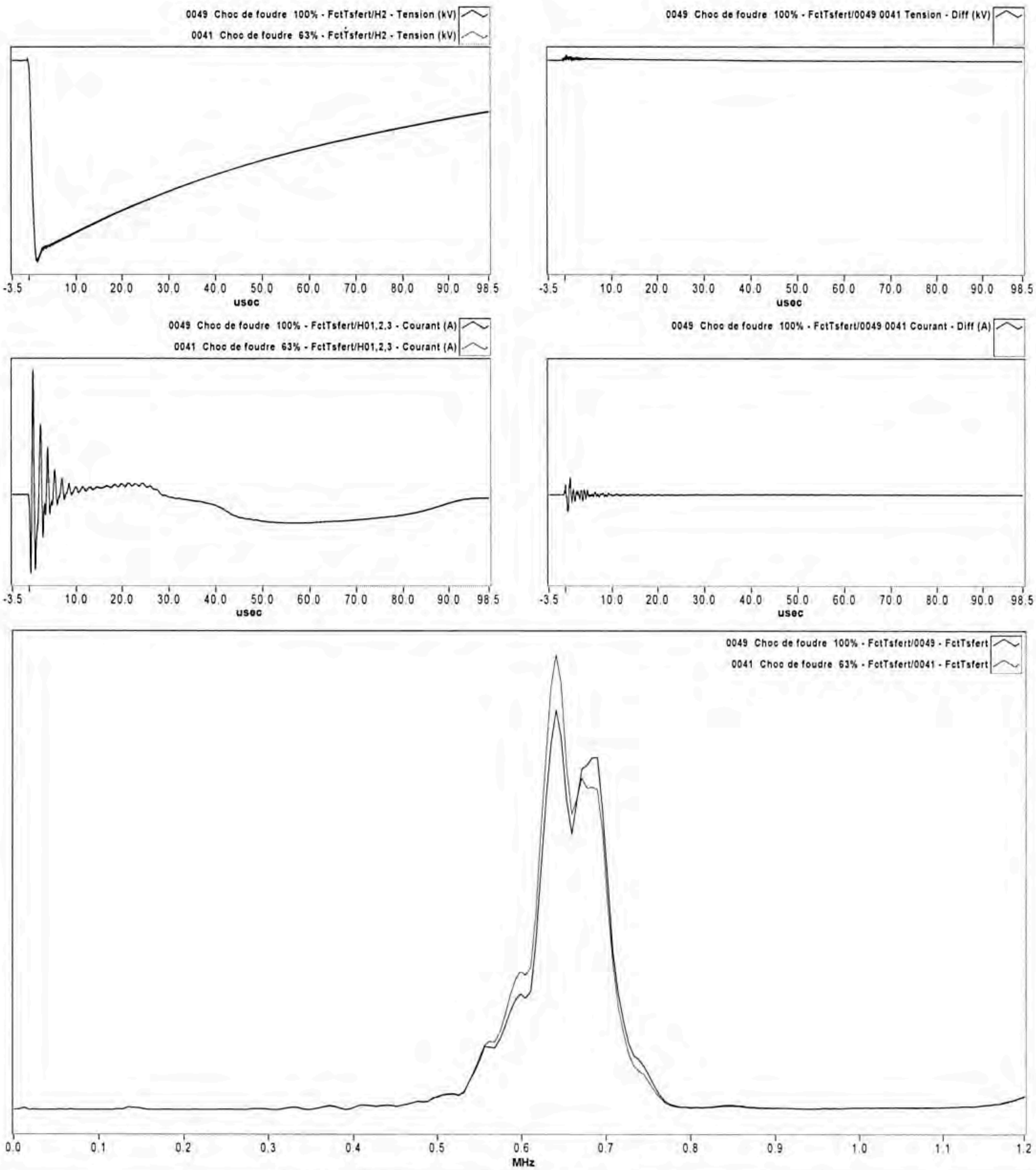
Imax: 198.4 A Imin: -126.1 A

Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB



Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB

#	Type d'impulsion	Type de signal	Max		Min		
1	0051 Choc de foudre 63%	H3 - Tension (kV)	1.5 kV	-670.7 kV	Tf: 1.334 us	Tq: 48.704 us	
2	0051 Choc de foudre 63%	H01,2,3 - Courant (A)	139.1 A	-78.1 A			
3	0052 Choc de foudre 63%	H3 - Tension (kV)	9.2 kV	-673.9 kV	Tf: 1.300 us	Tq: 48.454 us	
4	0052 Choc de foudre 63%	H01,2,3 - Courant (A)	148.9 A	-81.1 A			
5	0053 Choc de foudre 100%	H3 - Tension (kV)	5.1 kV	-1060.1 kV	Tf: 1.287 us	Tq: 49.773 us	
6	0053 Choc de foudre 100%	H01,2,3 - Courant (A)	239.9 A	-130.3 A			
7	0054 Choc coupé 68%	H3 - Tension (kV)	23.1 kV	-737.8 kV	Tf: 1.305 us	Tc: 3.85 us	
8	0054 Choc coupé 68%	H01,2,3 - Courant (A)	213.5 A	-192.2 A			
9	0055 Choc coupé 68%	H3 - Tension (kV)	23.6 kV	-736.6 kV	Tf: 1.278 us	Tc: 3.85 us	
10	0055 Choc coupé 68%	H01,2,3 - Courant (A)	215.3 A	-191.9 A			
11	0056 Choc coupé 110%	H3 - Tension (kV)	38.7 kV	-1172.0 kV	Tf: 1.291 us	Tc: 3.63 us	
12	0056 Choc coupé 110%	H01,2,3 - Courant (A)	306.2 A	-306.0 A			
13	0057 Choc coupé 110%	H3 - Tension (kV)	38.4 kV	-1165.2 kV	Tf: 1.294 us	Tc: 3.62 us	
14	0057 Choc coupé 110%	H01,2,3 - Courant (A)	294.8 A	-315.8 A			
15	0058 Choc de foudre 100%	H3 - Tension (kV)	6.7 kV	-1062.8 kV	Tf: 1.291 us	Tq: 49.564 us	
16	0058 Choc de foudre 100%	H01,2,3 - Courant (A)	237.8 A	-130.7 A			
17	0059 Choc de foudre 100%	H3 - Tension (kV)	6.3 kV	-1060.8 kV	Tf: 1.248 us	Tq: 49.817 us	
18	0059 Choc de foudre 100%	H01,2,3 - Courant (A)	238.3 A	-132.6 A			

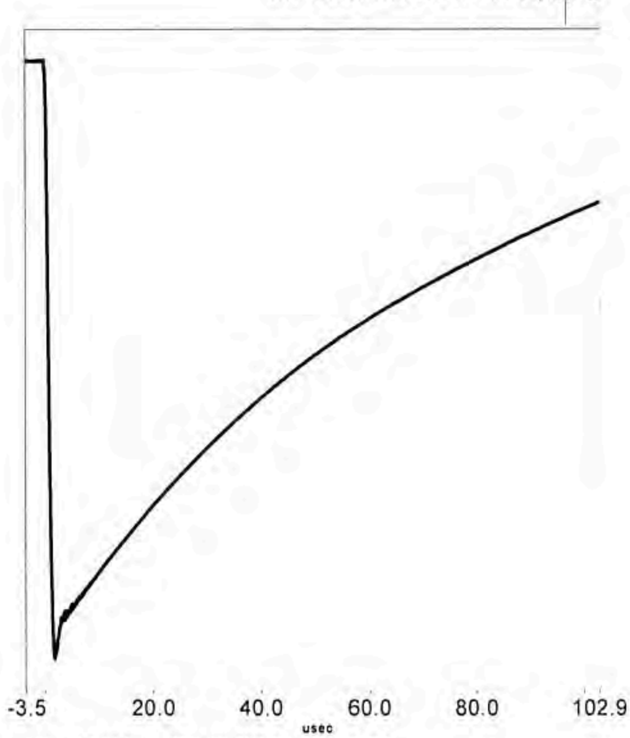
Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

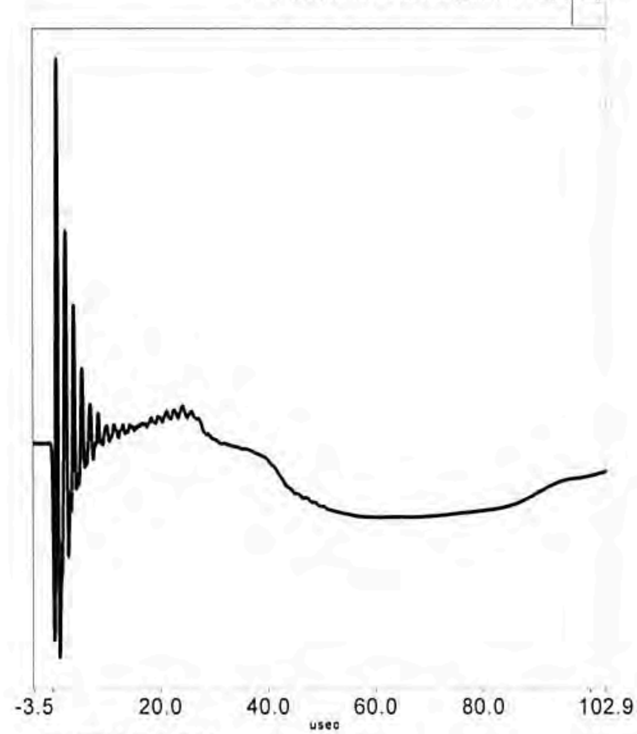
Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB

0051 Choc de foudre 63%/H3 - Tension (kV)



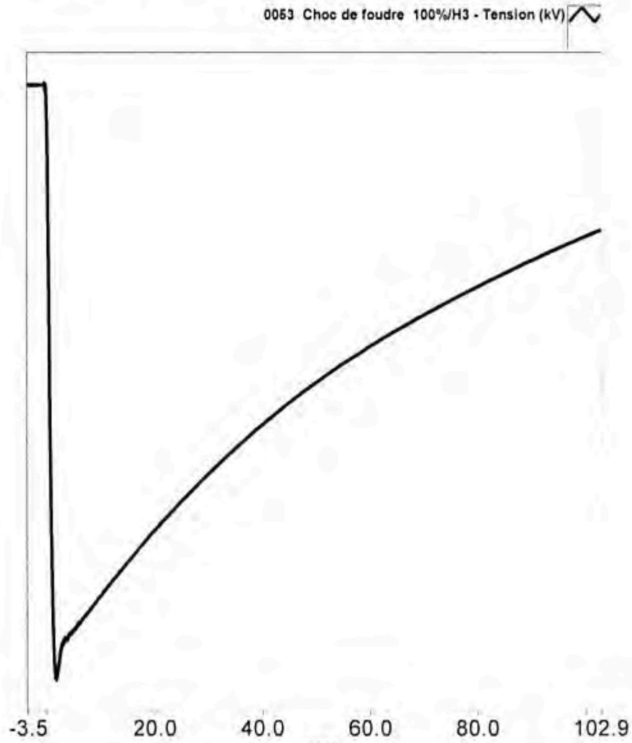
Vmax: 1.5 kV Vmin: -670.7 kV Tf: 1.334 us Tq: 48.704 us

0051 Choc de foudre 63%/H01,2,3 - Courant (A)



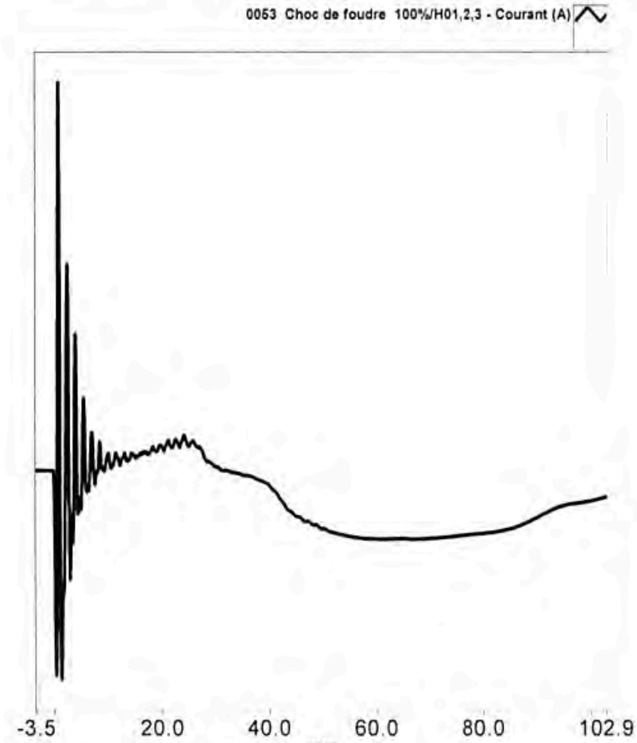
Imax: 139.1 A Imin: -78.1 A

0053 Choc de foudre 100%/H3 - Tension (kV)



Vmax: 5.1 kV Vmin: -1060.1 kV Tf: 1.287 us Tq: 49.773 us

0053 Choc de foudre 100%/H01,2,3 - Courant (A)



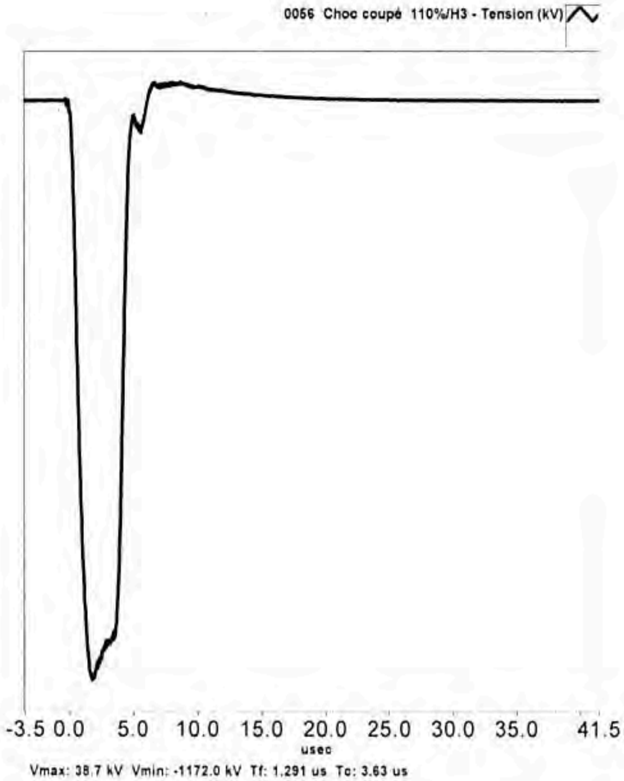
Imax: 239.9 A Imin: -130.3 A

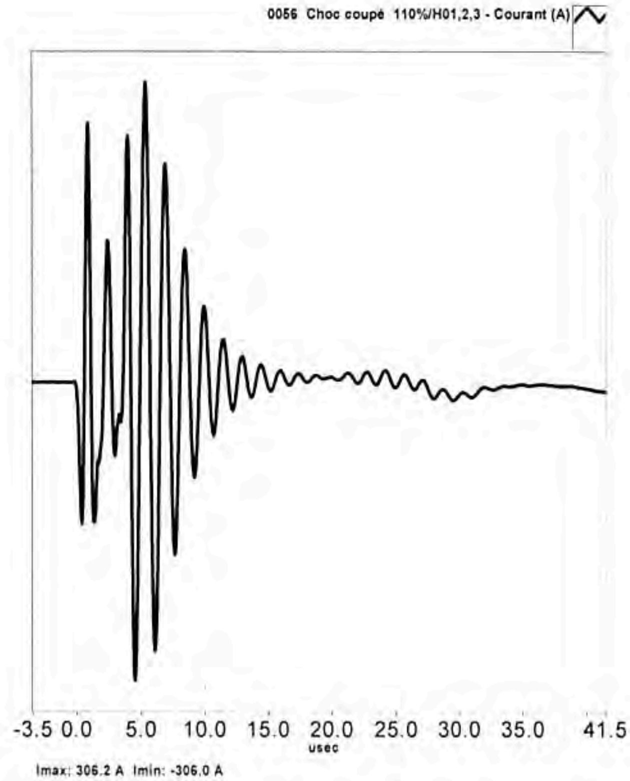
Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

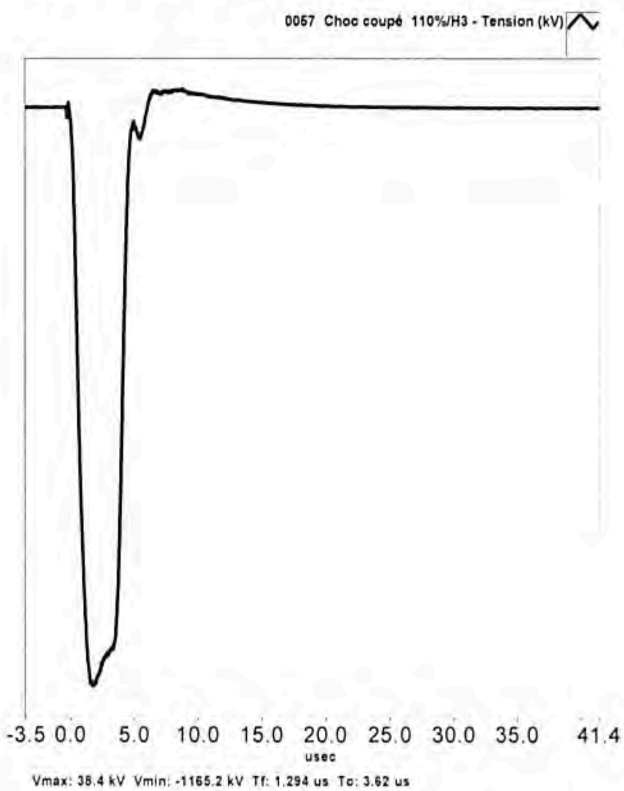
Hydro Québec

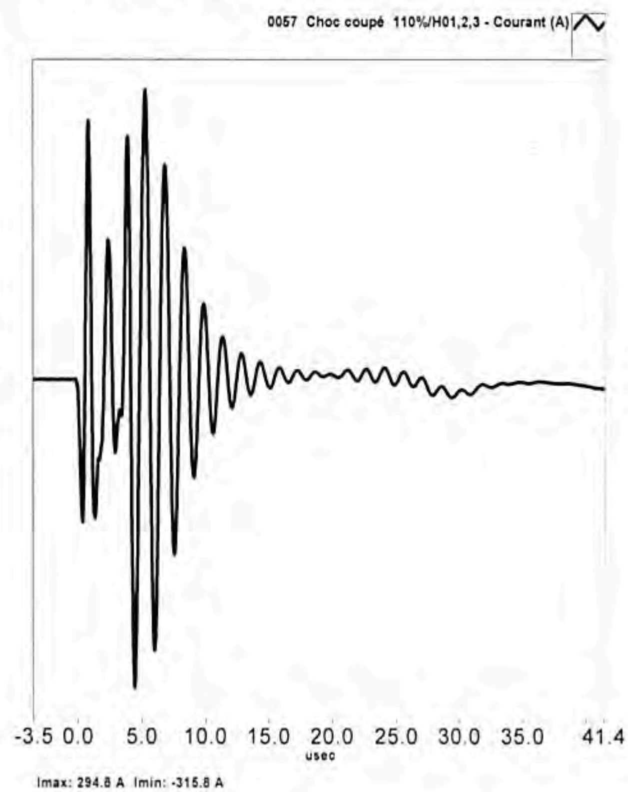
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai :CHOCS
Objet d'essai :INDUCTANCE SHUNT 3 PH., 140MVAR
No de série :15079-01
No de contrat :J794315045
Client :ABB









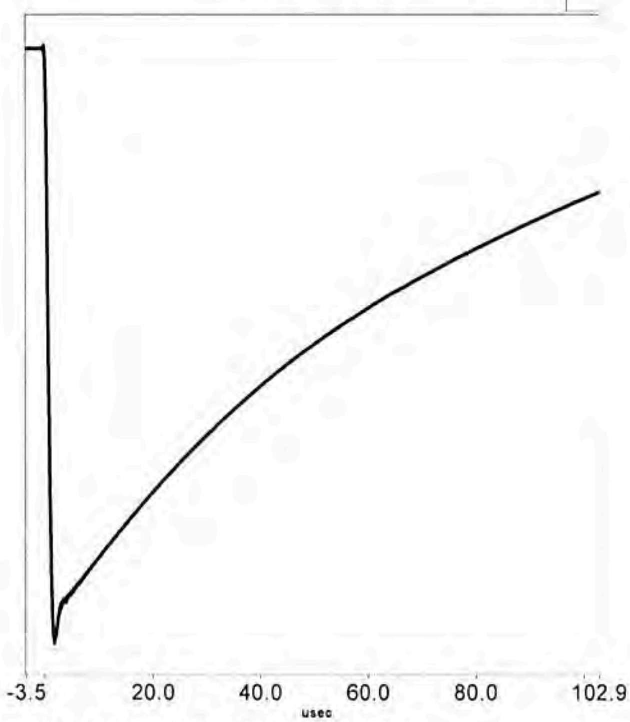
Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

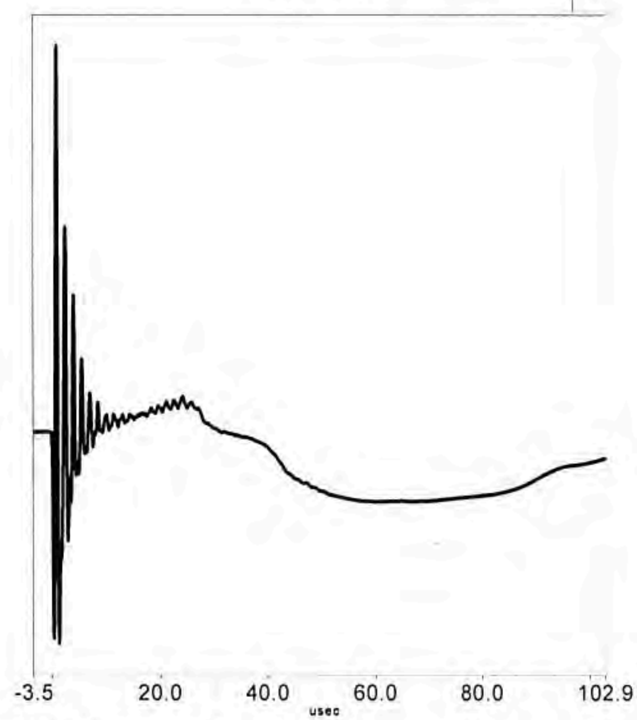
Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB

0058 Choc de foudre 100%/H3 - Tension (kV)



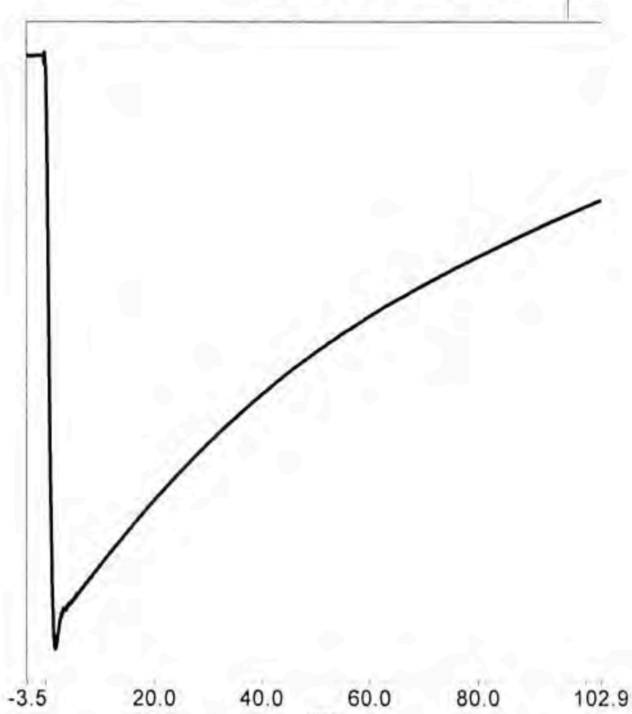
Vmax: 6.7 kV Vmin: -1062.8 kV Tf: 1.291 us Tq: 49.564 us

0058 Choc de foudre 100%/H01,2,3 - Courant (A)



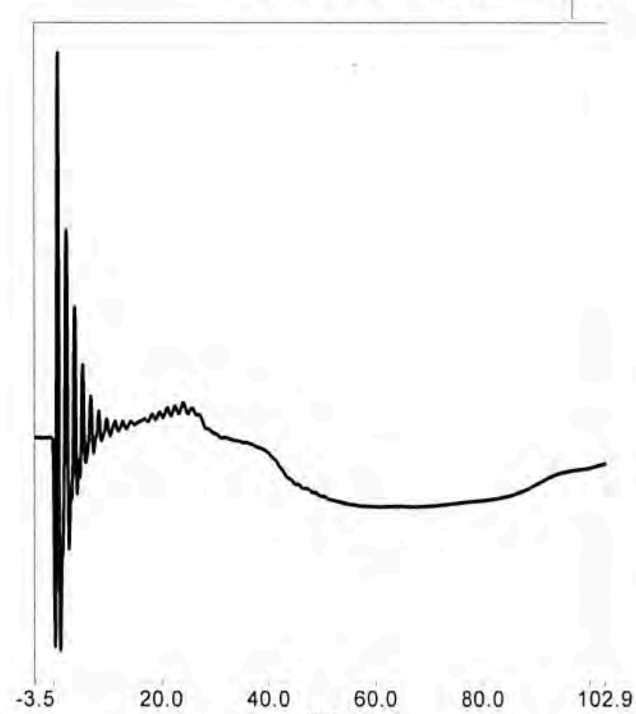
Imax: 237.8 A Imin: -130.7 A

0059 Choc de foudre 100%/H3 - Tension (kV)



Vmax: 6.3 kV Vmin: -1060.8 kV Tf: 1.248 us Tq: 49.817 us

0059 Choc de foudre 100%/H01,2,3 - Courant (A)



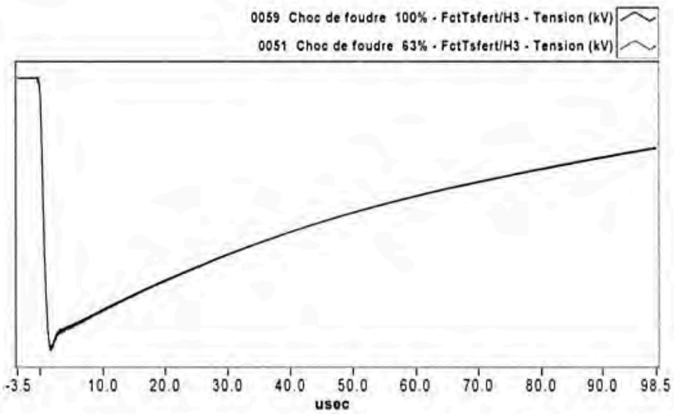
Imax: 238.3 A Imin: -132.6 A

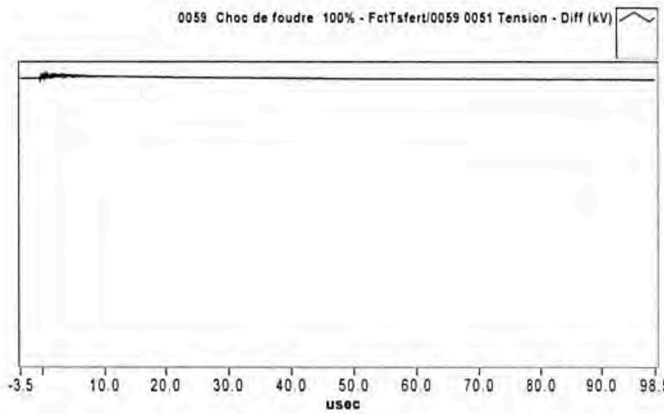
Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

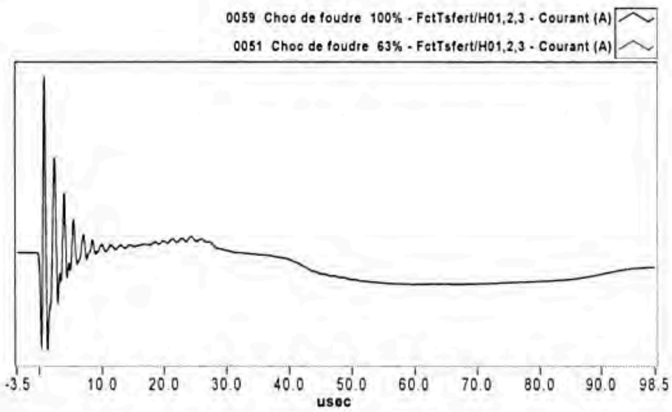
Hydro Québec

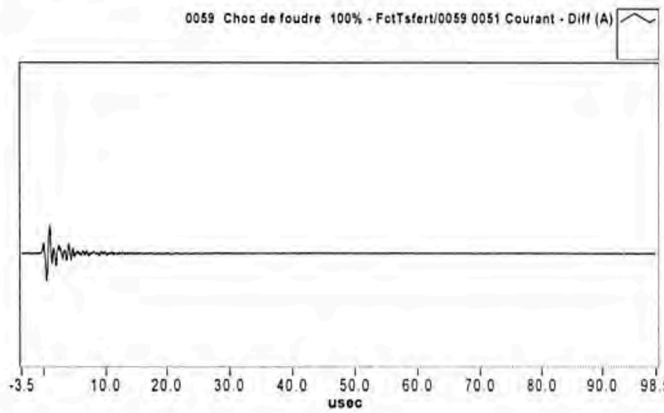
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

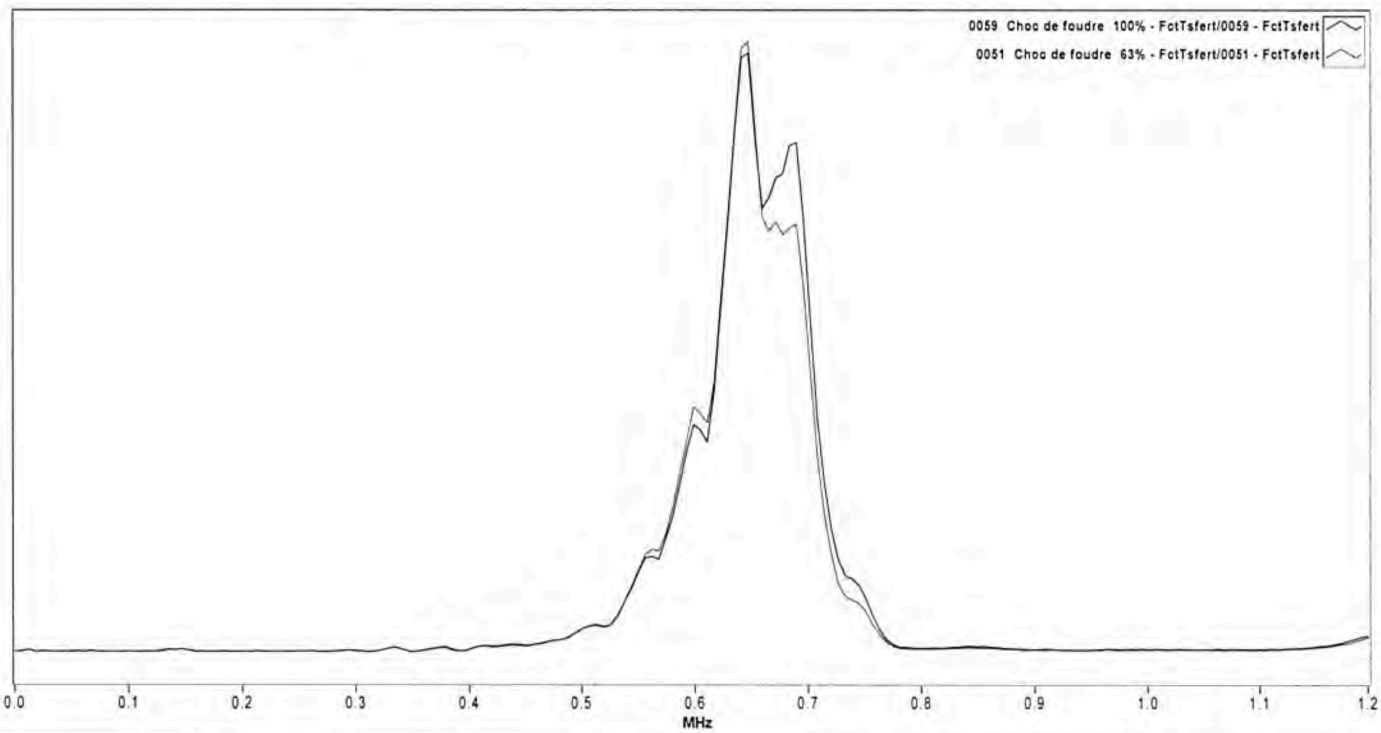
Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB









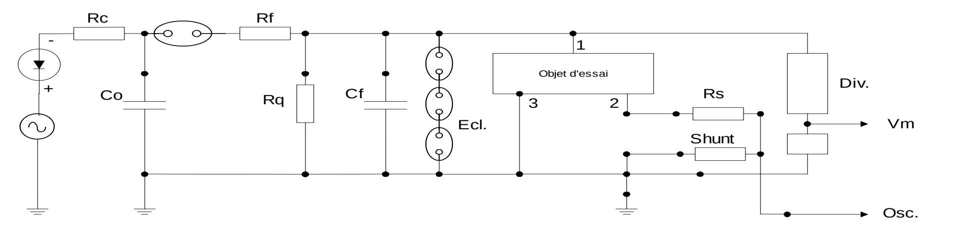


Essai réalisé par : R.B.,R.P.   Date : 2015-10-23   Page :

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Essai de Chocs sur H01, H02, H03
Objet d'essais	Inductance shunt 3-ph. 140 MVARS
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.



BORNES

1 = H01,2,3

3 = H1,H2,H3

PARAMÈTRES DU CIRCUIT D'ESSAI

Rc =	51 k	ohm
Rf =	150 * 2	ohm
Rq =	(400 // 400 // 600) * 2	ohm
Cf =	7,5 / 5	nF
Co =	312/2	nF
Ecl=	---	éclateurs
Rs =	---	ohm

DIVISEUR DE TENSION

R Rd/1 : 295,76

Shunt (ohm) 9,997

FORME D'ONDE

Forme d'onde	3,6/49,1	µs
Lancée de tension	0	%
Lancée inverse	3,7	%
U appliquée	250	kV
Tension sur	0	% BIL
Correction		%

EFFICACITÉ DU CIRCUIT

$$\text{Efficacité} = \frac{\text{Vm} * 100}{\text{U charge} * \text{nombre d'étages}} = \frac{57,4 * 100}{50 * 2} \quad 57,4 \ \%$$

Séquence d'essai Nb	Forme	Pol.	Volt Appliq. kV	Gén. de chocs Charge kV	Pression en kV	kV	% Pleine	Pos. du C.P.	Système de mesure Balayage Tension, courant (µs)	Éclateurs Ecart. mm	Rq 1 Ratio / 1	
2	RP	N	158	137,6	165	158	63,2	---	102			
3	P	N	250	217,8	261	250	100,0	---	102			

Remarques :

Essais par : R.B., R.M.

Date : 2015-10-26

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Essai de Chocs sur H01, H02, H03	
Objet d'essais	Inductance shunt 3-ph.	140 MVARS
Nº Série	15079-01	
Nº Contrat	J794315045	
Client	ABB Inc.	

IDENTIFICATION DES INSTRUMENTS UTILISÉS

	ENTRÉE #1	ENTRÉE #2
SHUNTS		36B0330
DIVISEURS	32A191	
BRAS BASSE TENSION	36C0431	
ATTÉNUATEUR DU DIVISEUR		
TERMINAISONS 50 OHMS	36A0420	36A0422
DIGITALISATEUR (GAGE)	2040217	2040217
ATTÉNUATEUR DU DIGITALISATEUR	0327602	0327603
PONT DE RAPPORT DE DIVISEUR	32A049	

Essais par : R.B., R.M.   Date : 2015-10-26

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB

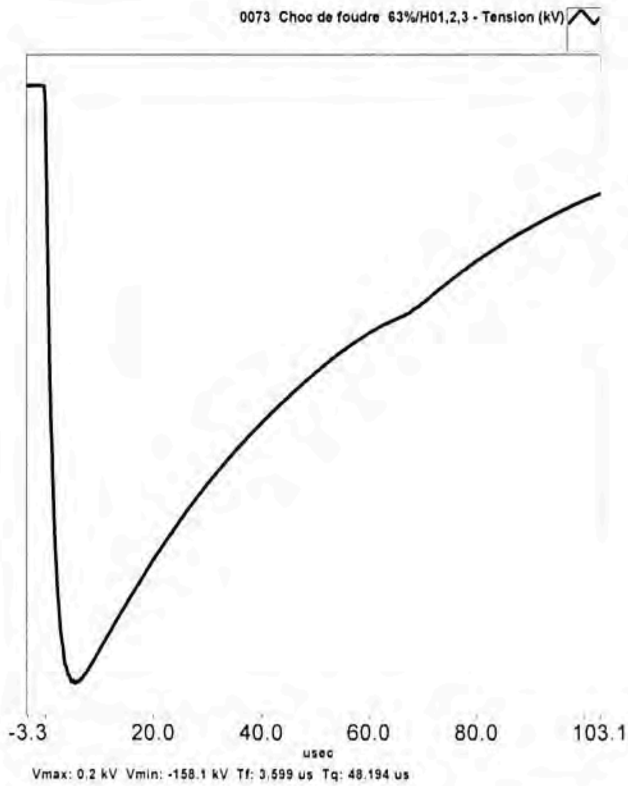
#	Type d'impulsion	Type de signal	Max		Min		
1	0073 Choc de foudre 63%	H01,2,3 - Tension (kV)	0.2 kV	-158.1 kV	Tf: 3.599 us	Tq: 48.194 us	
2	0073 Choc de foudre 63%	H1,2,3 - Courant (A)	20.9 A	-22.8 A			
3	0074 Choc de foudre 63%	H01,2,3 - Tension (kV)	0.6 kV	-157.9 kV	Tf: 3.598 us	Tq: 47.989 us	
4	0074 Choc de foudre 63%	H1,2,3 - Courant (A)	21.2 A	-23.3 A			
5	0075 Choc de foudre 100%	H01,2,3 - Tension (kV)	0.8 kV	-250.0 kV	Tf: 3.634 us	Tq: 48.874 us	
6	0075 Choc de foudre 100%	H1,2,3 - Courant (A)	34.2 A	-37.3 A			
7	0076 Choc de foudre 100%	H01,2,3 - Tension (kV)	0.4 kV	-249.8 kV	Tf: 3.641 us	Tq: 49.099 us	
8	0076 Choc de foudre 100%	H1,2,3 - Courant (A)	31.0 A	-34.0 A			
9	0077 Choc de foudre 100%	H01,2,3 - Tension (kV)	0.3 kV	-249.8 kV	Tf: 3.599 us	Tq: 49.148 us	
10	0077 Choc de foudre 100%	H1,2,3 - Courant (A)	30.7 A	-33.5 A			

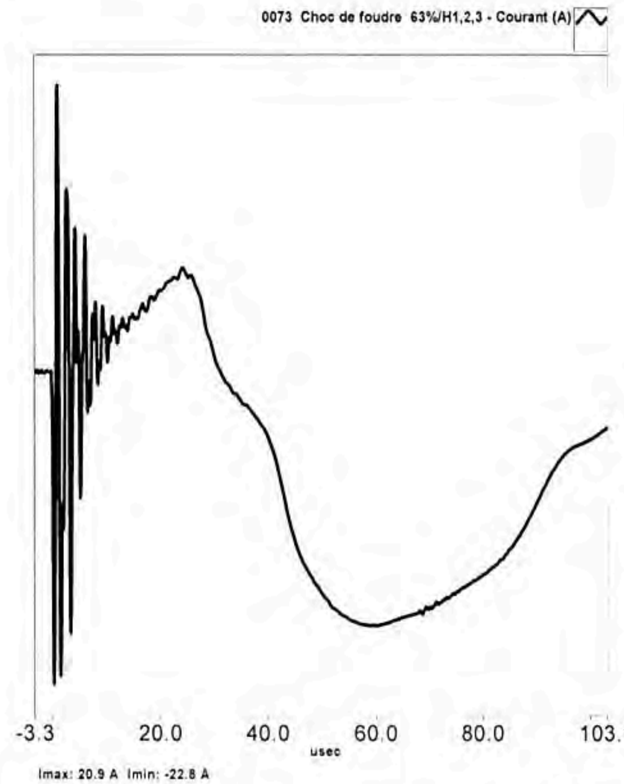
Essai réalisé par : R.B.,R.M.　　Date : 2015-10-26　　Page :

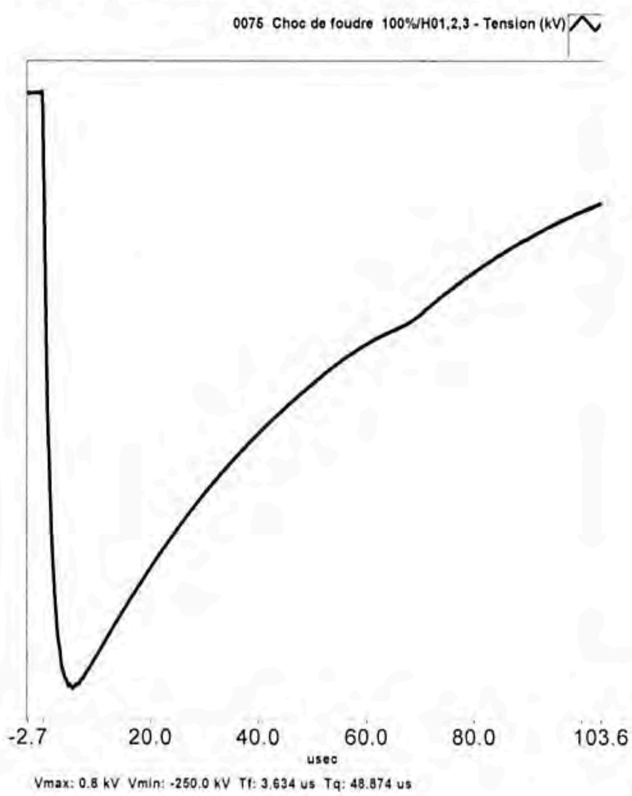
Hydro Québec

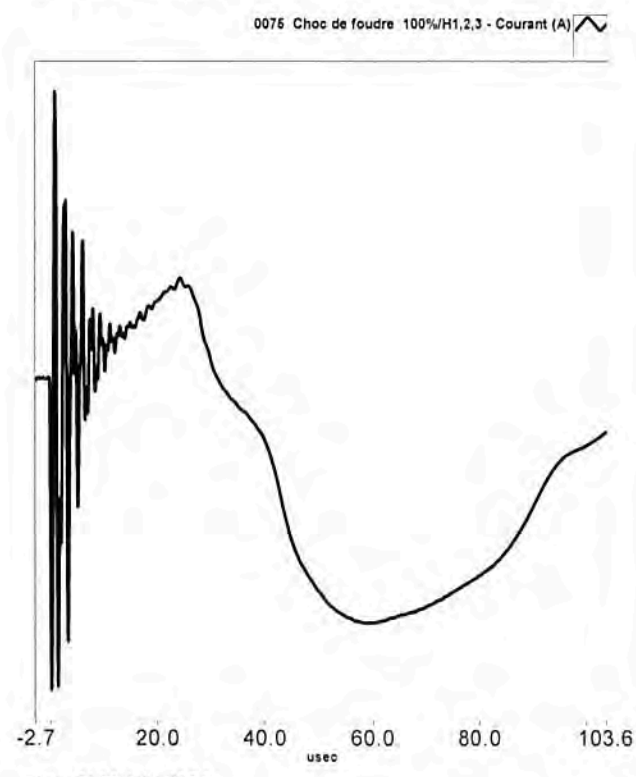
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai	: CHOCS
Objet d'essai	: INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	: 15079-01
No de contrat	: J794315045
Client	: ABB









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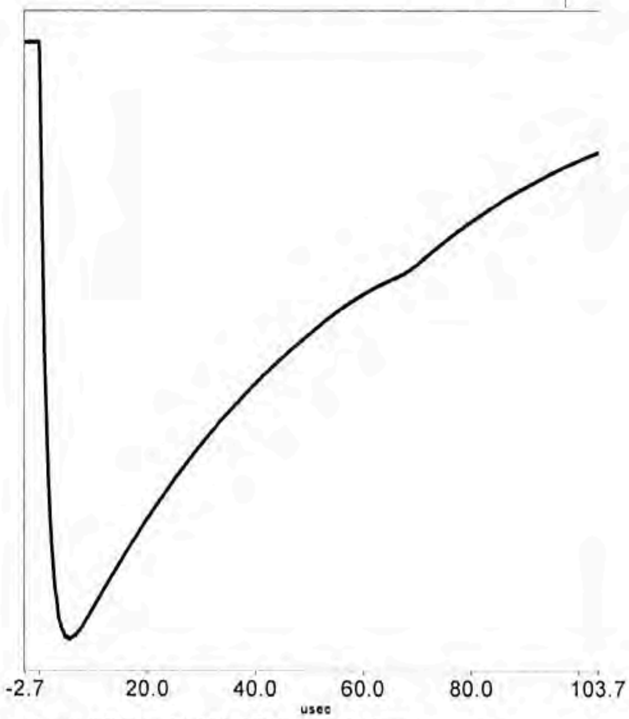
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

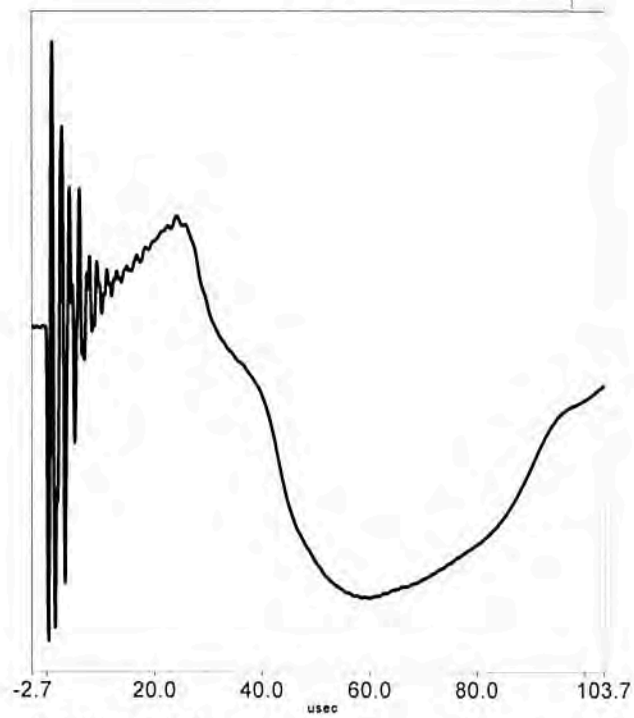
Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB

0076 Choc de foudre 100%/H01,2,3 - Tension (kV)



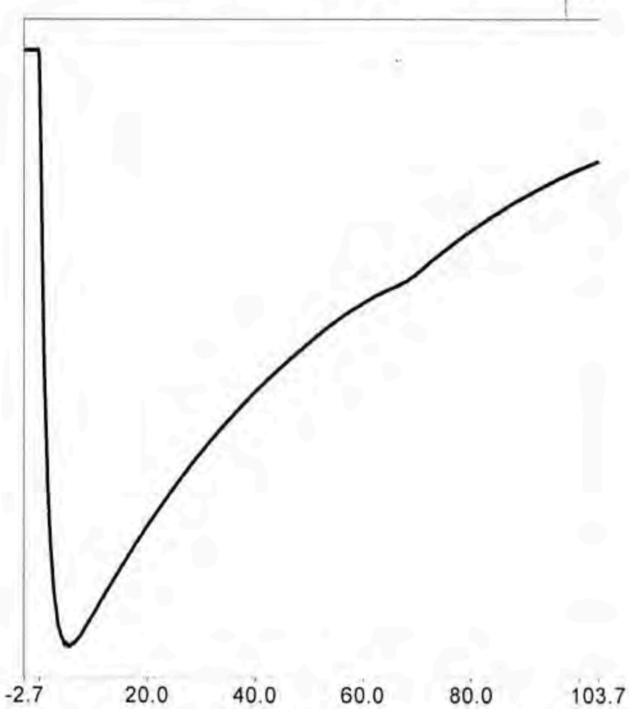
Vmax: 0.4 kV Vmin: -249.8 kV Tf: 3.641 us Tq: 49.099 us

0076 Choc de foudre 100%/H1,2,3 - Courant (A)



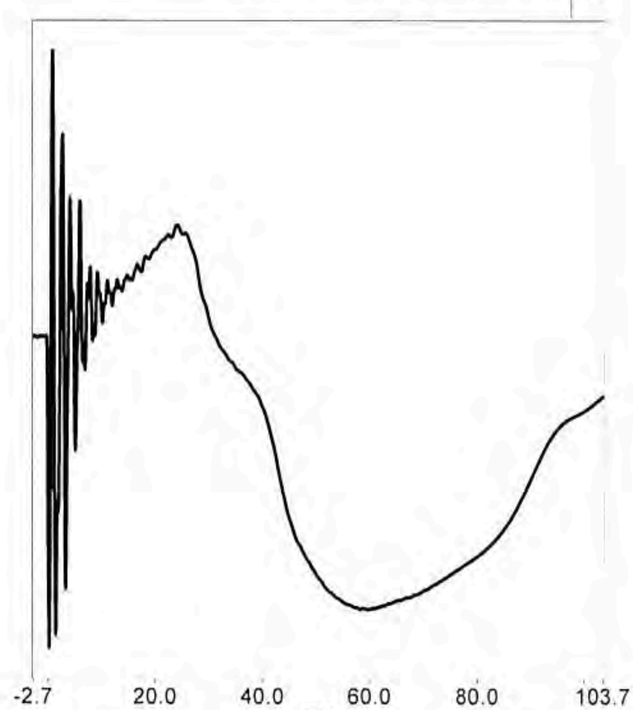
Imax: 31.0 A Imin: -34.0 A

0077 Choc de foudre 100%/H01,2,3 - Tension (kV)



Vmax: 0.3 kV Vmin: -249.8 kV Tf: 3.599 us Tq: 49.148 us

0077 Choc de foudre 100%/H1,2,3 - Courant (A)



Imax: 30.7 A Imin: -33.5 A

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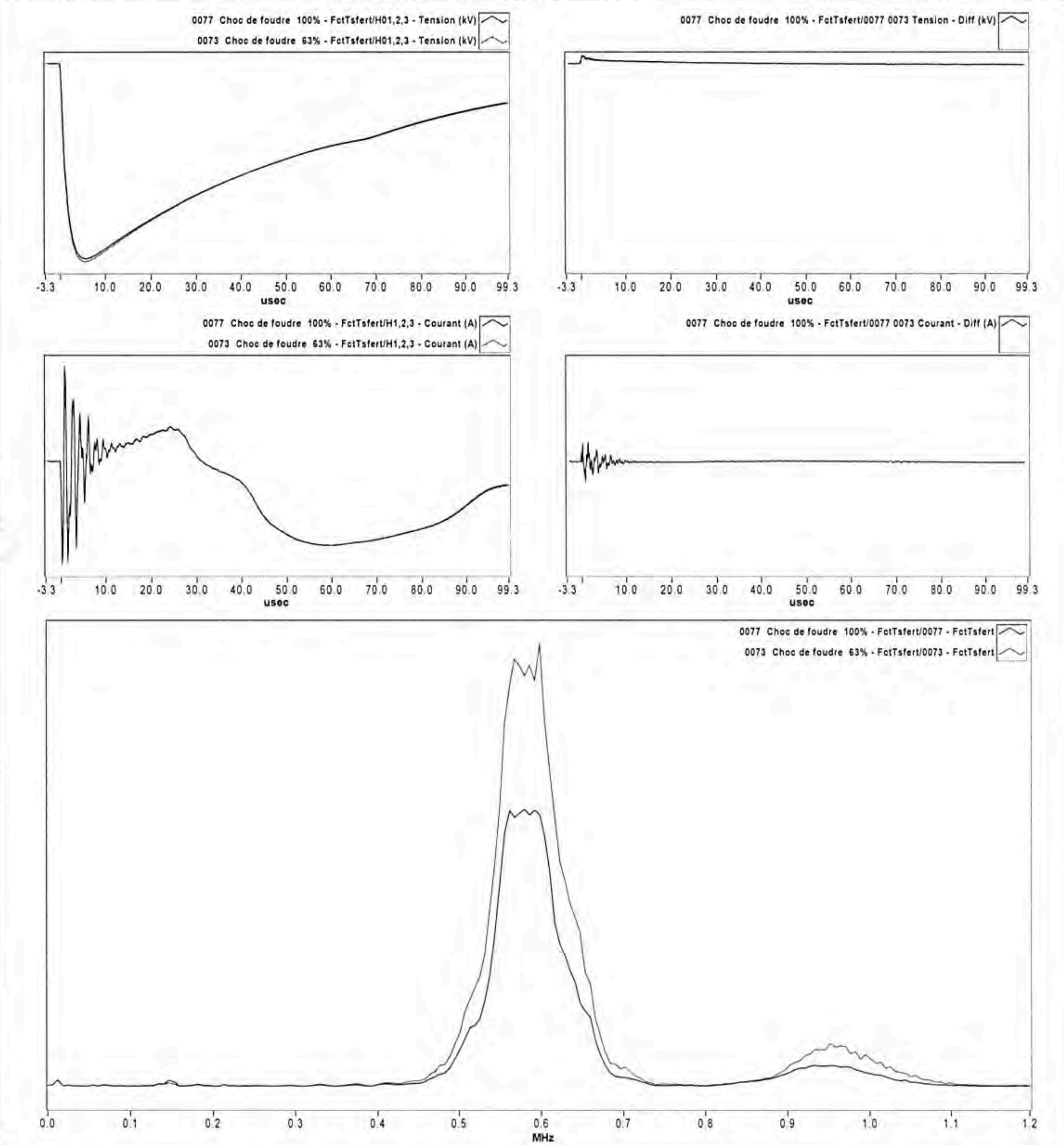
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB

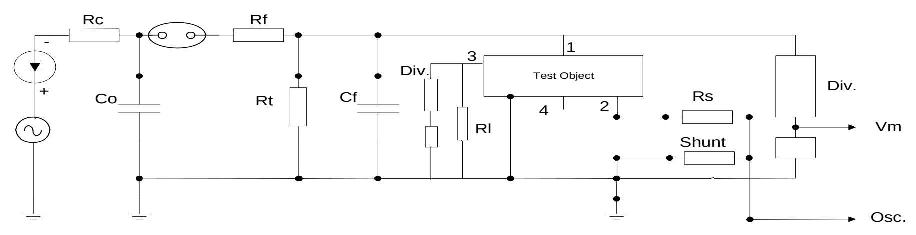


Essai réalisé par : R.B.,R.M. Date : 2015-10-26 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION

Type d'essai	Surtension de manoeuvre sur H1, H2, H3
Objet d'essais	Inductance shunt 3-ph. 140 MVARS
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.



BORNES

1 = H1
2 = H01, 2 ,3

4 = H2,H3

PARAMÈTRES DU CIRCUIT D'ESSAI			DIVISEUR DE TENSION		FORME D'ONDE		
Rc =	51 k * 3	ohm	RC-4 Rd/1 :	2082,6	Forme d'onde	191/216/1019	µs
Rf =	(470) * 4	ohm			Lancée de tension	0	%
Rq =	51 k * 4	ohm			Lancée inverse	52,8	%
Cf =	28*2/3 + 28/6+ 28/5	nF	Shunt (ohm)	2,9942	U appliquée	850	kV
Co =	312*3/4	nF			Tension sur H01, 2 ,3	0	% BIL
Ecl=	---	éclateurs			Correction		%
Rs =	0	ohm					

EFFICACITÉ DU CIRCUIT

$$\text{Efficacité} = \frac{\text{Vm} * 100}{\text{U charge} * \text{nombre d'étages}} = \frac{528{,}2 * 100}{175{,}4 * 4} \quad 75{,}3\ \%$$

Séquence d'essai Nb	Forme	Pol.	Volt Appliq. kV	Gén. de chocs Charge kV	Pression en kV	kV	% Pleine	Pos. du C.P.	Système de mesure Balayage Tension, courant (µs)	Éclateurs Ecart. mm	Rq 1 Ratio / 1	Ligne à délai kV
2	RP	P	529	175,7	197	529	62,2	---				
3	P	P	850	282,3	316	850	100,0	---				

Remarques :

Essais par : R.B. R.P.

Date : 2015-10-23

LABORATOIRE HAUTE TENSION

Type d'essai	Surtension de manoeuvre sur H1, H2, H3
Objet d'essais	Inductance shunt 3-ph. 140 MVARS
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

IDENTIFICATION DES INSTRUMENTS UTILISÉS

	ENTRÉE #1	ENTRÉE #2
SHUNTS		36B0327
DIVISEURS	32A186	
BRAS BASSE TENSION	36A0458	
ATTÉNUATEUR DU DIVISEUR		
TERMINAISONS 50 OHMS		36A0422
DIGITALISATEUR (GAGE)	2040217	2040217
ATTÉNUATEUR DU DIGITALISATEUR	0327602	0327603
PONT DE RAPPORT DE DIVISEUR	32A049	

Essais par : R.B. R.P.　　Date : 2015-10-23

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB

#	Type d'impulsion	Type de signal	Max		Min			
1	0009 Choc de manoeuvre (60 hz) 63%	H1 - Tension (kV)	527.0 kV	-283.2 kV	Tp: 191 us	Td: 216.5 us	T0: 1019 us	
2	0009 Choc de manoeuvre (60 hz) 63%	H01,2,3 - Courant (A)	149.9 A	-55.7 A				
3	0011 Choc de manoeuvre (60 hz) 63%	H1 - Tension (kV)	527.4 kV	-283.6 kV	Tp: 190 us	Td: 217.7 us	T0: 1020 us	
4	0011 Choc de manoeuvre (60 hz) 63%	H01,2,3 - Courant (A)	149.9 A	-55.6 A				
5	0013 Choc de manoeuvre (60 hz) 100%	H1 - Tension (kV)	855.6 kV	-452.9 kV	Tp: 192 us	Td: 217.6 us	T0: 1030 us	
6	0013 Choc de manoeuvre (60 hz) 100%	H01,2,3 - Courant (A)	245.9 A	-88.6 A				
7	0014 Choc de manoeuvre (60 hz) 100%	H1 - Tension (kV)	854.7 kV	-451.5 kV	Tp: 192 us	Td: 217.7 us	T0: 1032 us	
8	0014 Choc de manoeuvre (60 hz) 100%	H01,2,3 - Courant (A)	245.6 A	-88.2 A				
9	0015 Choc de manoeuvre (60 hz) 100%	H1 - Tension (kV)	853.6 kV	-450.6 kV	Tp: 193 us	Td: 217.4 us	T0: 1029 us	
10	0015 Choc de manoeuvre (60 hz) 100%	H01,2,3 - Courant (A)	245.1 A	-88.3 A				

Essai réalisé par : R.B.,R.P.
Date : 2015-10-23
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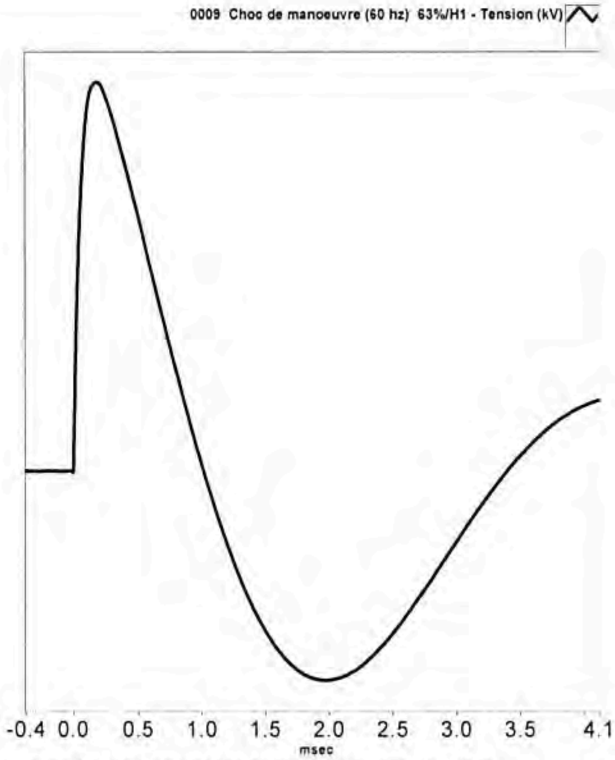
Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

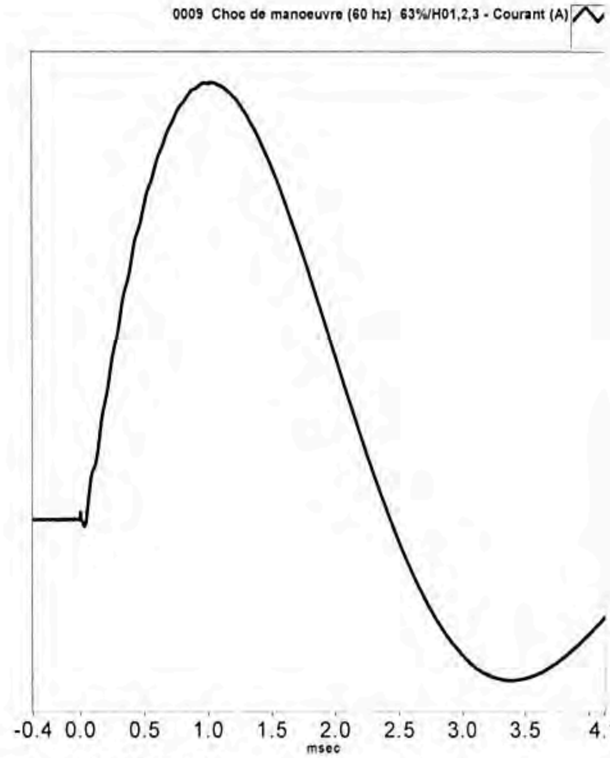
Type d'essai	: CHOCS
Objet d'essai	: INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	: 15079-01
No de contrat	: J794315045
Client	: ABB

0009 Choc de manoeuvre (60 hz) 63%/H1 - Tension (kV)



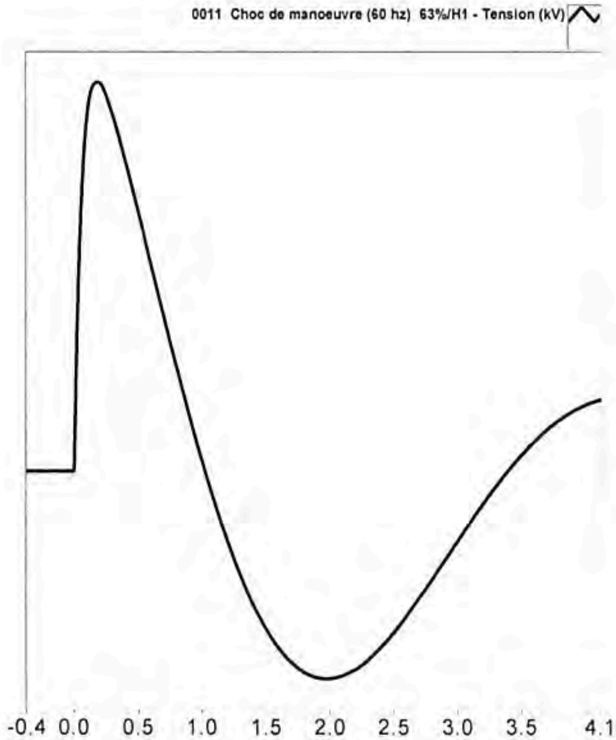
Vmax: 527.0 kV Vmin: -283.2 kV Tp: 191 us Td: 216.5 us T0: 1019 us

0009 Choc de manoeuvre (60 hz) 63%/H01,2,3 - Courant (A)



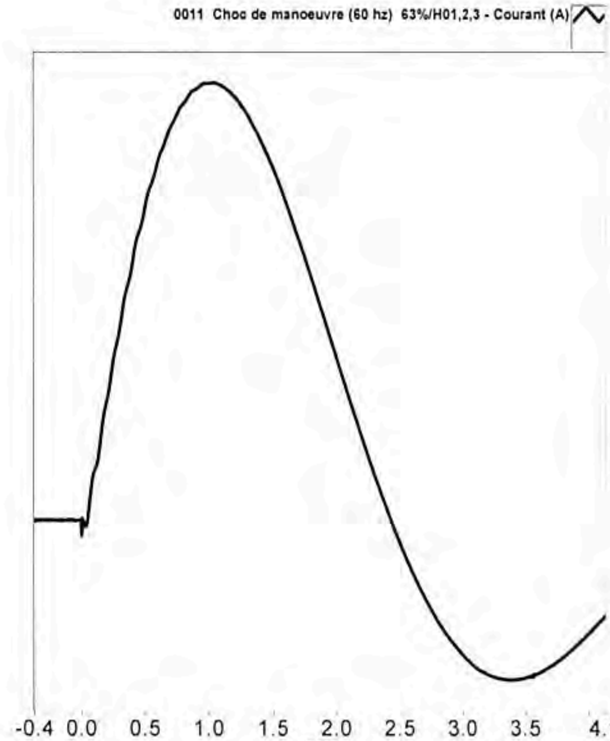
Imax: 149.9 A Imin: -55.7 A

0011 Choc de manoeuvre (60 hz) 63%/H1 - Tension (kV)



Vmax: 527.4 kV Vmin: -283.6 kV Tp: 190 us Td: 217.7 us T0: 1020 us

0011 Choc de manoeuvre (60 hz) 63%/H01,2,3 - Courant (A)



Imax: 149.9 A Imin: -55.6 A

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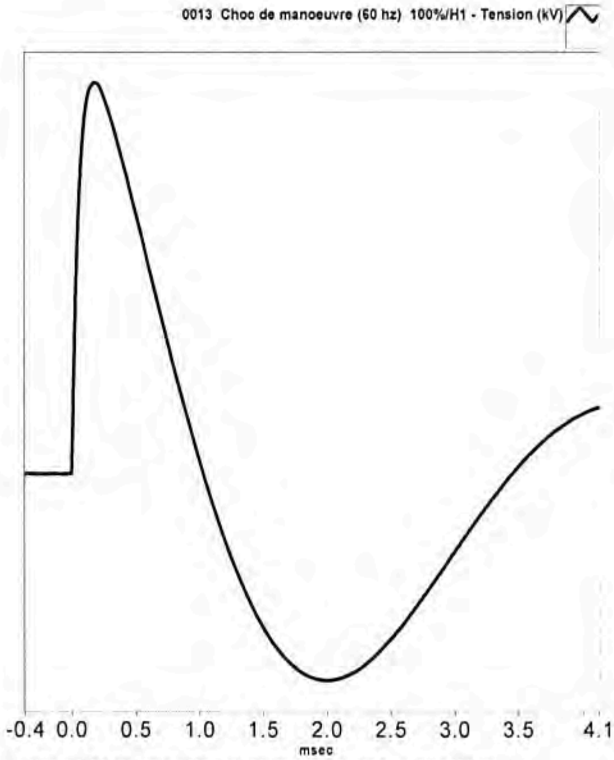
Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

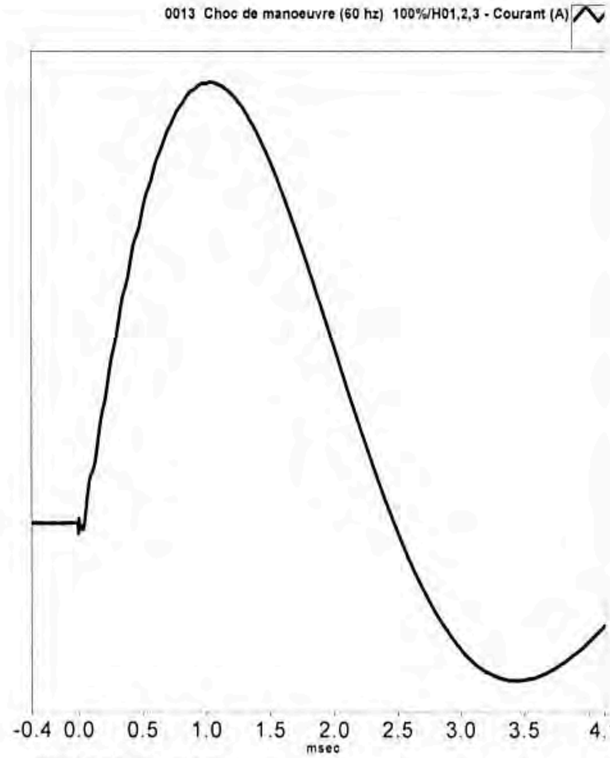
Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB

0013 Choc de manoeuvre (60 hz) 100%/H1 - Tension (kV)



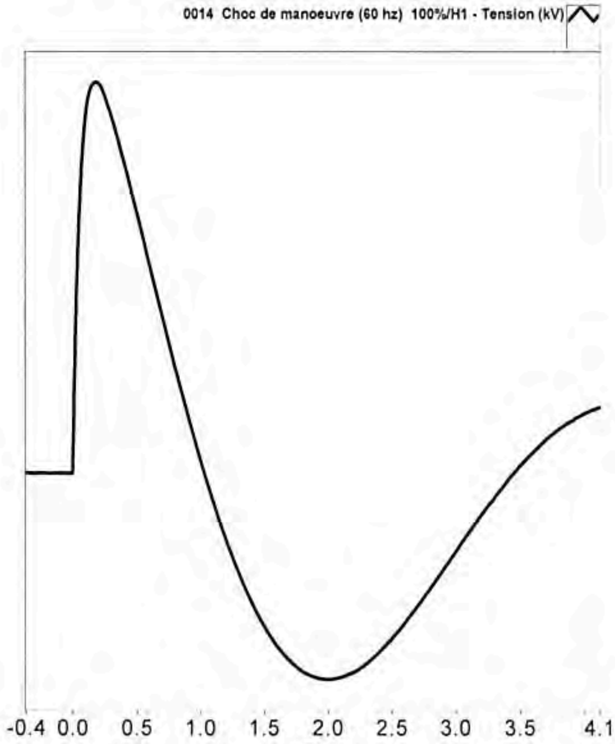
Vmax: 855.6 kV Vmin: -452.9 kV Tp: 192 us Td: 217.6 us T0: 1030 us

0013 Choc de manoeuvre (60 hz) 100%/H01,2,3 - Courant (A)



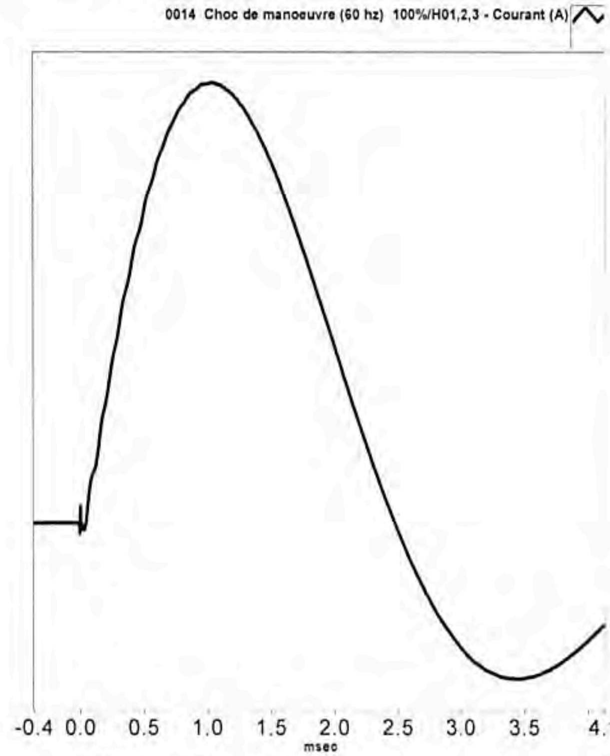
Imax: 245.9 A Imin: -88.6 A

0014 Choc de manoeuvre (60 hz) 100%/H1 - Tension (kV)



Vmax: 854.7 kV Vmin: -451.5 kV Tp: 192 us Td: 217.7 us T0: 1032 us

0014 Choc de manoeuvre (60 hz) 100%/H01,2,3 - Courant (A)



Imax: 245.6 A Imin: -88.2 A

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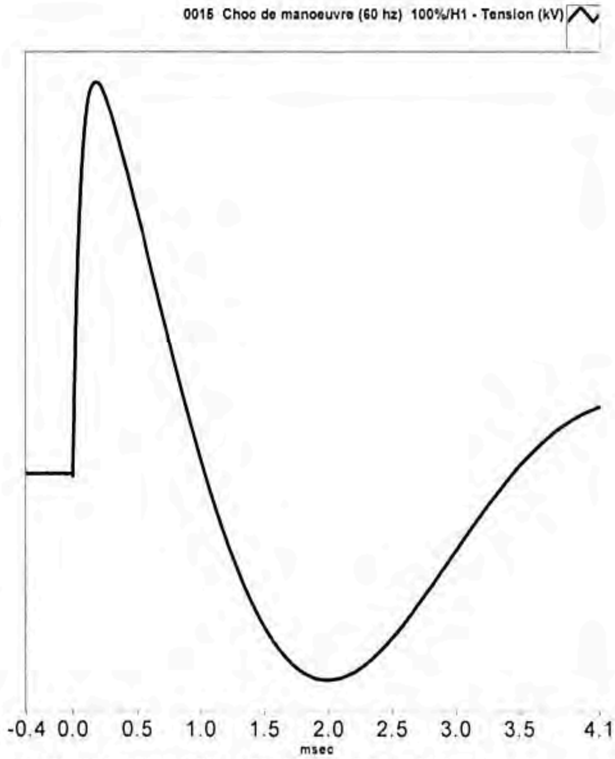
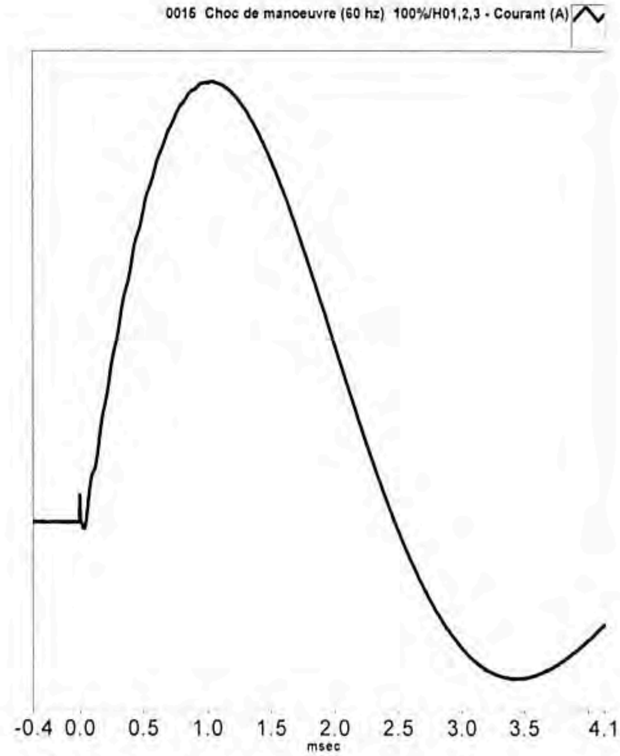
Hydro Québec	Type d'essai	:CHOCS
	Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
	No de série	:15079-01
LABORATOIRE HAUTE TENSION	No de contrat	:J794315045
Chocs V5.5.11	Client	:ABB

0015 Choc de manoeuvre (60 hz) 100%/H1 - Tension (kV)

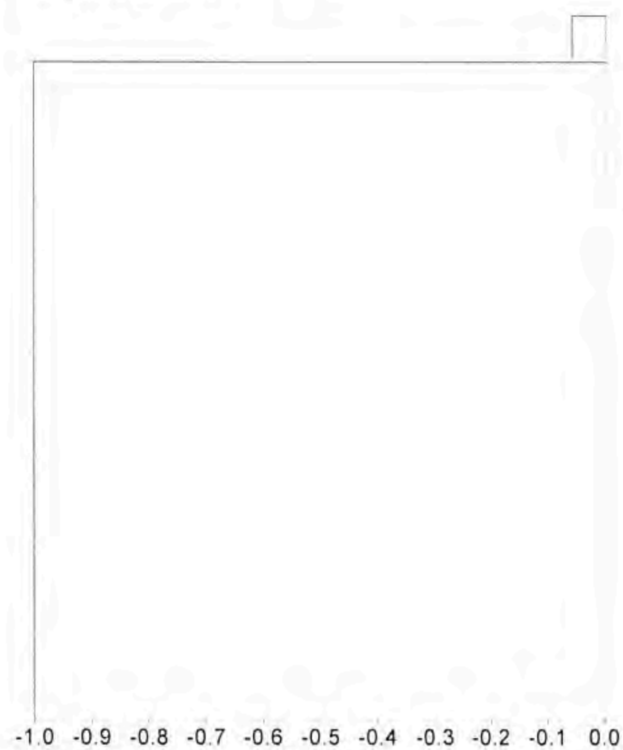


Vmax: 853.6 kV Vmin: -450.6 kV Tp: 193 us Td: 217.4 us T0: 1029 us

0015 Choc de manoeuvre (60 hz) 100%/H01,2,3 - Courant (A)



Imax: 245.1 A Imin: -88.3 A



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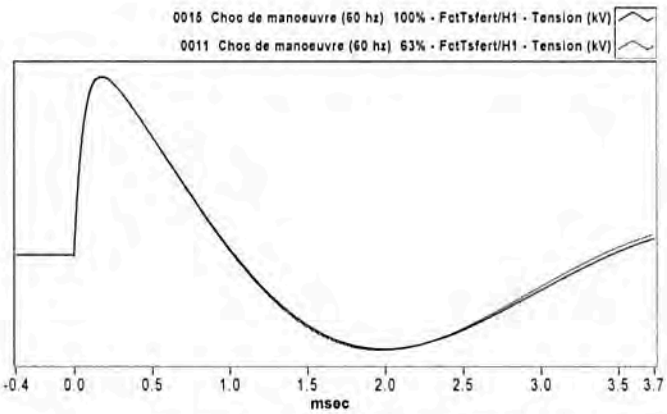
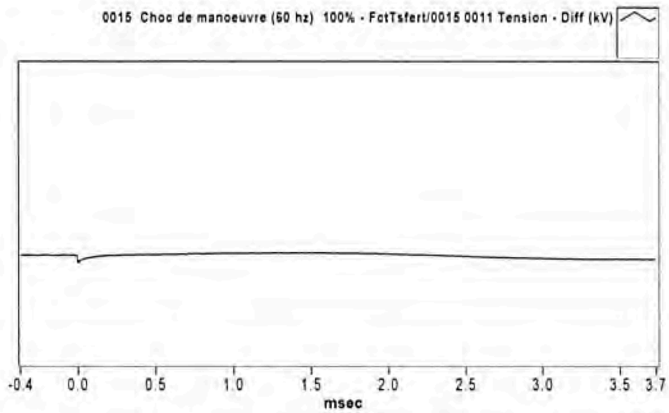
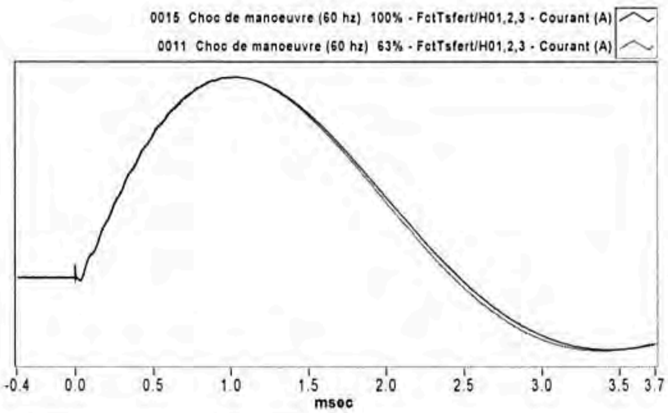
Hydro Québec

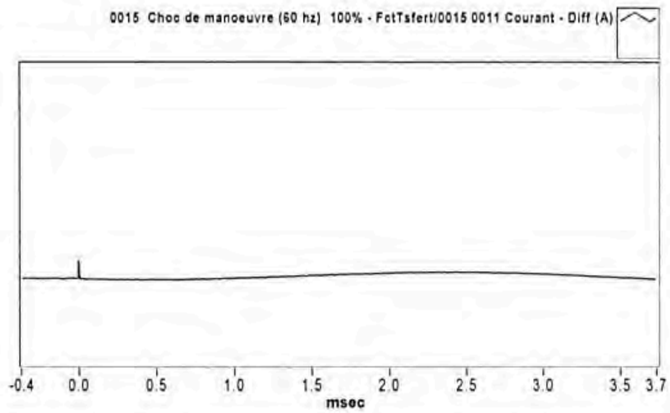
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

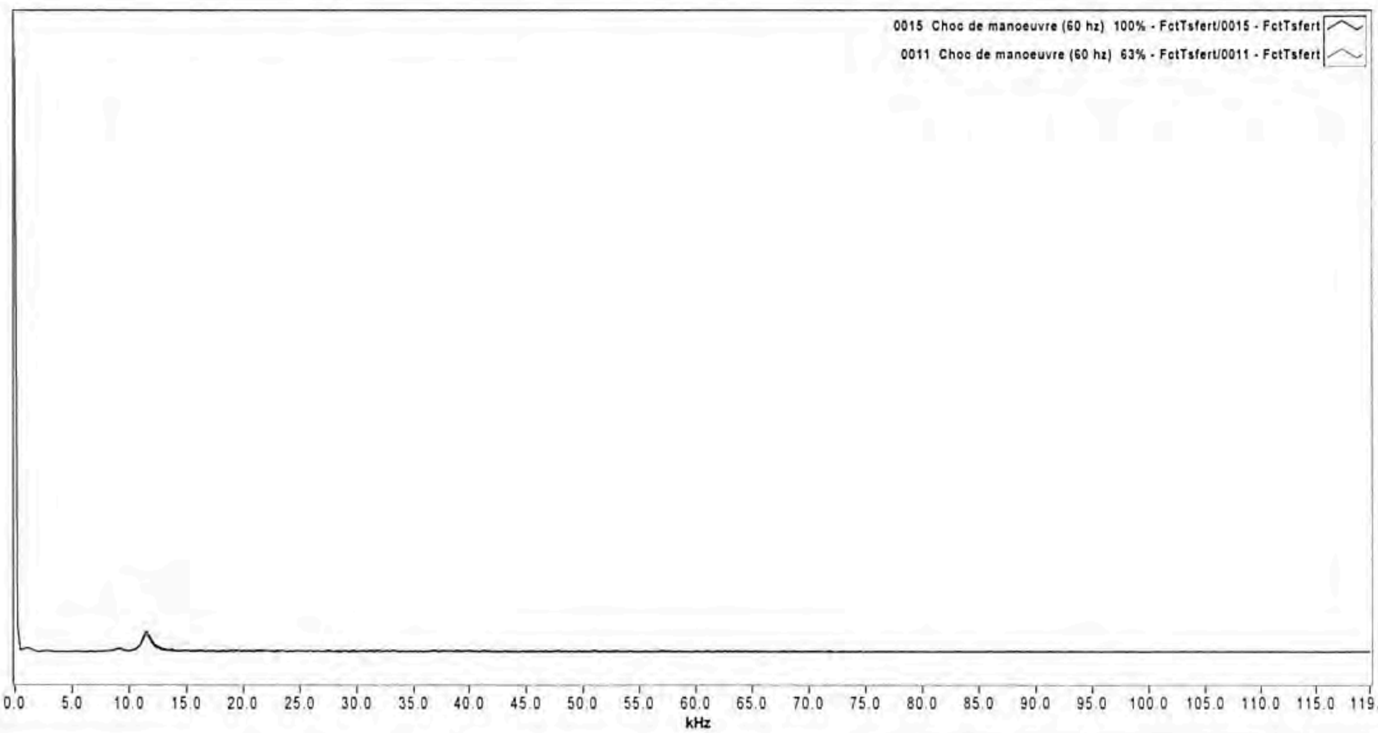
Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB











Essai réalisé par : R.B.,R.P.

Date : 2015-10-23

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LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB

#	Type d'impulsion	Type de signal	Max		Min			
1	0017 Choc de manoeuvre (60 hz) 63%	H2 - Tension (kV)	528.0 kV	-283.3 kV	Tp: 191 us	Td: 214.5 us	T0: 1019 us	
2	0017 Choc de manoeuvre (60 hz) 63%	H01,2,3 - Courant (A)	150.3 A	-55.6 A				
3	0018 Choc de manoeuvre (60 hz) 63%	H2 - Tension (kV)	528.4 kV	-283.2 kV	Tp: 191 us	Td: 214.3 us	T0: 1017 us	
4	0018 Choc de manoeuvre (60 hz) 63%	H01,2,3 - Courant (A)	150.3 A	-55.7 A				
5	0019 Choc de manoeuvre (60 hz) 100%	H2 - Tension (kV)	855.9 kV	-452.2 kV	Tp: 192 us	Td: 215.2 us	T0: 1029 us	
6	0019 Choc de manoeuvre (60 hz) 100%	H01,2,3 - Courant (A)	246.3 A	-88.6 A				
7	0020 Choc de manoeuvre (60 hz) 100%	H2 - Tension (kV)	854.8 kV	-451.4 kV	Tp: 192 us	Td: 215.9 us	T0: 1029 us	
8	0020 Choc de manoeuvre (60 hz) 100%	H01,2,3 - Courant (A)	245.8 A	-88.5 A				
9	0021 Choc de manoeuvre (60 hz) 100%	H2 - Tension (kV)	854.0 kV	-452.1 kV	Tp: 192 us	Td: 215.0 us	T0: 1028 us	
10	0021 Choc de manoeuvre (60 hz) 100%	H01,2,3 - Courant (A)	245.7 A	-88.4 A				

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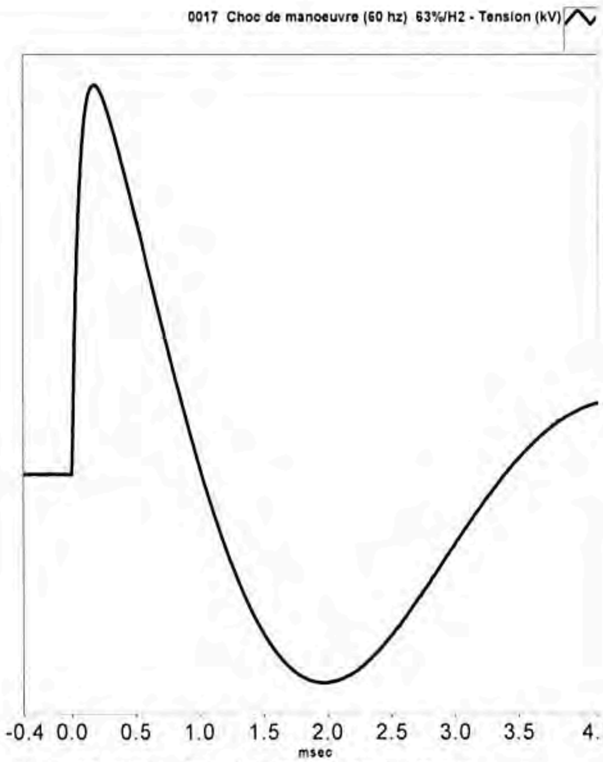
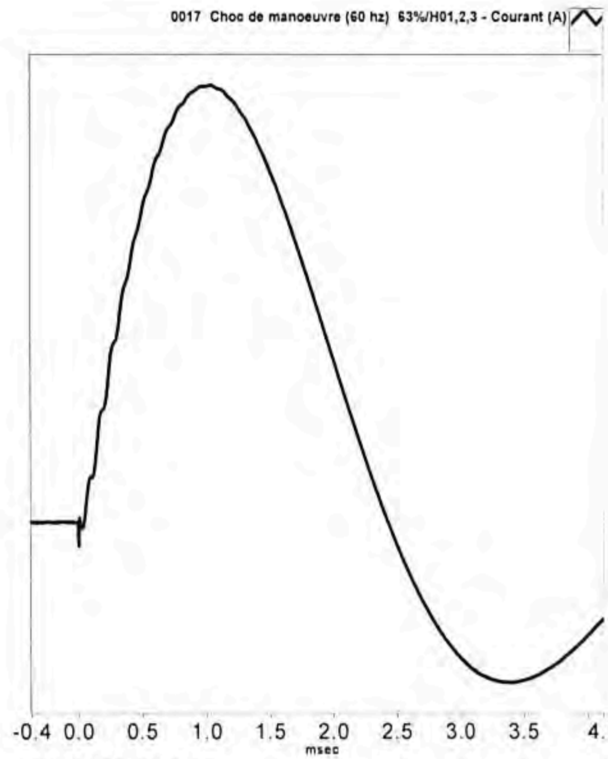
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

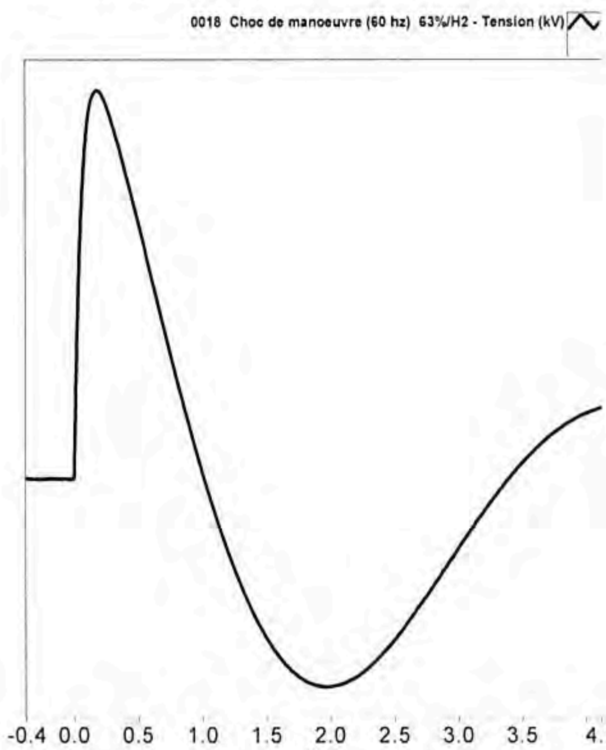
Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB



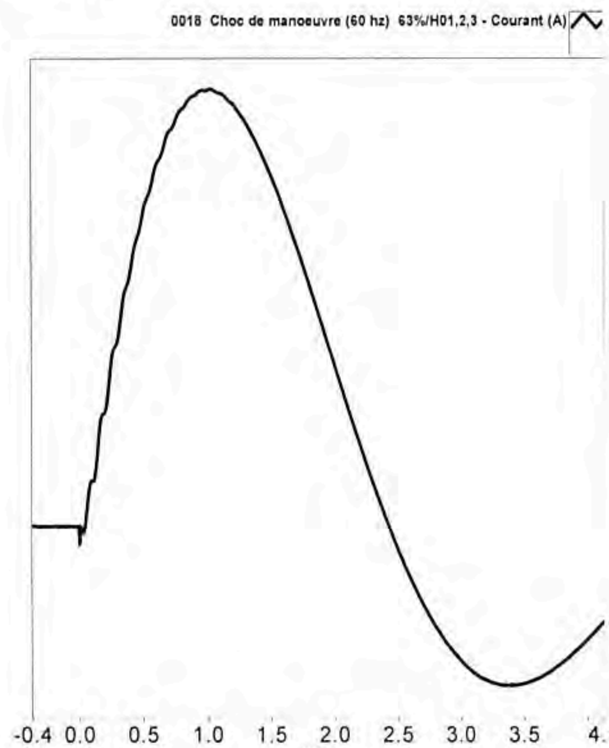
Vmax: 528.0 kV Vmin: -283.3 kV Tp: 191 us Td: 214.5 us T0: 1019 us



Imax: 150.3 A Imin: -55.6 A



Vmax: 528.4 kV Vmin: -283.2 kV Tp: 191 us Td: 214.3 us T0: 1017 us



Imax: 150.3 A Imin: -55.7 A

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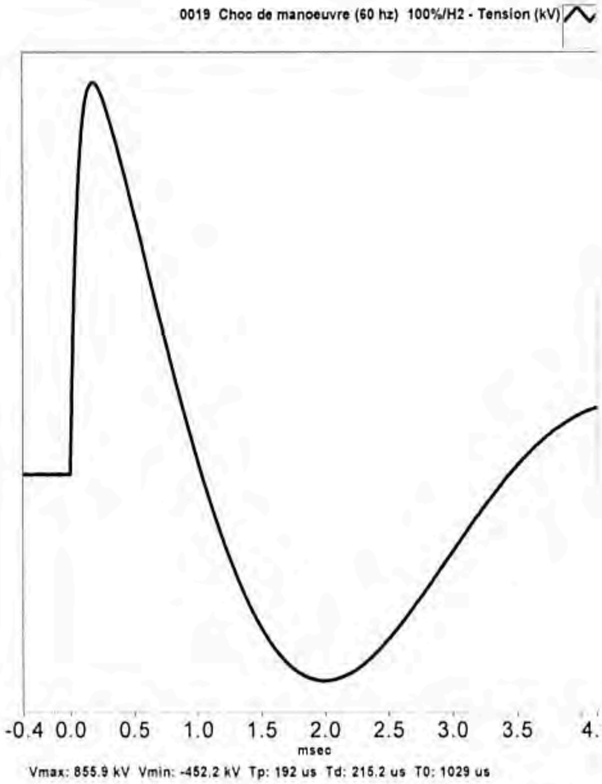
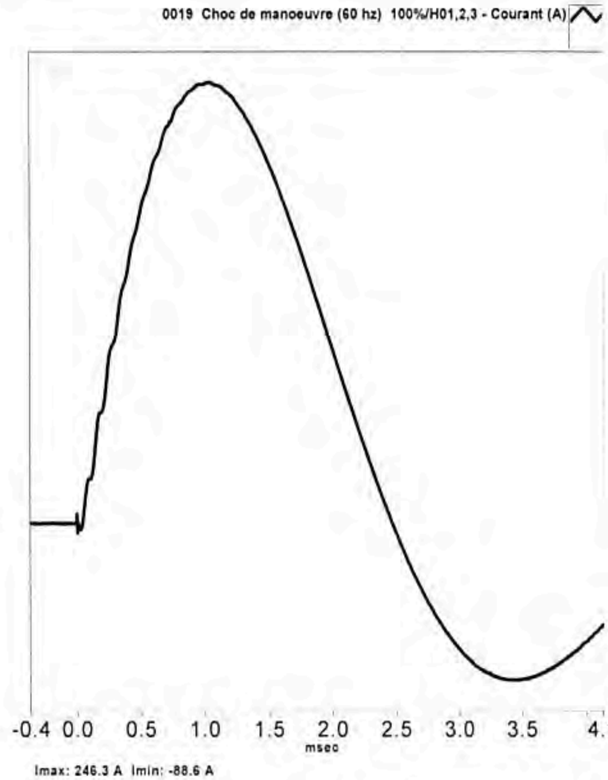
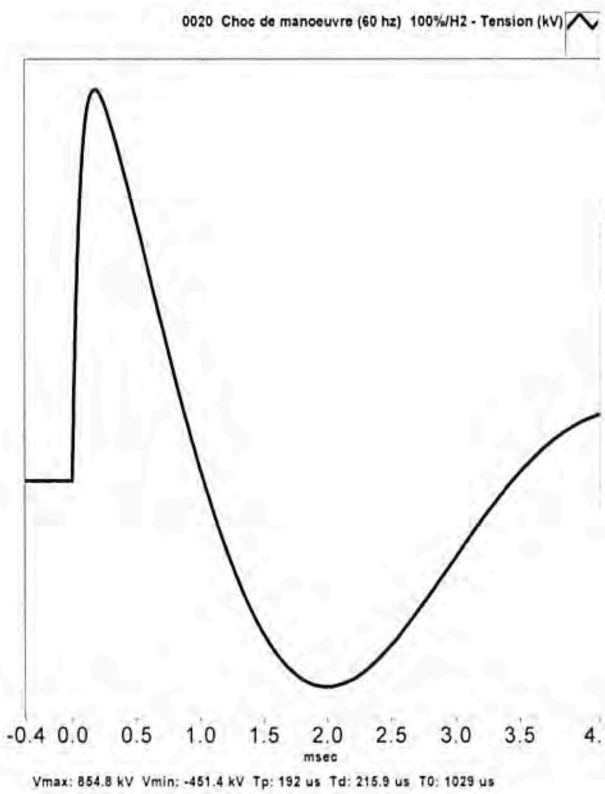
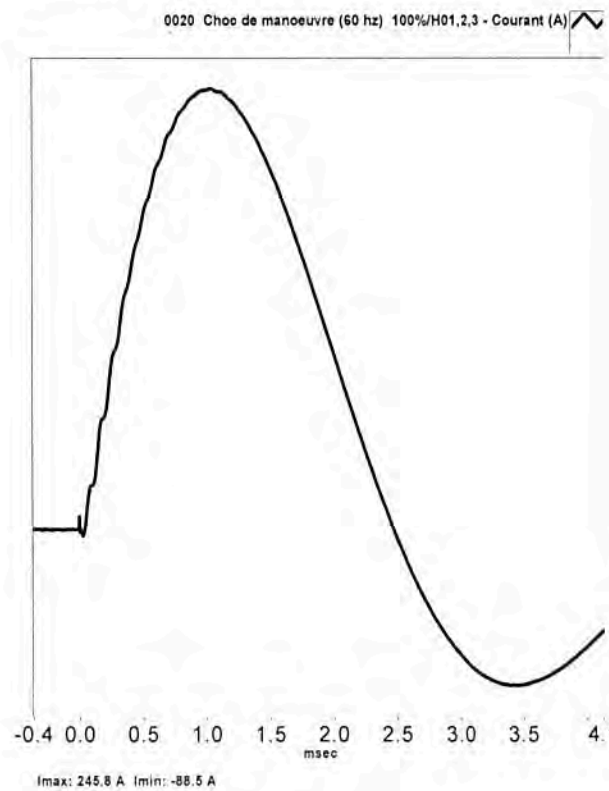
LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai	: CHOCS
Objet d'essai	: INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	: 15079-01
No de contrat	: J794315045
Client	: ABB







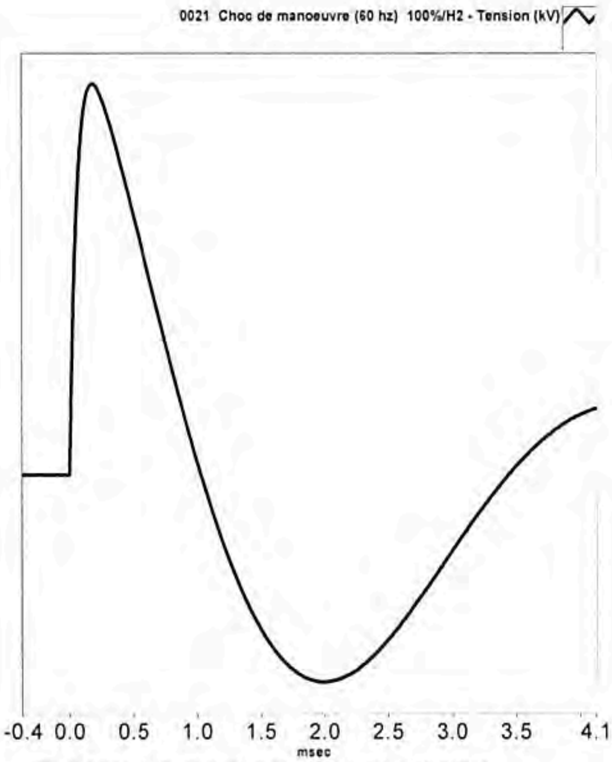


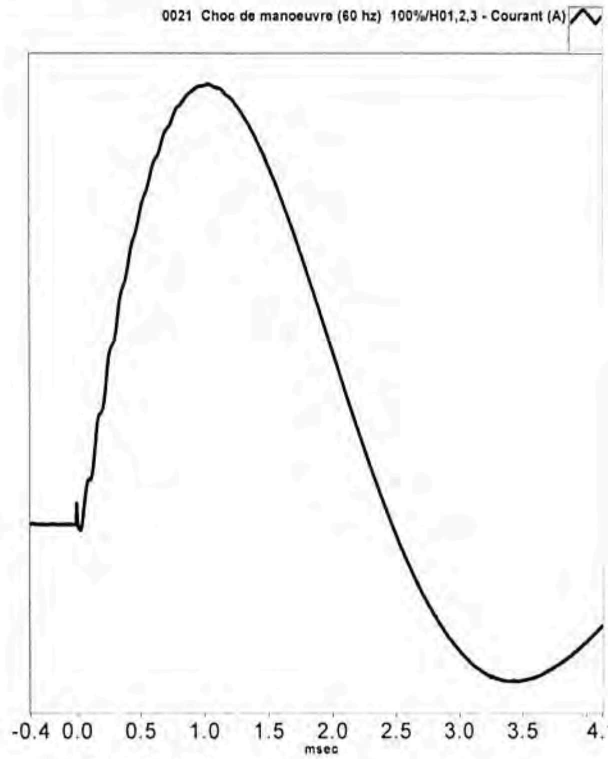
Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

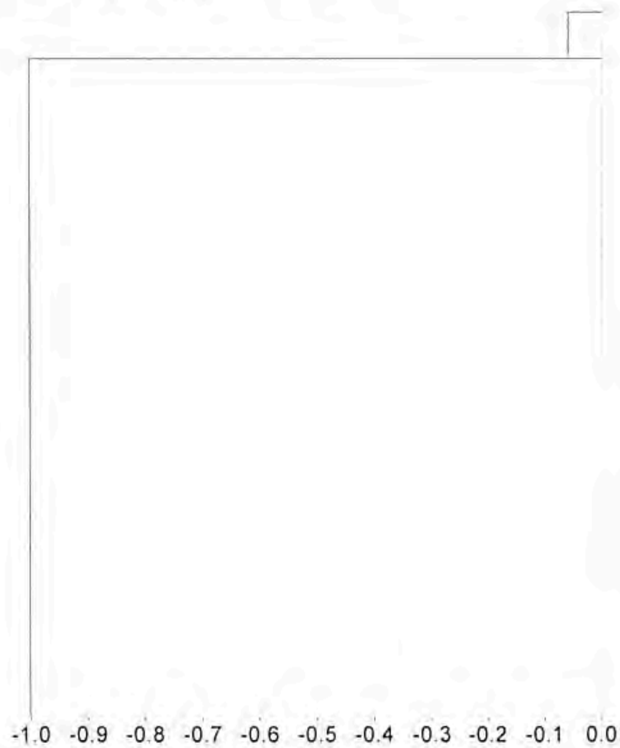
Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB





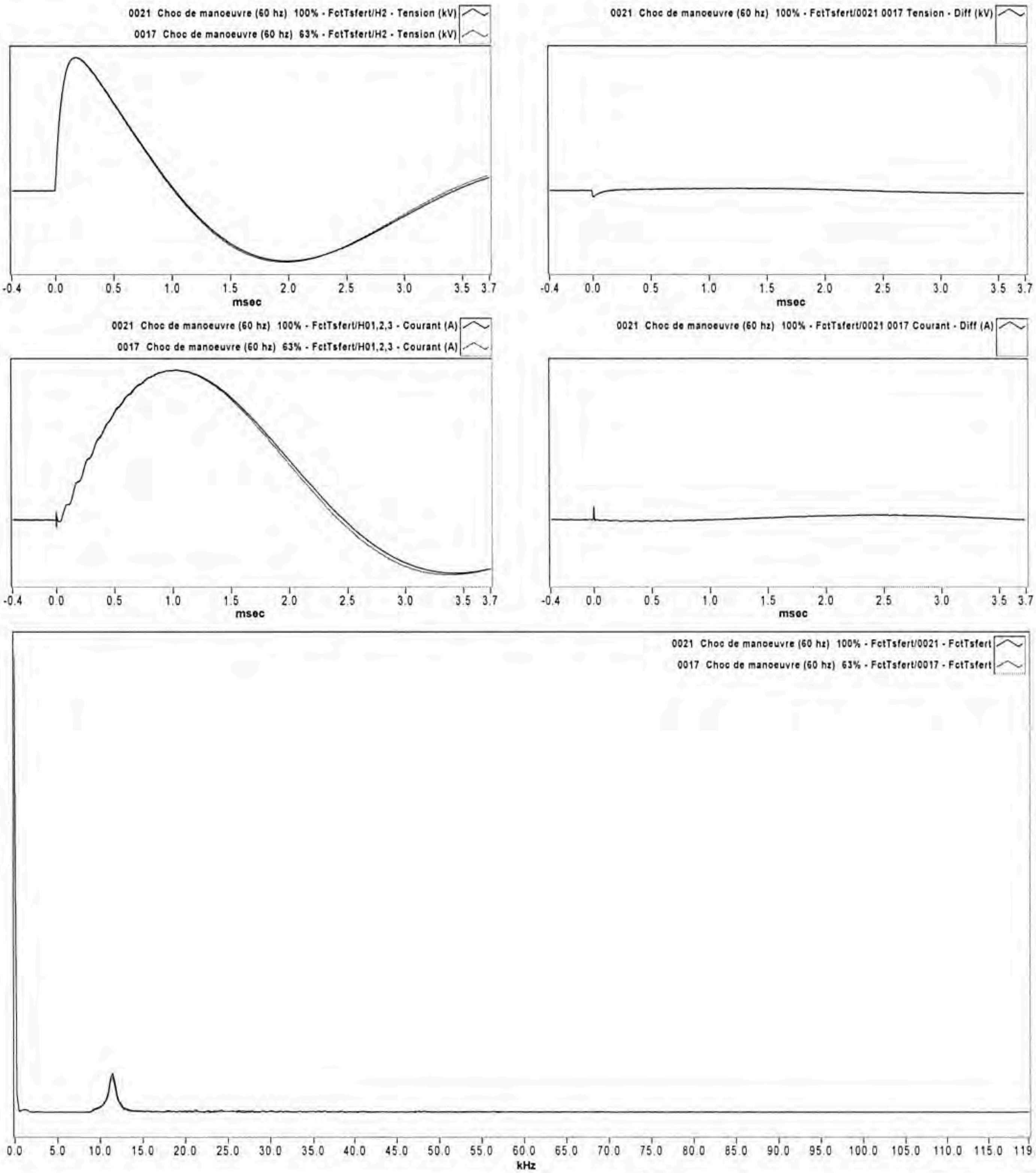


Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB



Essai réalisé par : R.B.,R.P.
Date : 2015-10-23
Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai : CHOCS
Objet d'essai : INDUCTANCE SHUNT 3 PH., 140MVAR
No de série : 15079-01
No de contrat : J794315045
Client : ABB

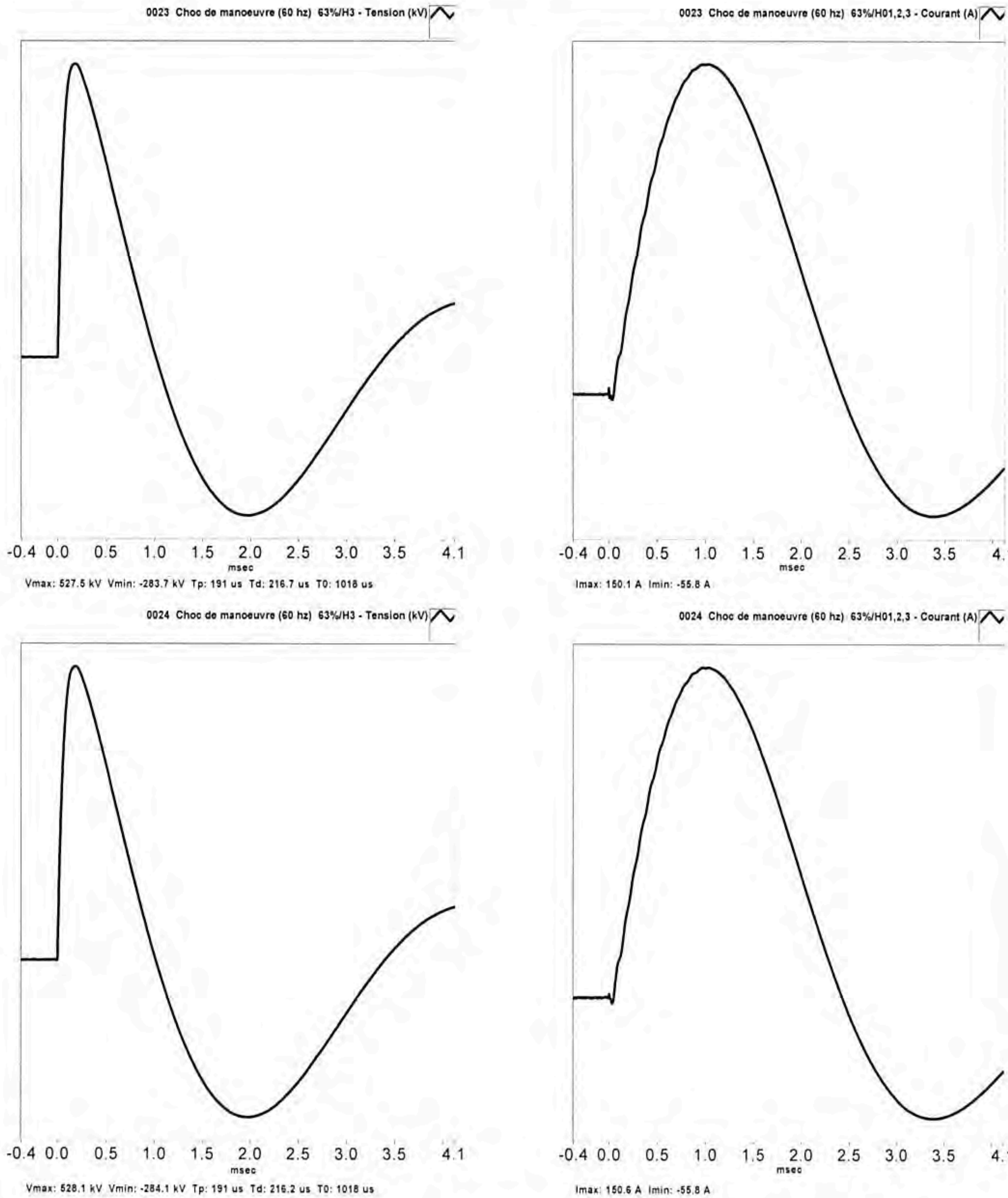
#	Type d'impulsion	Type de signal	Max		Min			
1	0023 Choc de manoeuvre (60 hz) 63%	H3 - Tension (kV)	527.5 kV	-283.7 kV	Tp: 191 us	Td: 216.7 us	T0: 1018 us	
2	0023 Choc de manoeuvre (60 hz) 63%	H01,2,3 - Courant (A)	150.1 A	-55.8 A				
3	0024 Choc de manoeuvre (60 hz) 63%	H3 - Tension (kV)	528.1 kV	-284.1 kV	Tp: 191 us	Td: 216.2 us	T0: 1018 us	
4	0024 Choc de manoeuvre (60 hz) 63%	H01,2,3 - Courant (A)	150.6 A	-55.8 A				
5	0025 Choc de manoeuvre (60 hz) 100%	H3 - Tension (kV)	852.9 kV	-451.8 kV	Tp: 193 us	Td: 217.3 us	T0: 1027 us	
6	0025 Choc de manoeuvre (60 hz) 100%	H01,2,3 - Courant (A)	245.2 A	-88.5 A				
7	0026 Choc de manoeuvre (60 hz) 100%	H3 - Tension (kV)	855.0 kV	-452.1 kV	Tp: 192 us	Td: 217.3 us	T0: 1031 us	
8	0026 Choc de manoeuvre (60 hz) 100%	H01,2,3 - Courant (A)	246.3 A	-88.5 A				
9	0027 Choc de manoeuvre (60 hz) 100%	H3 - Tension (kV)	852.0 kV	-451.0 kV	Tp: 193 us	Td: 218.1 us	T0: 1029 us	
10	0027 Choc de manoeuvre (60 hz) 100%	H01,2,3 - Courant (A)	245.6 A	-88.3 A				

Essai réalisé par : R.B.,R.P.   Date : 2015-10-23   Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB



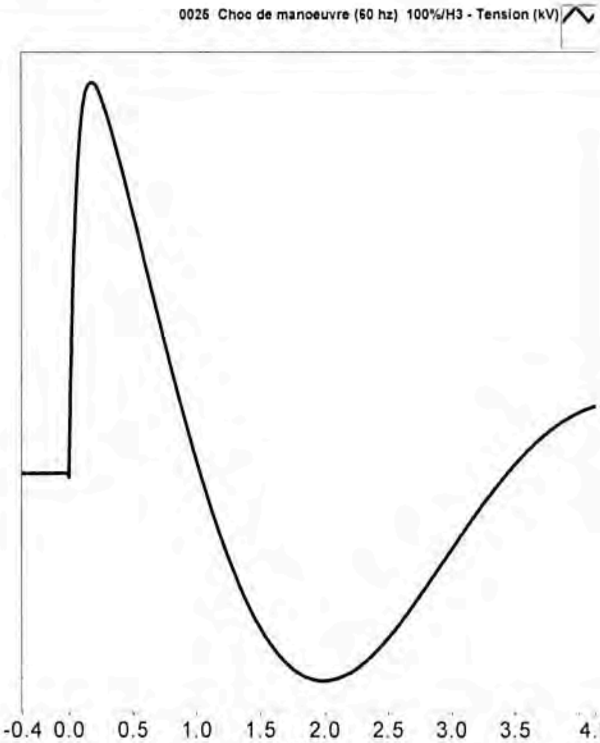
Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

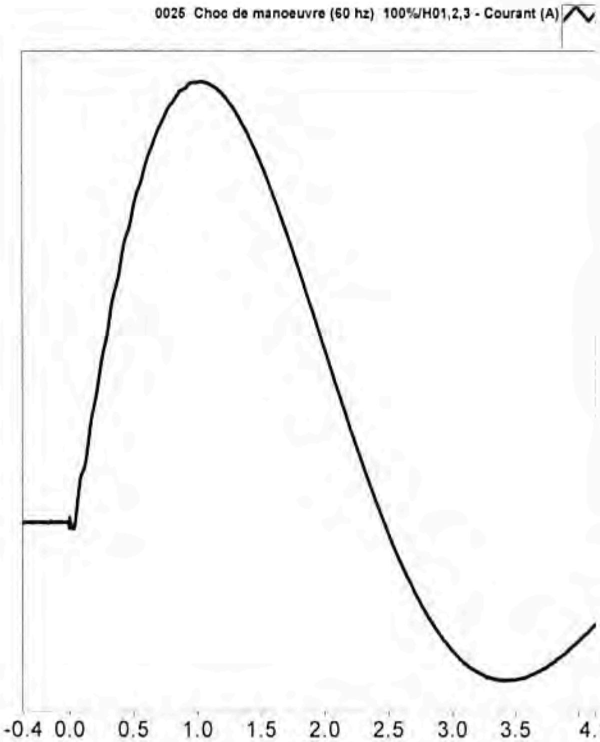
Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB

0026 Choc de manoeuvre (60 hz) 100%/H3 - Tension (kV)



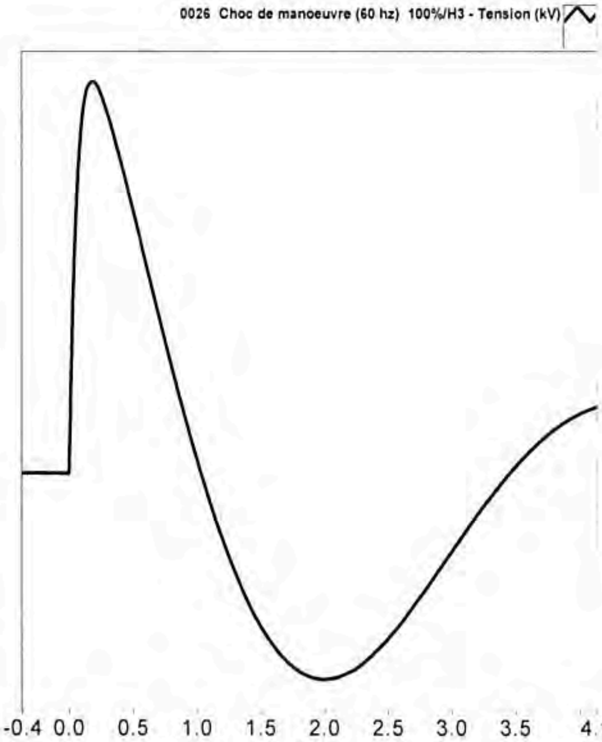
Vmax: 852.9 kV Vmin: -451.8 kV Tp: 193 us Td: 217.3 us T0: 1027 us

0026 Choc de manoeuvre (60 hz) 100%/H01,2,3 - Courant (A)



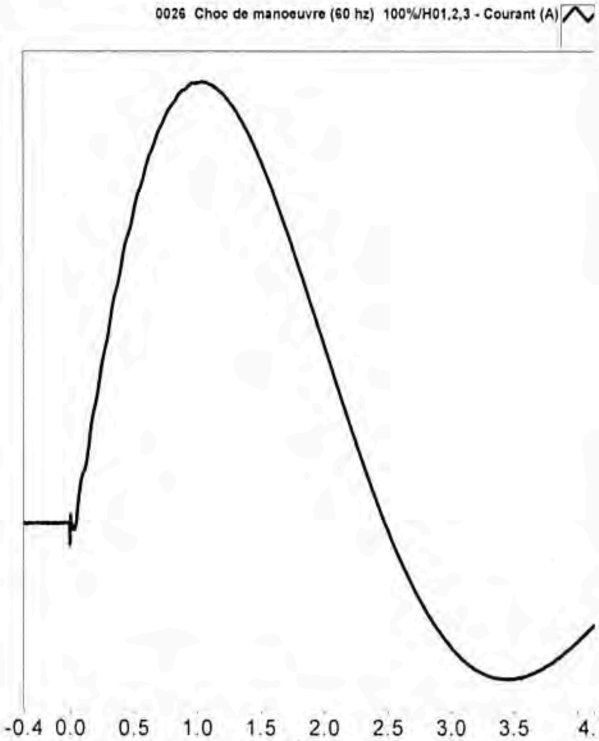
Imax: 245.2 A Imin: -88.5 A

0026 Choc de manoeuvre (60 hz) 100%/H3 - Tension (kV)



Vmax: 855.0 kV Vmin: -452.1 kV Tp: 192 us Td: 217.3 us T0: 1031 us

0026 Choc de manoeuvre (60 hz) 100%/H01,2,3 - Courant (A)



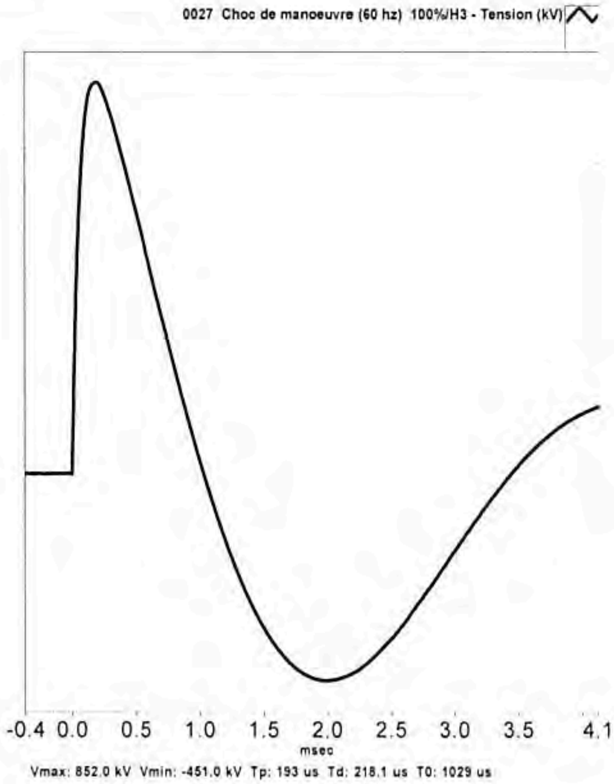
Imax: 246.3 A Imin: -88.5 A

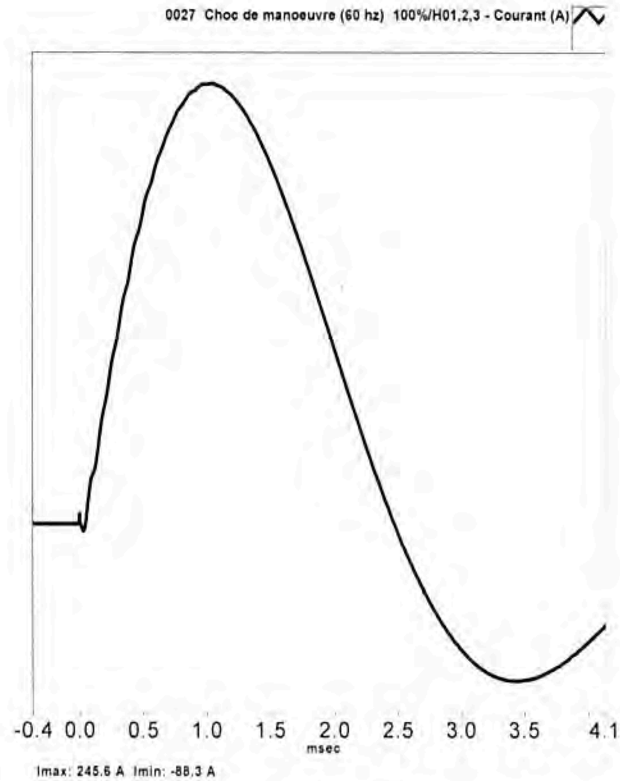
Essai réalisé par : R.B.,R.P. Date : 2015-10-23 Page :

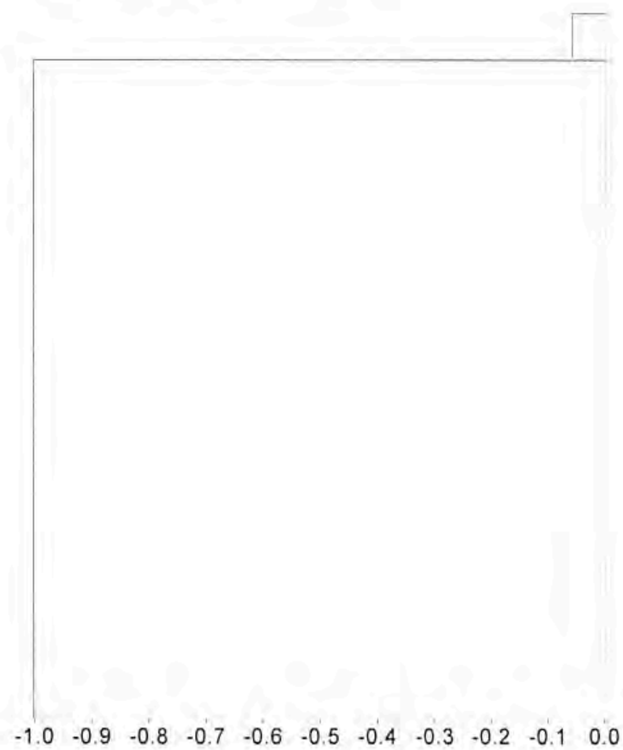
Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai	:CHOCS
Objet d'essai	:INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	:15079-01
No de contrat	:J794315045
Client	:ABB





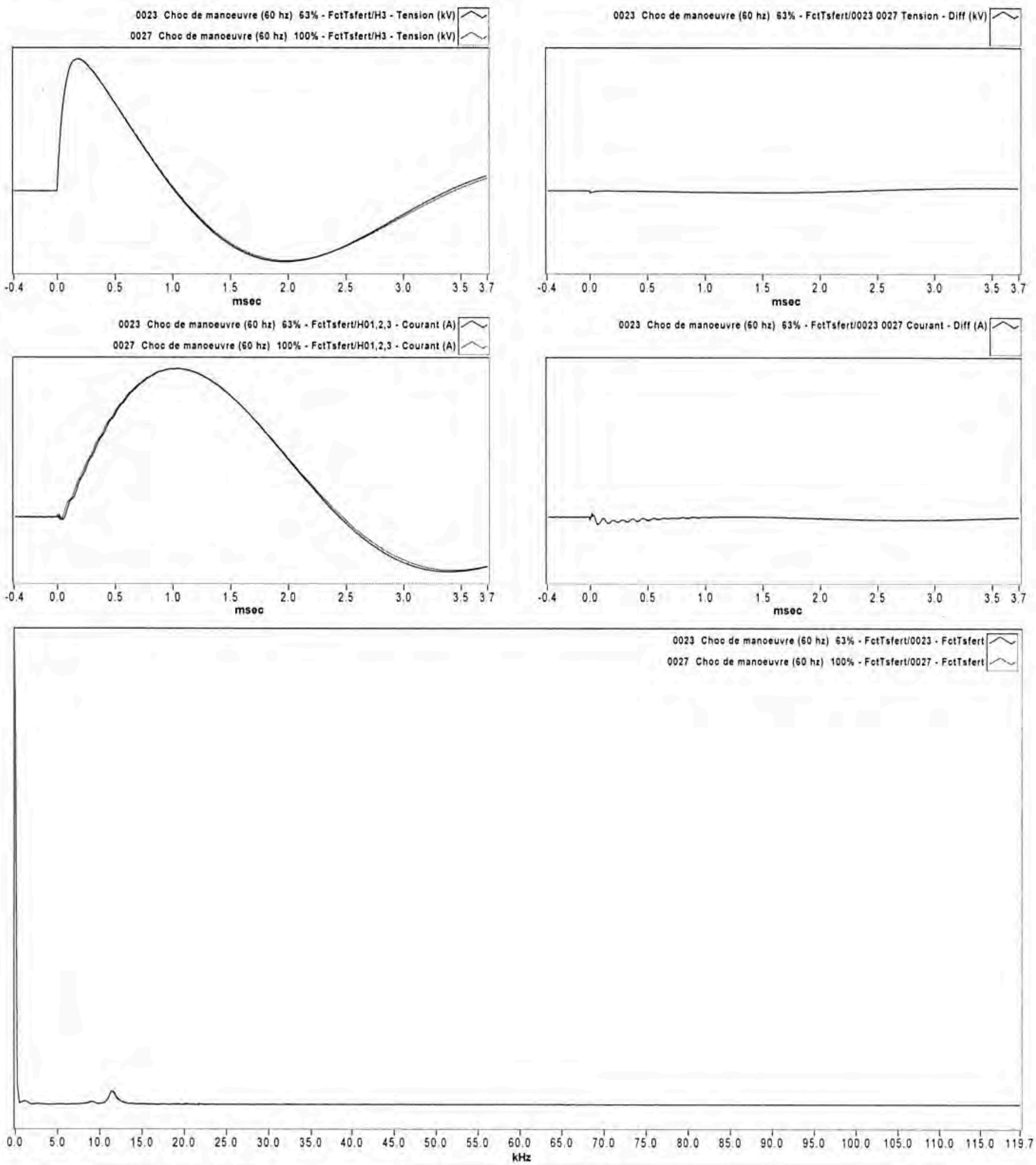


Essai réalisé par : R.B.,R.P.   Date : 2015-10-23   Page :

Hydro Québec

LABORATOIRE HAUTE TENSION
Chocs V5.5.11

Type d'essai	: CHOCS
Objet d'essai	: INDUCTANCE SHUNT 3 PH., 140MVAR
No de série	: 15079-01
No de contrat	: J794315045
Client	: ABB



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ANNEXE A

Analyse d'huile

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LAB
Accrédité CCN

OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297846A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-28

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	LEM
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-27 14:30
Additional info:					
Description:	Inductance				

DGA

2015-10-27	Parameter	Screening Code(T/R)	Test Method
< 3	Hydrogen		D3612-02
< 0.1	Acetylene		ppm (V/V)
< 0.1	Ethane		at 273 K
< 0.1	Ethylene		and 760 Torr
0.3	Methane		
< 5	Carbon Monoxide		
62	Carbon Dioxide		
6010	Nitrogen		
2930	Oxygen + Argon		
0.9	Total Dissolved Gas (%)		

OIL QUALITY

2015-10-27	Parameter	Screening Code(T/R)	Test Method
	Moisture in Oil (ppm)		SOP 5.5-03-01
	Moisture in Oil (ppm)		D 1533-12
	Interfacial Tension (mN/m)		D 971-12
	Acid Number (mg KOH/g)		D 974-14e1
	Color Number		D1500-12
	Free Water		D 1524-94
	Visual Examination		D 1524-94
	Sediment Examination		D 1524-94
	Dielectric Breakdown (kV)		D 877-13
	Dielectric Breakdown 2 mm (kV)		D 1816-12
	Power Factor @ 25 °C (%)		D 924-08
	Power Factor @ 100 °C (%)		D 924-08
	Specific Gravity		D 1298-12b
	Oxidation Inhibitor DBP (wt. %)		D 4768-11
	Oxidation Inhibitor DBPC (wt. %)		D 4768-11
	PCB - Total Arochlor Content (ppm)		D 4059-00
	Corrosive Sulphur Method B		D 1275-06
	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-12
	furfuryl alcohol (ppb)		D 5837-12
	2-furaldehyde (ppb)		D 5837-12
	2-acetylfuran (ppb)		D 5837-12
	5-methyl-2-furaldehyde (ppb)		D 5837-12

COMMENTS: Apres l'induit, apres les essais.
Seringue:S001033

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LAB Accrédité CCN

OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297846A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-28

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	LEM
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-27 14:30
Additional info:					
Description:	Inductance				

LAB COMMENTS

H2 < 1 PPM

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OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297462A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-22

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	LT
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-21 11:10
Additional info:					
Description:	Inductance				

DGA

2015-10-21	Parameter	Screening Code(T/R)	Test Method
< 3	Hydrogen		D3612-02
< 0.1	Acetylene		ppm (V/V)
< 0.1	Ethane		at 273 K
< 0.1	Ethylene		and 760 Torr
0.3	Methane		
< 5	Carbon Monoxide		
64	Carbon Dioxide		
6970	Nitrogen		
3400	Oxygen + Argon		
1.04	Total Dissolved Gas (%)		

OIL QUALITY

2015-10-21	Parameter	Screening Code(T/R)	Test Method
	Moisture in Oil (ppm)		SOP 5.5-03-01
	Moisture in Oil (ppm)		D 1533-12
	Interfacial Tension (mN/m)		D 971-12
	Acid Number (mg KOH/g)		D 974-14e1
	Color Number		D1500-12
	Free Water		D 1524-94
	Visual Examination		D 1524-94
	Sediment Examination		D 1524-94
	Dielectric Breakdown (kV)		D 877-13
	Dielectric Breakdown 2 mm (kV)		D 1816-12
	Power Factor @ 25 °C (%)		D 924-08
	Power Factor @ 100 °C (%)		D 924-08
	Specific Gravity		D 1298-12b
	Oxidation Inhibitor DBP (wt. %)		D 4768-11
	Oxidation Inhibitor DBPC (wt. %)		D 4768-11
	PCB - Total Arochlor Content (ppm)		D 4059-00
	Corrosive Sulphur Method B		D 1275-06
	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-12
	furfuryl alcohol (ppb)		D 5837-12
	2-furaldehyde (ppb)		D 5837-12
	2-acetylfuran (ppb)		D 5837-12
	5-methyl-2-furaldehyde (ppb)		D 5837-12

COMMENTS: Avant surtensions de manœuvre, avant diélectriques.
Seringue:S002622

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OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297462A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-22

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	LT
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-21 11:10
Additional info:					
Description:	Inductance				

LAB COMMENTS

H_2 < 1 PPM

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LAB
Accrédité CCN

OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297268A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	GGC
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	L.T.
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-19 13:10
Additional info:					
Description:	Inductance				

DGA

2015-10-19	Parameter	Screening Code(T/R)	Test Method
< 3	Hydrogen		D3612-02
< 0.1	Acetylene		ppm (V/V)
< 0.1	Ethane		at 273 K
< 0.1	Ethylene		and 760 Torr
0.5	Methane		
< 5	Carbon Monoxide		
55	Carbon Dioxide		
5700	Nitrogen		
2780	Oxygen + Argon		
0.85	Total Dissolved Gas (%)		

OIL QUALITY

2015-10-19	Parameter	Screening Code(T/R)	Test Method
	Moisture in Oil (ppm)		SOP 5.5-03-01
	Moisture in Oil (ppm)		D 1533-12
	Interfacial Tension (mN/m)		D 971-12
	Acid Number (mg KOH/g)		D 974-14e1
	Color Number		D1500-12
	Free Water		D 1524-94
	Visual Examination		D 1524-94
	Sediment Examination		D 1524-94
	Dielectric Breakdown (kV)		D 877-13
	Dielectric Breakdown 2 mm (kV)		D 1816-12
	Power Factor @ 25 °C (%)		D 924-08
	Power Factor @ 100 °C (%)		D 924-08
	Specific Gravity		D 1298-12b
	Oxidation Inhibitor DBP (wt. %)		D 4768-11
	Oxidation Inhibitor DBPC (wt. %)		D 4768-11
	PCB - Total Arochlor Content (ppm)		D 4059-00
	Corrosive Sulphur Method B		D 1275-06
	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-12
	furfuryl alcohol (ppb)		D 5837-12
	2-furaldehyde (ppb)		D 5837-12
	2-acetylfuran (ppb)		D 5837-12
	5-methyl-2-furaldehyde (ppb)		D 5837-12

COMMENTS: Apres l`echauffement / 3 heures apres
Bas de cuve / # seringue: S005811

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OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297268A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	GGC
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	L.T.
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-19 13:10
Additional info:					
Description:	Inductance				

LAB COMMENTS

H2 < 1 ppm

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OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297267A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	GGC
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	L.T.
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-19 13:00
Additional info:					
Description:	Inductance				

DGA

2015-10-19	Parameter	Screening Code(T/R)	Test Method
< 3	Hydrogen		D3612-02
< 0.1	Acetylene		ppm (V/V)
< 0.1	Ethane		at 273 K
< 0.1	Ethylene		and 760 Torr
0.4	Methane		
< 5	Carbon Monoxide		
61	Carbon Dioxide		
6440	Nitrogen		
3140	Oxygen + Argon		
0.96	Total Dissolved Gas (%)		

OIL QUALITY

2015-10-19	Parameter	Screening Code(T/R)	Test Method
	Moisture in Oil (ppm)		SOP 5.5-03-01
	Moisture in Oil (ppm)		D 1533-12
	Interfacial Tension (mN/m)		D 971-12
	Acid Number (mg KOH/g)		D 974-14e1
	Color Number		D1500-12
	Free Water		D 1524-94
	Visual Examination		D 1524-94
	Sediment Examination		D 1524-94
	Dielectric Breakdown (kV)		D 877-13
	Dielectric Breakdown 2 mm (kV)		D 1816-12
	Power Factor @ 25 °C (%)		D 924-08
	Power Factor @ 100 °C (%)		D 924-08
	Specific Gravity		D 1298-12b
	Oxidation Inhibitor DBP (wt. %)		D 4768-11
	Oxidation Inhibitor DBPC (wt. %)		D 4768-11
	PCB - Total Arochlor Content (ppm)		D 4059-00
	Corrosive Sulphur Method B		D 1275-06
	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-12
	furfuryl alcohol (ppb)		D 5837-12
	2-furaldehyde (ppb)		D 5837-12
	2-acetylfuran (ppb)		D 5837-12
	5-methyl-2-furaldehyde (ppb)		D 5837-12

COMMENTS: Apres l`echauffement / 3 heures apres
Haut de cuve / # seringue: S003125

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Accrédité CCN

OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297267A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	GGC
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	L.T.
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-19 13:00
Additional info:					
Description:	Inductance				

LAB COMMENTS

H2 < 1 ppm

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OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297247A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	LT
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-19 08:50
Additional info:					
Description:	Inductance				

DGA

2015-10-19	Parameter	Screening Code(T/R)	Test Method
< 3	Hydrogen		D3612-02
< 0.1	Acetylene		ppm (V/V)
< 0.1	Ethane		at 273 K
< 0.1	Ethylene		and 760 Torr
0.1	Methane		
< 5	Carbon Monoxide		
60	Carbon Dioxide		
5290	Nitrogen		
2580	Oxygen + Argon		
0.79	Total Dissolved Gas (%)		

OIL QUALITY

2015-10-19	Parameter	Screening Code(T/R)	Test Method
	Moisture in Oil (ppm)		SOP 5.5-03-01
	Moisture in Oil (ppm)		D 1533-12
	Interfacial Tension (mN/m)		D 971-12
	Acid Number (mg KOH/g)		D 974-14e1
	Color Number		D1500-12
	Free Water		D 1524-94
	Visual Examination		D 1524-94
	Sediment Examination		D 1524-94
	Dielectric Breakdown (kV)		D 877-13
	Dielectric Breakdown 2 mm (kV)		D 1816-12
	Power Factor @ 25 °C (%)		D 924-08
	Power Factor @ 100 °C (%)		D 924-08
	Specific Gravity		D 1298-12b
	Oxidation Inhibitor DBP (wt. %)		D 4768-11
	Oxidation Inhibitor DBPC (wt. %)		D 4768-11
	PCB - Total Arochlor Content (ppm)		D 4059-00
	Corrosive Sulphur Method B		D 1275-06
	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-12
	furfuryl alcohol (ppb)		D 5837-12
	2-furaldehyde (ppb)		D 5837-12
	2-acetylfuran (ppb)		D 5837-12
	5-methyl-2-furaldehyde (ppb)		D 5837-12

COMMENTS: Apres l'echauffement, haut de la cuve.
Seringue:S001235

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LAB Accrédité CCN

OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297247A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	LT
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-19 08:50
Additional info:					
Description:	Inductance				

LAB COMMENTS

H_2 < 1 PPM

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LAB
Accrédité CCN

OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297246A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	LT
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-19 08:55
Additional info:					
Description:	Inductance				

DGA

2015-10-19	Parameter	Screening Code(T/R)	Test Method
< 3	Hydrogen		D3612-02
< 0.1	Acetylene		ppm (V/V)
< 0.1	Ethane		at 273 K
< 0.1	Ethylene		and 760 Torr
0.2	Methane		
< 5	Carbon Monoxide		
57	Carbon Dioxide		
5000	Nitrogen		
2440	Oxygen + Argon		
0.75	Total Dissolved Gas (%)		

OIL QUALITY

2015-10-19	Parameter	Screening Code(T/R)	Test Method
	Moisture in Oil (ppm)		SOP 5.5-03-01
	Moisture in Oil (ppm)		D 1533-12
	Interfacial Tension (mN/m)		D 971-12
	Acid Number (mg KOH/g)		D 974-14e1
	Color Number		D1500-12
	Free Water		D 1524-94
	Visual Examination		D 1524-94
	Sediment Examination		D 1524-94
	Dielectric Breakdown (kV)		D 877-13
	Dielectric Breakdown 2 mm (kV)		D 1816-12
	Power Factor @ 25 °C (%)		D 924-08
	Power Factor @ 100 °C (%)		D 924-08
	Specific Gravity		D 1298-12b
	Oxidation Inhibitor DBP (wt. %)		D 4768-11
	Oxidation Inhibitor DBPC (wt. %)		D 4768-11
	PCB - Total Arochlor Content (ppm)		D 4059-00
	Corrosive Sulphur Method B		D 1275-06
	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-12
	furfuryl alcohol (ppb)		D 5837-12
	2-furaldehyde (ppb)		D 5837-12
	2-acetylfuran (ppb)		D 5837-12
	5-methyl-2-furaldehyde (ppb)		D 5837-12

COMMENTS: Apres l'echauffement, bas de la cuve.
Seringue:S002299

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OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297246A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	LT
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-19 08:55
Additional info:					
Description:	Inductance				

LAB COMMENTS

H2 < 1 PPM

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OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297245A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	DL
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-18 10:40
Additional info:					
Description:	Inductance				

DGA

2015-10-18	Parameter	Screening Code(T/R)	Test Method
< 3	Hydrogen		D3612-02
< 0.1	Acetylene		ppm (V/V)
< 0.1	Ethane		at 273 K
< 0.1	Ethylene		and 760 Torr
0.2	Methane		
< 5	Carbon Monoxide		
22	Carbon Dioxide		
5540	Nitrogen		
2700	Oxygen + Argon		
0.83	Total Dissolved Gas (%)		

OIL QUALITY

2015-10-18	Parameter	Screening Code(T/R)	Test Method
	Moisture in Oil (ppm)		SOP 5.5-03-01
	Moisture in Oil (ppm)		D 1533-12
	Interfacial Tension (mN/m)		D 971-12
	Acid Number (mg KOH/g)		D 974-14e1
	Color Number		D1500-12
	Free Water		D 1524-94
	Visual Examination		D 1524-94
	Sediment Examination		D 1524-94
	Dielectric Breakdown (kV)		D 877-13
	Dielectric Breakdown 2 mm (kV)		D 1816-12
	Power Factor @ 25 °C (%)		D 924-08
	Power Factor @ 100 °C (%)		D 924-08
	Specific Gravity		D 1298-12b
	Oxidation Inhibitor DBP (wt. %)		D 4768-11
	Oxidation Inhibitor DBPC (wt. %)		D 4768-11
	PCB - Total Arochlor Content (ppm)		D 4059-00
	Corrosive Sulphur Method B		D 1275-06
	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-12
	furfuryl alcohol (ppb)		D 5837-12
	2-furaldehyde (ppb)		D 5837-12
	2-acetylfuran (ppb)		D 5837-12
	5-methyl-2-furaldehyde (ppb)		D 5837-12

COMMENTS: Avant l'echauffement, haut de la cuve.
Seringue:S009851

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OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297245A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	DL
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-18 10:40
Additional info:					
Description:	Inductance				

LAB COMMENTS

H2 < 1 PPM

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Accrédité CCN

OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297244A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	DL
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-18 10:40
Additional info:					
Description:	Inductance				

DGA

2015-10-18	Parameter	Screening Code(T/R)	Test Method
< 3	Hydrogen		D3612-02
< 0.1	Acetylene		ppm (V/V)
< 0.1	Ethane		at 273 K
< 0.1	Ethylene		and 760 Torr
0.1	Methane		
< 5	Carbon Monoxide		
29	Carbon Dioxide		
4330	Nitrogen		
2110	Oxygen + Argon		
0.65	Total Dissolved Gas (%)		

OIL QUALITY

2015-10-18	Parameter	Screening Code(T/R)	Test Method
	Moisture in Oil (ppm)		SOP 5.5-03-01
	Moisture in Oil (ppm)		D 1533-12
	Interfacial Tension (mN/m)		D 971-12
	Acid Number (mg KOH/g)		D 974-14e1
	Color Number		D1500-12
	Free Water		D 1524-94
	Visual Examination		D 1524-94
	Sediment Examination		D 1524-94
	Dielectric Breakdown (kV)		D 877-13
	Dielectric Breakdown 2 mm (kV)		D 1816-12
	Power Factor @ 25 °C (%)		D 924-08
	Power Factor @ 100 °C (%)		D 924-08
	Specific Gravity		D 1298-12b
	Oxidation Inhibitor DBP (wt. %)		D 4768-11
	Oxidation Inhibitor DBPC (wt. %)		D 4768-11
	PCB - Total Arochlor Content (ppm)		D 4059-00
	Corrosive Sulphur Method B		D 1275-06
	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-12
	furfuryl alcohol (ppb)		D 5837-12
	2-furaldehyde (ppb)		D 5837-12
	2-acetylfuran (ppb)		D 5837-12
	5-methyl-2-furaldehyde (ppb)		D 5837-12

COMMENTS: Avant l'echauffement, bas de la cuve.
Seringue:S003628

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Accrédité CCN

OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M297244A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-19

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	DL
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-18 10:40
Additional info:					
Description:	Inductance				

LAB COMMENTS

H2 < 1 PPM

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OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M296990A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-15

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	CR
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-14 16:30
Additional info:					
Description:	Inductance				

DGA

2015-10-14	Parameter	Screening Code(T/R)	Test Method
< 3	Hydrogen		D3612-02
< 0.1	Acetylene		ppm (V/V)
< 0.1	Ethane		at 273 K
< 0.1	Ethylene		and 760 Torr
0.2	Methane		
< 5	Carbon Monoxide		
19	Carbon Dioxide		
4200	Nitrogen		
2050	Oxygen + Argon		
0.63	Total Dissolved Gas (%)		

OIL QUALITY

2015-10-14	Parameter	Screening Code(T/R)	Test Method
	Moisture in Oil (ppm)		SOP 5.5-03-01
	Moisture in Oil (ppm)		D 1533-12
	Interfacial Tension (mN/m)		D 971-12
	Acid Number (mg KOH/g)		D 974-14e1
	Color Number		D1500-12
	Free Water		D 1524-94
	Visual Examination		D 1524-94
	Sediment Examination		D 1524-94
	Dielectric Breakdown (kV)		D 877-13
	Dielectric Breakdown 2 mm (kV)		D 1816-12
	Power Factor @ 25 °C (%)		D 924-08
	Power Factor @ 100 °C (%)		D 924-08
	Specific Gravity		D 1298-12b
	Oxidation Inhibitor DBP (wt. %)		D 4768-11
	Oxidation Inhibitor DBPC (wt. %)		D 4768-11
	PCB - Total Arochlor Content (ppm)		D 4059-00
	Corrosive Sulphur Method B		D 1275-06
	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-12
	furfuryl alcohol (ppb)		D 5837-12
	2-furaldehyde (ppb)		D 5837-12
	2-acetylfuran (ppb)		D 5837-12
	5-methyl-2-furaldehyde (ppb)		D 5837-12

COMMENTS: Pas d'indication d'essai, haut de la cuve.
Seringue:S011789

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LAB
Accrédité CCN

OIL ANALYSIS REPORT

REFERENCE

Client:	Jérome Ndayizamba (CAS18)	Sample No:	M296990A
E-mail:	jerome.m.ndayizamba@ca.abb.com	Authorized by:	
Company:	ABB -IREQ	Sent Date:	2015-10-15

EQUIPMENT

Apparatus Type:	IND	KV:	330	Sampling Point:	MAIN
Location:	Hydro-Québec - Pos...	MVA:	140	Oil Temp. (°C):	
Equipment No:	15079-01	Oil type:	Mineral Oil	Sampled by:	CR
Serial No.:	15079-01	Year built:	2016	Sampling Date:	2015-10-14 16:30
Additional info:					
Description:	Inductance				

LAB COMMENTS

H2 < 1 PPM

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LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance 3 ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

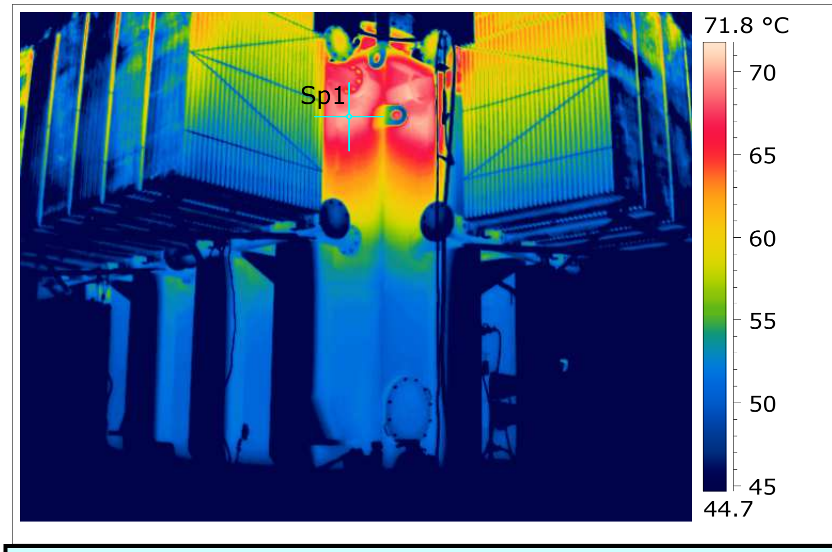
ANNEXE B

Thermographie

LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contra t	J794315045
Client	ABB Inc.

Échauffement (ONAN)

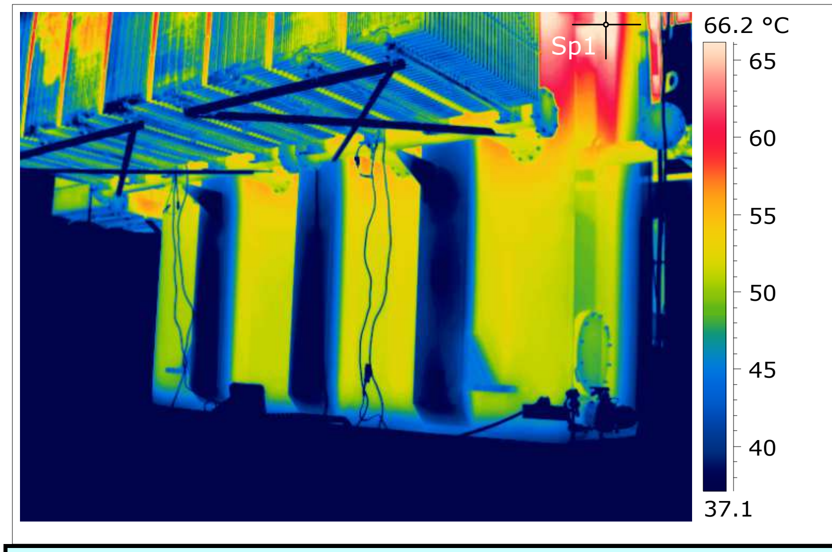


Emissivité		0.95
Info de la Photo		**Valeur**
Date		2015-10-19
Heure		06:56:35
Nom du fichier		IR_11664.jpg
N° série de la caméra :	404000503	N° IREQ 2050426
Sp1 Température		70.0 °C

Hydro Québec
LABORATOIRE HAUTE TENSION

Objet d'essais	**Inductance shunt 3-ph.**
Nº Série	**15079-01**
Nº Contra t	**J794315045**
Client	**ABB Inc.**

Échauffement (ONAN)

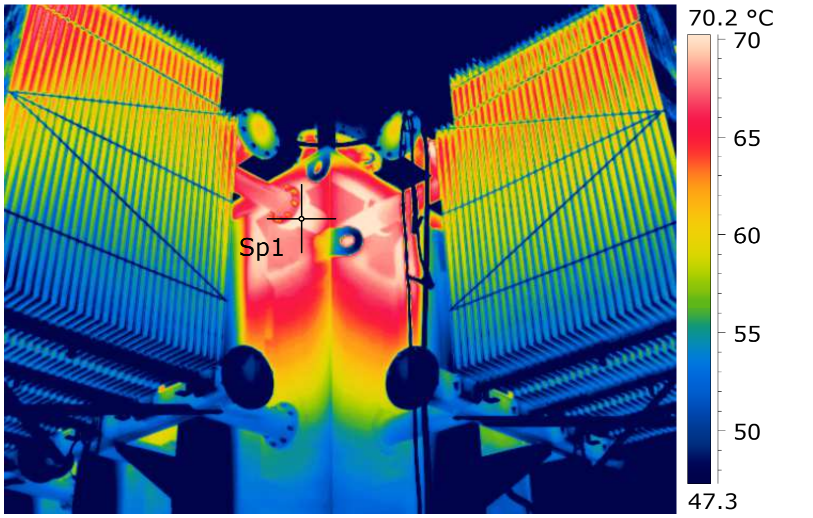


Emissivité		**0.95**
Info de la Photo		**Valeur**
Date		**2015-10-19**
Heure		**06:57:03**
Nom du fichier		**IR_11666.jpg**
N° série de la caméra :	**404000503**	**N° IREQ 2050426**
Sp1 Température		68.0 °C

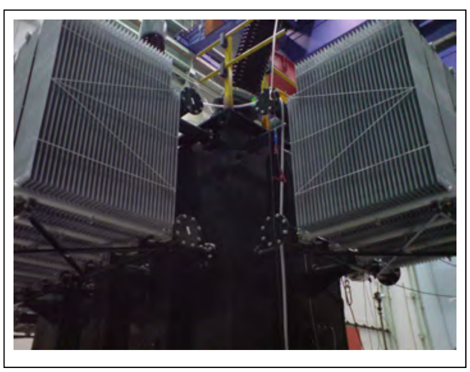
Hydro Québec
LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Échauffement (ONAN)



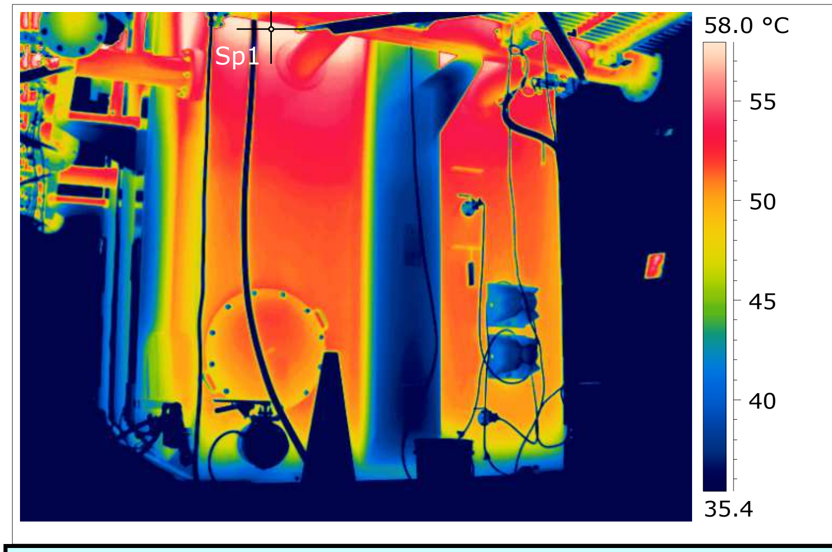
Emissivité		**0.95**
Info de la Photo		**Valeur**
Date		**2015-10-19**
Heure		**06:57:23**
Nom du fichier		**IR_11668.jpg**
N° série de la caméra :	**404000503**	**N° IREQ 2050426**
Sp1 Température		70.5 °C



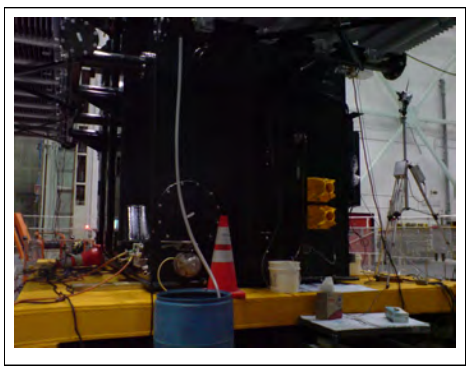
Hydro Québec
LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Échauffement (ONAN)



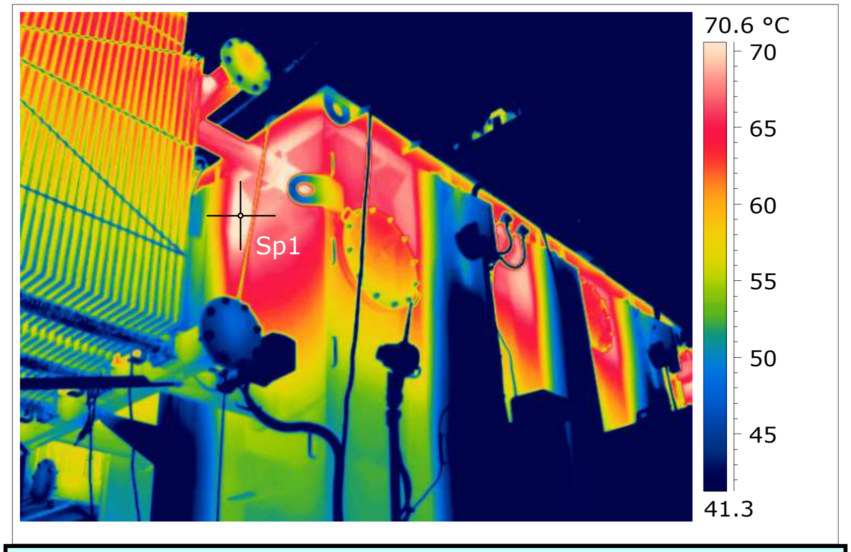
Emissivité		0.95
Info de la Photo		**Valeur**
Date		2015-10-19
Heure		06:57:38
Nom du fichier		IR_11670.jpg
N° série de la caméra :	404000503	N° IREQ 2050426
Sp1 Température		58.5 °C



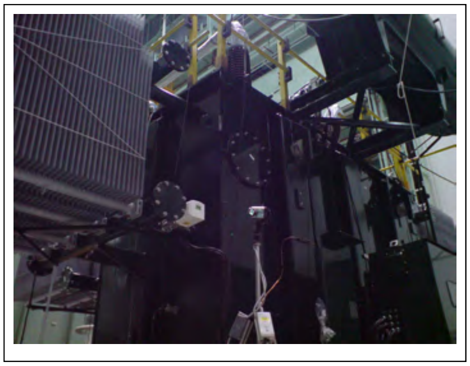
LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Échauffement (ONAN)



Emissivité		**0.95**
Info de la Photo		**Valeur**
Date		**2015-10-19**
Heure		**06:58:01**
Nom du fichier		**IR_11672.jpg**
N° série de la caméra :	**404000503**	**N° IREQ 2050426**
Sp1 Température		71.0 °C

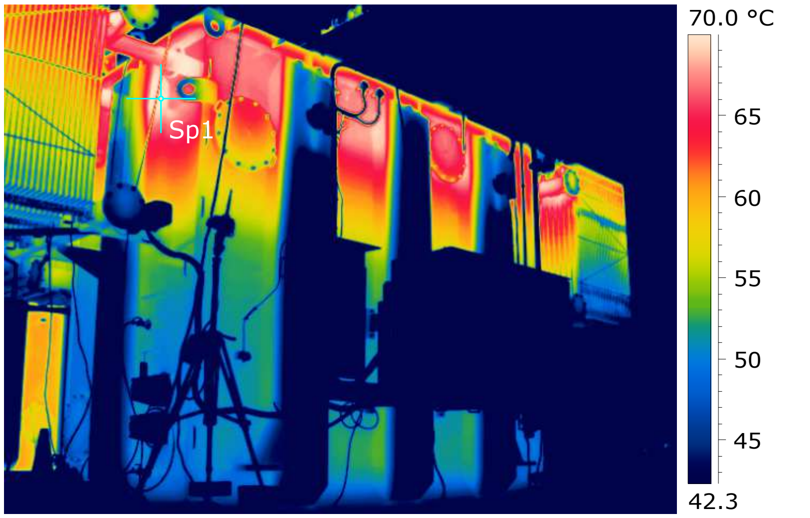


Hydro Québec

LABORATOIRE HAUTE TENSION

Objet d'essais	**Inductance shunt 3-ph.**
Nº Série	**15079-01**
Nº Contrat	**J794315045**
Client	**ABB Inc.**

Échauffement (ONAN)

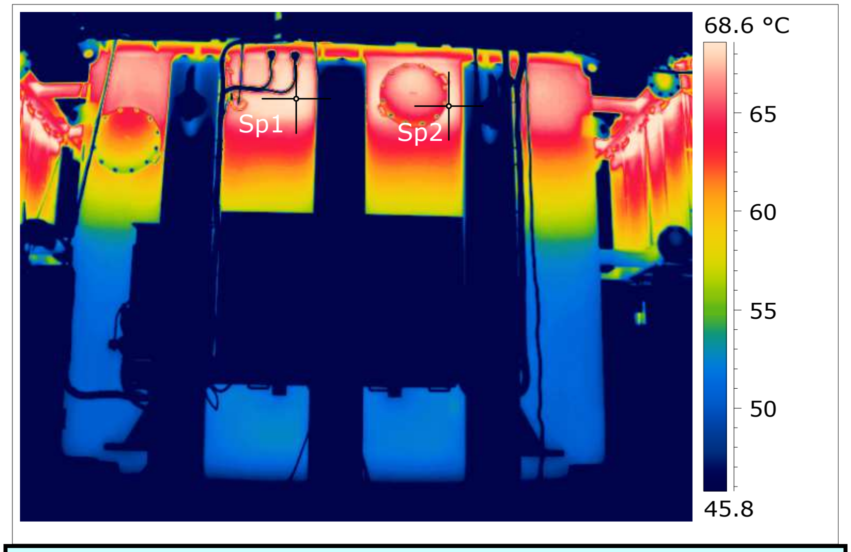


Emissivité		**0.95**
Info de la Photo		**Valeur**
Date		**2015-10-19**
Heure		**06:58:23**
Nom du fichier		**IR_11674.jpg**
N° série de la caméra :	**404000503**	**N° IREQ 2050426**
Sp1 Température		70.4 °C

Hydro Québec
LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Échauffement (ONAN)

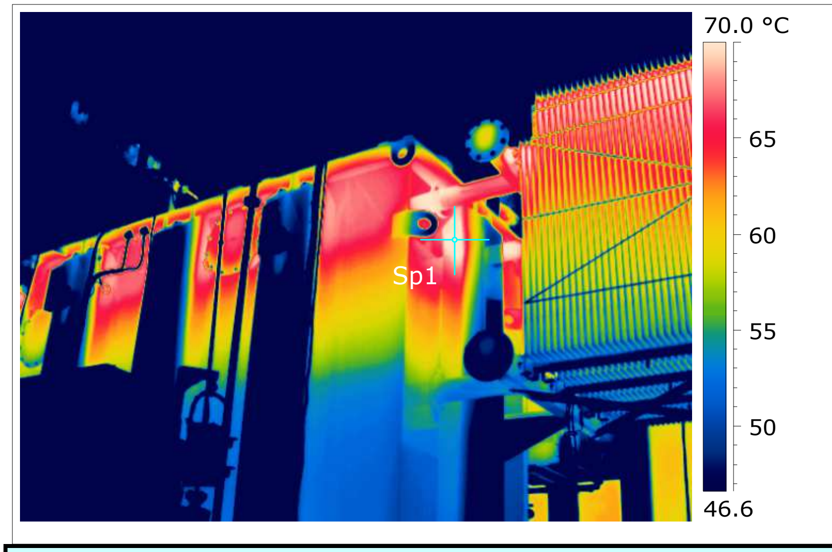


Emissivité		0.95
Info de la Photo		**Valeur**
Date		2015-10-19
Heure		06:58:48
Nom du fichier		IR_11676.jpg
N° série de la caméra :	404000503	N° IREQ 2050426
Sp1 Température		68.7 °C
Sp2 Température		68.6 °C

Hydro Québec
LABORATOIRE HAUTE TENSION

Objet d'essais	**Inductance shunt 3-ph.**
Nº Série	**15079-01**
Nº Contrat	**J794315045**
Client	**ABB Inc.**

Échauffement (ONAN)

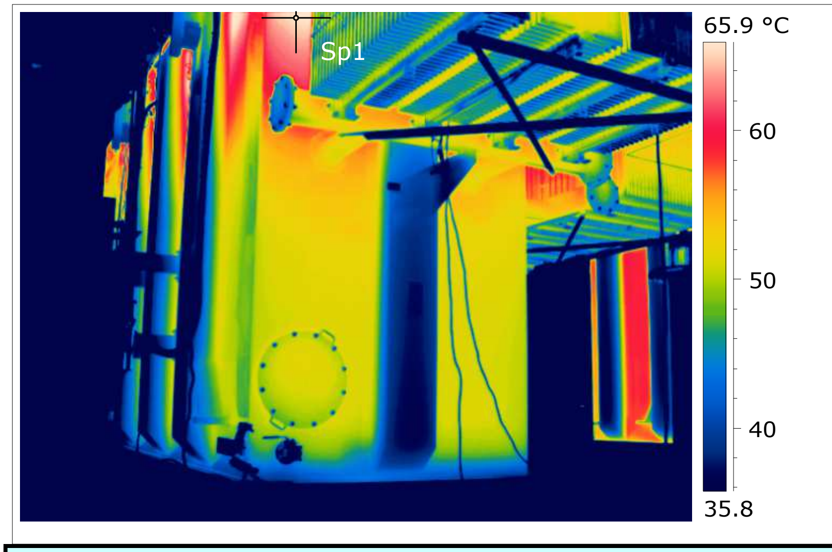


Emissivité		**0.95**
Info de la Photo		**Valeur**
Date		**2015-10-19**
Heure		**06:59:24**
Nom du fichier		**IR_11678.jpg**
N° série de la caméra :	**404000503**	**N° IREQ 2050426**
Sp1 Température		70.8 °C

Hydro Québec
LABORATOIRE HAUTE TENSION

Objet d'essais	Inductance shunt 3-ph.
Nº Série	15079-01
Nº Contrat	J794315045
Client	ABB Inc.

Échauffement (ONAN)

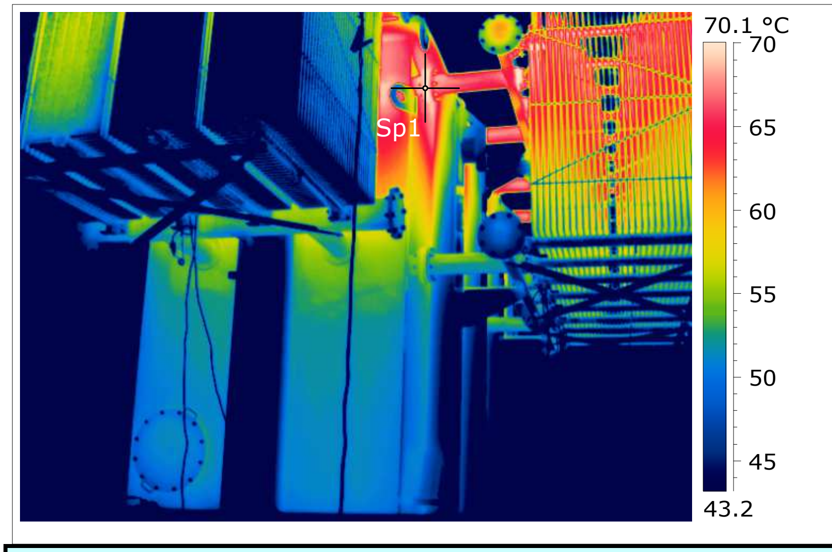


Emissivité		0.95
Info de la Photo		**Valeur**
Date		2015-10-19
Heure		06:59:43
Nom du fichier		IR_11680.jpg
N° série de la caméra :	404000503	N° IREQ 2050426
Sp1 Température		65.7 °C

Hydro Québec
LABORATOIRE HAUTE TENSION

Objet d'essais	**Inductance shunt 3-ph.**
Nº Série	**15079-01**
Nº Contrat	**J794315045**
Client	**ABB Inc.**

Échauffement (ONAN)



Emissivité		**0.95**
Info de la Photo		**Valeur**
Date		**2015-10-19**
Heure		**07:00:08**
Nom du fichier		**IR_11682.jpg**
N° série de la caméra :	**404000503**	**N° IREQ 2050426**
Sp1 Température		70.1 °C

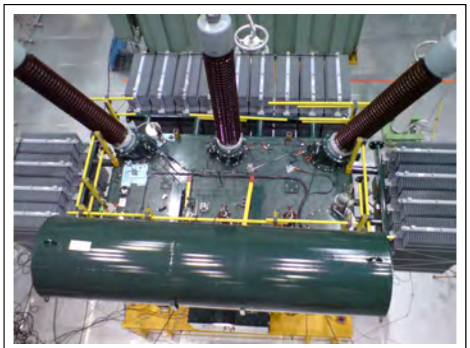
Hydro Québec

LABORATOIRE HAUTE TENSION

Objet d'essais	**Inductance shunt 3-ph.**
Nº Série	**15079-01**
Nº Contrat	**J794315045**
Client	**ABB Inc.**

Échauffement (ONAN)

Emissivité		**0.95**
Info de la Photo		**Valeur**
Date		**2015-10-19**
Heure		**07:05:57**
Nom du fichier		**IR_11684.jpg**
N° série de la caméra :	**404000503**	**N° IREQ 2050426**
Sp1 Température		71.3 °C



NO	NOTES
1	PLAQUE EN ACIER INOXDABLE SÉRIE 300, T=0,037"
2	LETTRAGE ACIER SUR FOND NOIR AVEC PROCÉDÉ "ETCHING"
3	LES DONNÉES MANQUANTES SERONT GRAVÉES AVANT L'EXPÉDITION
4	LES ESPACES À GRAVER DOIVENT AVOIR UN CONTOUR ACIER ET LE FOND NOIR

228 — 6 — ⌀5 (4X) — 333 — 345 — 6 — 240

ABB

INDUCTANCE SHUNT TRIPHASÉE 60 Hz
No DE SÉRIE 15079–01
140 Mvar   315 000 V   256,6 A

À BAIN D'HUILE AVEC CIRCULATION NATURELLE CLASSE ONAN

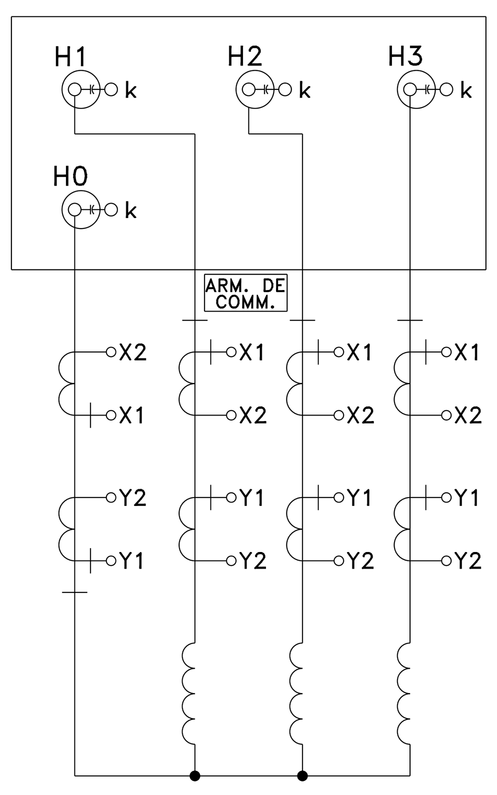
	DESCRIPTION DES TRAVERSÉES			
	TENSION NOMINALE	COURANT NOMINAL	TENUE AU CHOC DE FOUDRE	TYPE
H.T.	362 kV	2 500 A	1 175 kV	GOE
NEUTRE	46 kV	1 200 A	250 kV	250–012–T –081–02

	TENUE AU CHOC DE FOUDRE
	ENROULEMENT
H.T.	1 050 kV
NEUTRE	250 kV

TRANSFORMATEURS DE COURANT			
TRAVERSÉES	BORNES	RAPPORT:A	CLASSE
H1,H2,H3	X1 – X2	400:1	10VA 5P20
	Y1 – Y2		
H0	X1 – X2		
	Y1 – Y2		
k	PRISE CAPACITIVE		

NORME   SN–14.1h (A1, A2, A3)
NO DE COMMANDE H.Q.   4510181832
NOTICE D'ENTRETIEN   15079
ÉCHAUFFEMENT   55°C
SCHÉMA   XV15079004–B
LIQUIDE ISOLANT   CAN/CSA–C50–97 CLASSE A, TYPE II
ANNÉE DE FABRICATION
ENROULEMENT DE CUIVRE
TYPE D'ISOLATION DES CONDUCTEURS PAPIER THERMOSTABILISÉ

15079–01 EST LE No DE SÉRIE DE L'APPAREIL AYANT SUBI LES ESSAIS DE TYPE POUR LA COMMANDE 4510181832 D'HYDRO–QUÉBEC



PUISSANCE ACOUSTIQUE À 105% VN dB(A)
TENUE DE LA CUVE & DES RADIATEURS –101 kPa à +69 kPa
LE CONSERVATEUR TIENT LE VIDE
TENUE SISMIQUE SELON LA TET–APG–N–0001 = 0,45 g
ÉCHAUFFEMENT DE L'HUILE AU SOMMET DE LA CUVE
ΔT °C À 140 Mvar
ÉCHAUFFEMENT DU POINT CHAUD À 140 Mvar ΔT °C
PERTES TOTALES À 75°C À 140 Mvar kW

MASSES ±2%
NOYAU ET ENROULEMENTS kg
CUVE ET ACCESSOIRES kg
LIQUIDE ISOLANT kg
TOTAL kg
QUANTITÉ DE LIQUIDE ISOLANT ±2% À 15°C L
VOLUME D'HUILE TOTAL DU CONSERVATEUR PRINCIPAL 6 155 L

FABRIQUÉ À VARENNES, QUÉBEC

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
A	2014/11/05	TRAVERSÉE NEUTRE ÉTAIT E81H		RB/AZ	

NO	RÉFÉRENCES	NO

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
HYDRO–QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ____________________ DATE : ____-__-__

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

Cette vérification ne constitue d'aucune façon une vérification détaillée et complète de la conception

Recommandation
☐ Aucun commentaire
☐ Accepté tel que noté (doit être validé par un ingénieur si ça modifie le concept)
☐ Corriger et resoumettre avant les travaux
☐ Refusé

Signature ☐ Ingénieur ☐ Autre   Date
Nom   No de membre de l'OIQ

La vérification est restreinte à celle indiquée et ne garantit pas que les données du document revu sont exactes ou exhaustives. Elle ne dégage nullement la personne ou la firme qui l'a préparé de ses obligations de quelque nature que ce soit.

ABB Inc.
1600 Boul. Lionel Boulet
Varennes, Québec
J3X 1S4

DESSINÉ	R BRUNELLE	DATE	2014/03/11
VÉRIFIÉ	A BOUAICHA	DATE	2014/03/12
APPROUVÉ	A BOUAICHA	DATE	

POSTE DE L'OUTAOUAIS

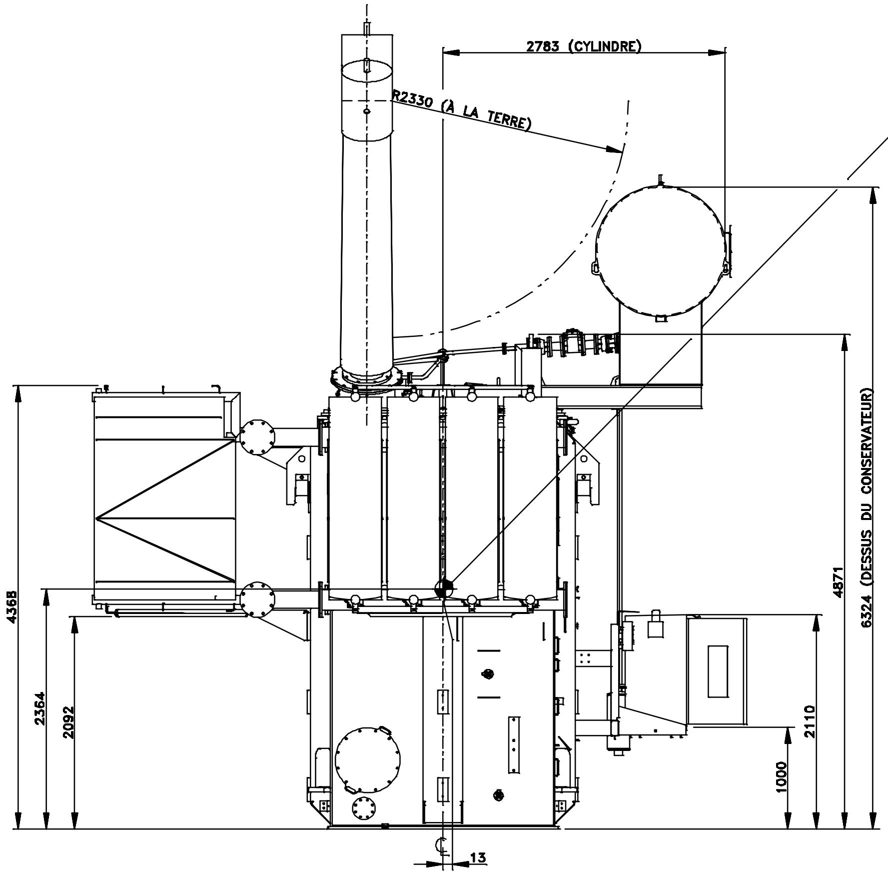
PLAQUE SIGNALÉTIQUE
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079–01
POSITION XL73

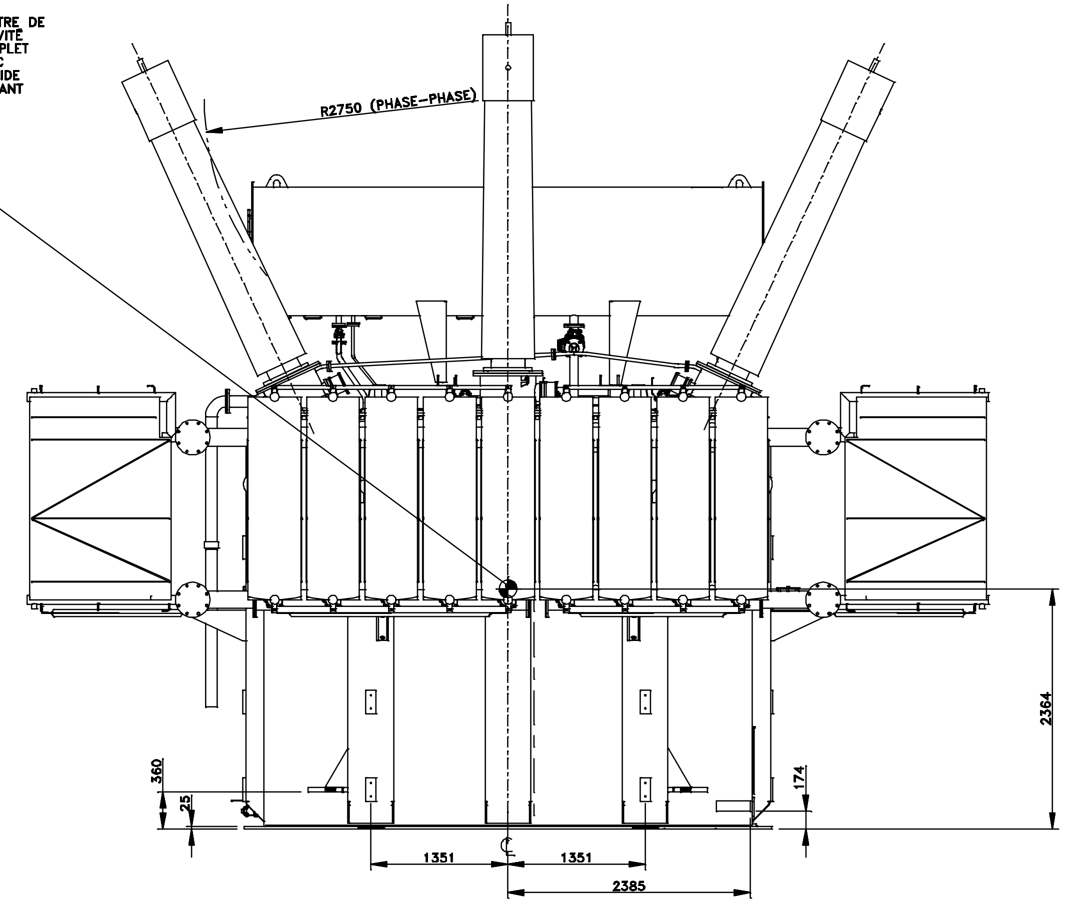
RAPPORT 1:1
DIMENSIONS EN mm

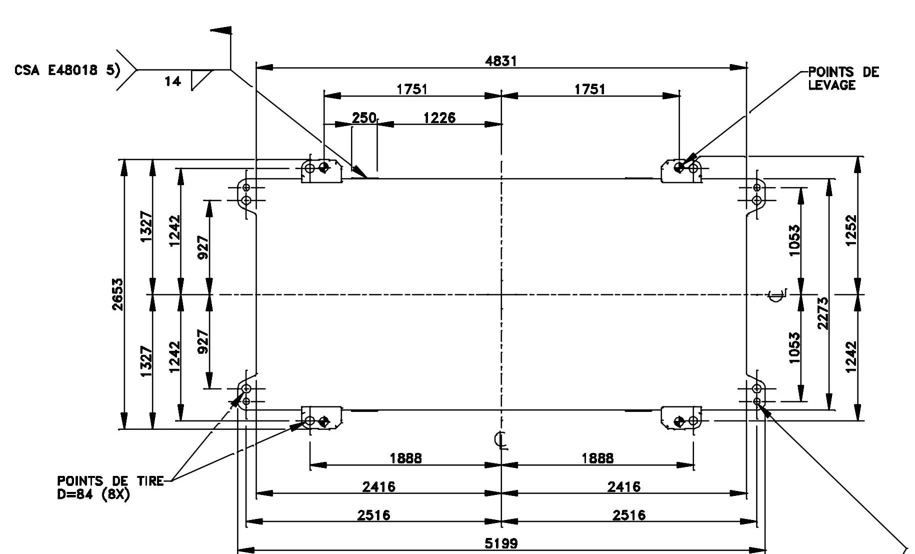
FEUILLE SUIVANTE ——

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOR.
6403	40140	A000060	XV15079004–B	01	A	1

M. DRAPEAU (2009-03)

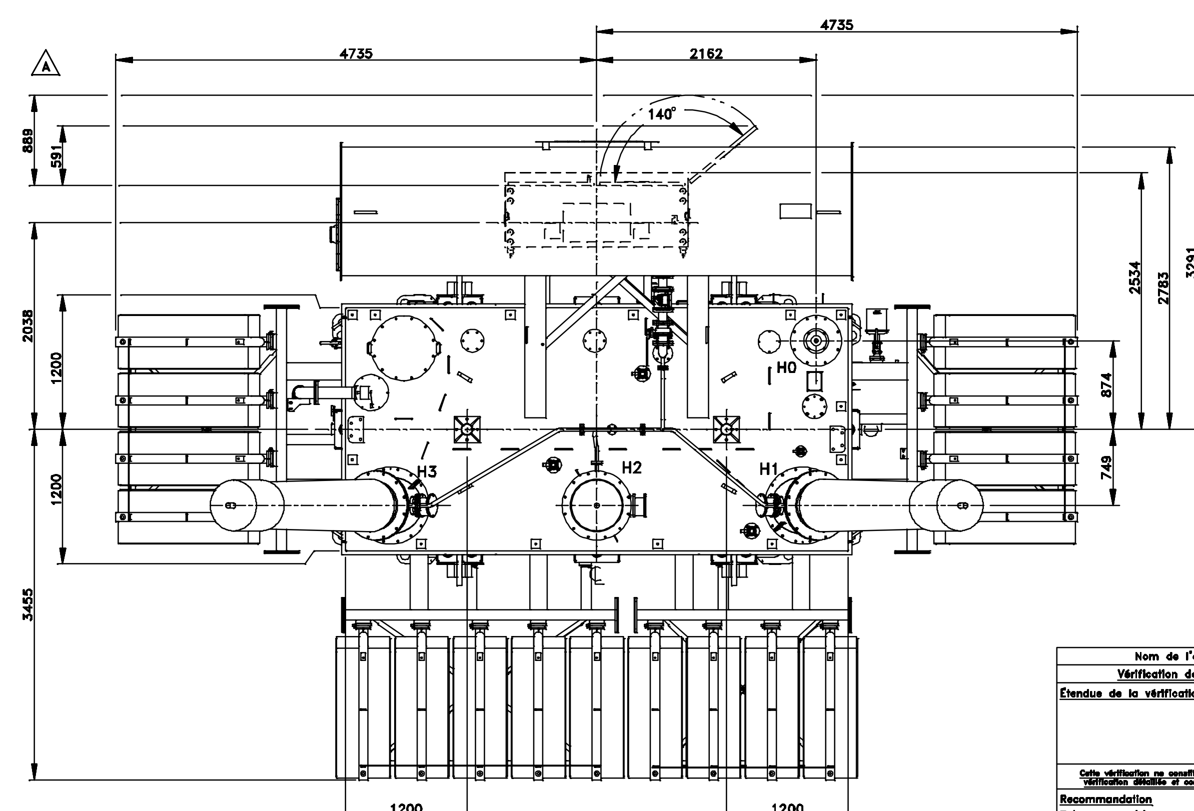






DIMENSIONS DU FOND

4 TROUS DE Ø64 POUR ANCRAGE AVEC TIGES FILETÉES M56 (ACIER CAN/CSA G40.21–M350W)



MASSES (±10%)		QUANTITÉ DE LIQUIDE ISOLANT À 15°C (±2%)	
NOYAU ET ENROULEMENTS	60840 kg	CUVE	32616 L
CUVE ET ACCESSOIRES	38076 kg	RADIATEURS	3417 L
LIQUIDE ISOLANT*	33949 kg	CONSERVATEUR(S) (50%)	3078 L
* DENSITÉ DU LIQUIDE ISOLANT 868 kg/m3 À 15°C			
TOTAL	132865 kg	TOTAL	39111 L

PRÉLIMINAIRE

NO	NOTES

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
A	2014/08/28	CONSERVATEUR, DIM. 2534 RELOCALISES. VUES À JOUR. TEXTE POINTS DE LEVAGE MODIFIÉ. DIM. 889, 591 AJOUTÉES.		DSH/PGR	

NO	RÉFÉRENCES	NO

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
HYDRO–QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ______________ DATE : ____-__-__

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

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Recommandation
☐ Aucun commentaire
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☐ Corriger et resoumettre avant les travaux
☐ Refusé

Signature ☐ Ingénieur ☐ Autre Date
Nom No de membre de l'OIQ

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ABB Inc.
1600 Boul. Lionel Boulet
Varennes, Québec
J3X 1S4

DESSINÉ	D. ST–HILAIRE	DATE	2014/05/12
VÉRIFIÉ	P. GAUTHIER	DATE	2014/05/12
APPROUVÉ	P. LAMOTHE	DATE	

POSTE DE L'OUTAOUAIS

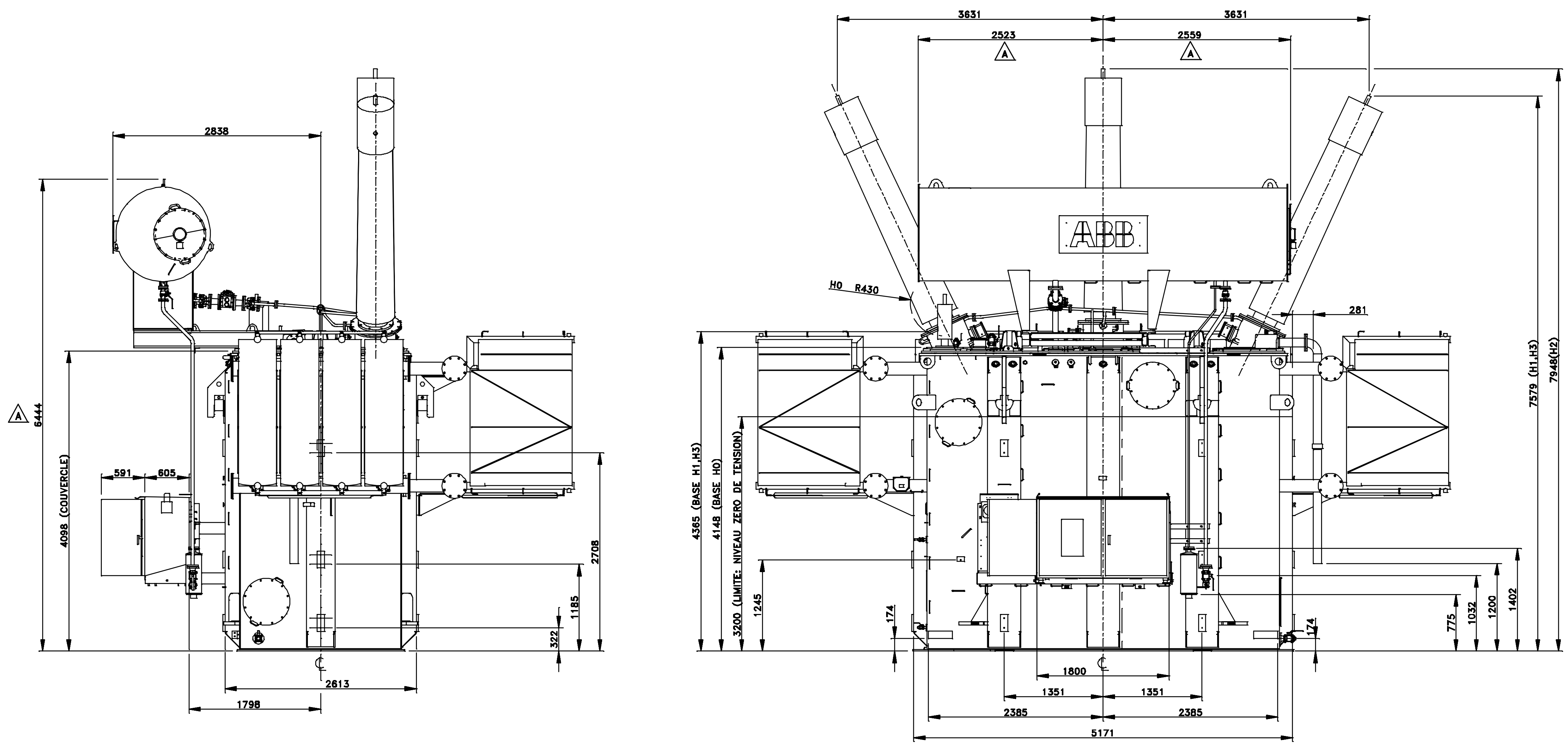
ENCOMBREMENT CIVIL
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079–01
POSITION XL73

RAPPORT 1:35
DIMENSIONS EN mm

FEUILLE SUIVANTE 02

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOR.
640	340140	A000060	XV15079004–C	01	A	1

M. DRAPEAU (2009–05)



NO	NOTES

NO	DATE	RÉVISIONS	R. de T.	EMET.	HQ
A	2014/08/28	DIM. 2523, 2559, 6444 ÉTAIENT 2720, 2362, 6408. VUES À JOUR.		DSH/PGR	

NO	RÉFÉRENCES	NO

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ______________________ DATE : ____-__-__

SCEAUX

NOTES

1– CE DESSIN EST CRÉÉ POUR QUE LE CLIENT PUISSE COMMENCER LES TRAVAUX D'INGÉNIERIE CIVILE ET POUR L'INFORMER DE L'EMPLACEMENT GÉNÉRAL DES ACCESSOIRES MAJEURS.

2– LES TOLÉRANCES INDIQUÉES SONT CHOISIES AFIN DE S'ASSURER QUE LES DIMENSIONS FINALES N'EXCÈDENT PAS CES TOLÉRANCES.

3– LES DIMENSIONS FINALES SERONT DONNÉES LORSQUE LE DESSIN DÉTAILLÉ SERA ÉMIS À MOINS QUE LE CLIENT NE LE VEUILLE DIFFÉREMENT.
TOLÉRANCES: ±200 mm POUR LES DIMENSIONS > 1000 mm.
±50 mm POUR LES DIMENSIONS < 1000 mm.

5– ANCRAGE RECOMMANDÉ EST 4 JOINTS SOUDÉS DE 250 mm.

6– TOLÉRANCE DE CONSTRUCTION POUR LA BASE DE BÉTON (HQ): SELON LA NORME SN-30.2. EXIGENCES MINIMALES POUR L'APPAREIL (ABB) : UNE DÉNIVELLATION MAXIMALE DE 2,5 mm PAR MÈTRE OU DE 8 mm ENTRE DEUX POINTS QUELCONQUES AU SOMMET DE LA FONDATION.
Réf.(ABB Varennes Transformateur de Puissance, Installation, 2011-05-04, 1ZCV4000-002, page1)
PRENDRE LES MESURES SELON LA NORME ASTM E1155M ET SIGNALER TOUT ÉCART DE CES TOLÉRANCES AU DÉPARTEMENT D'INGÉNIERIE MÉCANIQUE DE ABB VARENNES.

7– POUR LA QUALIFICATION PARASISMIQUE DE L'ÉQUIPEMENT SELON TET-APG-N-0001, VOIR LE RAPPORT SISMIQUE: XV15079004-FB

8– LES CHARGES SISMIQUES SONT DONNÉES SUR LE DESSIN XV15079004-F.

9– POUR LE COUPLE DE SERRAGE DES BOULONS, VOIR LE DOCUMENT 1ZCV450001-B DANS LE MANUEL D'ENTRETIEN ET D'EXPLOITATION.

M. DRAPEAU (2009-05)

PRÉLIMINAIRE

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

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Recommandation
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☐ Refusé

Signature ☐ Ingénieur ☐ Autre Date
Nom No de membre de l'OIQ

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ABB Inc.
1600 Boul. Lionel Boulet
Varennes, Québec
J3X 1S4

DESSINÉ	D. ST-HILAIRE	DATE	2014/05/12
VÉRIFIÉ	P. GAUTHIER	DATE	2014/05/12
APPROUVÉ	P. LAMOTHE	DATE	

POSTE DE L'OUTAOUAIS

ENCOMBREMENT CIVIL
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

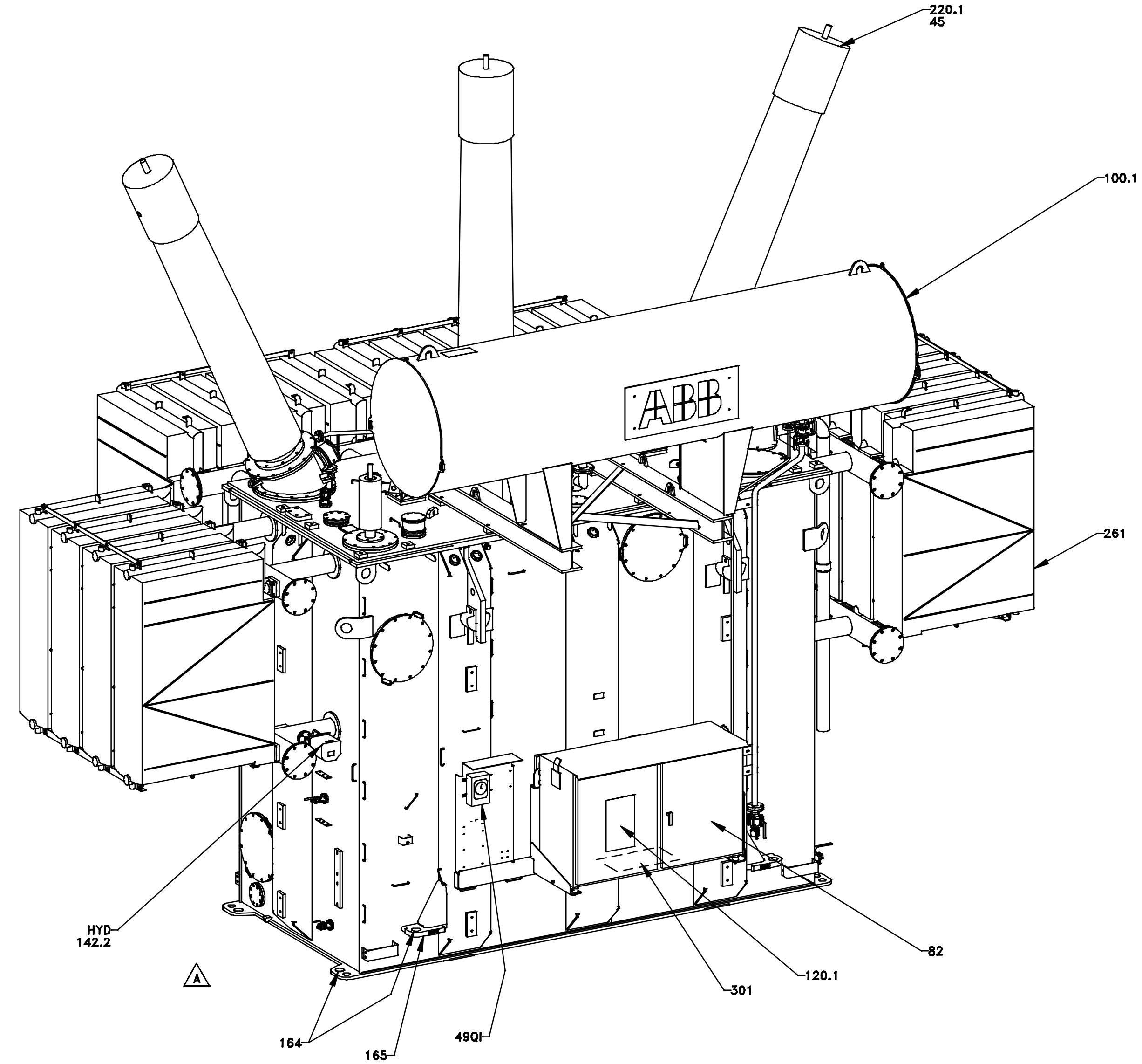
RAPPORT 1:35
DIMENSIONS EN mm

FEUILLE SUIVANTE —

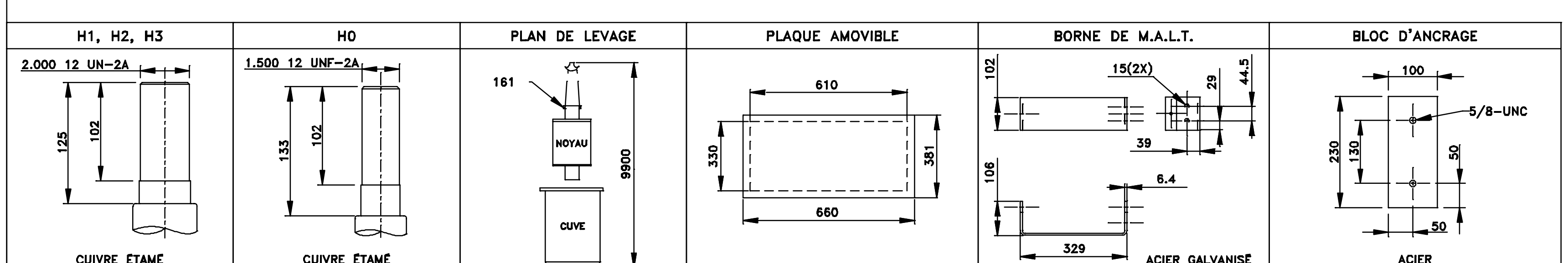
INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOR.
6403	40140	A000060	XV15079004-C	02	A	1

LISTE DES ACCESSOIRES

HYD	TRANSMETTEUR INTELLIGENT, GE MODÈLE HYDRAN M2
t-1, t-2	SONDE PYROMÉTRIQUE POUR TEMPÉRATURE DE L'HUILE, THERMO-KINETIC CO. LTD, CAT. RA11-D100A3-007.0-YB1.5-U0-SP-TW, 100 ohms PLATINE À 0°C,
45	BORNE CAPACITIVE DE TENSION (TYPIQUE)
49QI	INDICATEUR DE TEMPÉRATURE D'HUILE KIHLSTROM, TYPE 34 4 00 16-5.0
63GI	RELAIS DE DÉTECTION DES GAZ, COMEM BR 80LC, TYPE BUCHHOLZ
63QI	LIMITEUR DE PRESSION, QUALITROL, LPRD00-00007345, AVEC CAPOT, SLD000-00030028 ET TUYAUTERIE MÉTALLIQUE VERS LE SOL.
71QI	INDICATEUR DE NIVEAU D'HUILE POUR CONSERVATEUR, QUALITROL 032-302-01 CS-41616
82	ARMOIRE DE COMMANDE
100.1	CONSERVATEUR PRINCIPAL
103.1	DESSICCATEUR D'AIR POUR CONSERVATEUR PRINCIPAL AVEC TUYAUTERIE EN ACIER INOXYDABLE
106.1	DISPOSITIF D'ESSAI DU RELAIS DE DÉTECTION DES GAZ (63GI)
120.1	PLAQUE SIGNALÉTIQUE
126	PUITS POUR SONDE PYROMÉTRIQUE (t), #WT22-12-BRS-0055-00-00, (2X)
127	PUITS POUR THERMOMÈTRE D'HUILE (49QI)
140.1	ROBINET À TOURNANT SPHÉRIQUE, DE REMPLISSAGE ET DE VIDANGE, 2" NPT NORMALEMENT FERMÉ AVEC DÉFLECTEUR INTERNE POUR VIDANGE DE LA CUVE. (CADENASSABLE) (1X)
140.2	ROBINET À TOURNANT SPHÉRIQUE, DE VIDANGE, 2" NPT NORMALEMENT FERMÉ (1X) POUR LE CONSERVATEUR PRINCIPAL (CADENASSABLE) (1X)
140.3	BOUCHON DE VIDANGE 1/2" NPT POUR VIDANGE COMPLÈTE DU TRANSFORMATEUR (1X)
140.4	BOUCHON DE VIDANGE 1" NPT DES RADIATEURS (17X)
141.1	ROBINET À TOURNANT SPHÉRIQUE, POUR LE VIDE, 2"NPT NORMALEMENT FERMÉ (CADENASSABLE) (1X)
141.2	ROBINET À TOURNANT SPHÉRIQUE, POUR LA CIRCULATION, 2"NPT NORMALEMENT FERMÉ (CADENASSABLE) (1X)
141.3	ROBINET À TOURNANT SPHÉRIQUE, POUR LA SONDE DU POINT DE ROSÉE, 2" NPT NORMALEMENT FERMÉ (CADENASSABLE) (1X)
142.1	ROBINET À TOURNANT SPHÉRIQUE, POUR ESSAI D'HUILE, 1/2" NPT NORMALEMENT FERMÉ (1X)
142.2	ROBINET À TOURNANT SPHÉRIQUE, POUR HYDRAN, 1 1/2" NPT NORMALEMENT OUVERT (1X)
142.3	ROBINET À TOURNANT SPHÉRIQUE, POUR ÉQUIPEMENT DURANT LE TRANSPORT, 1/2" NPT NORM. FERMÉ (1X)
142.4	CONNEXION 4" POUR FILTRATION À L'USAGE DE ABB
143.1	ROBINET À PAPILLON 3" POUR LES RADIATEURS NORMALEMENT OUVERT (34X)
143.2	ROBINET À TOURNANT SPHÉRIQUE, POUR LE RELAIS DE DÉTECTION DES GAZ, 3" NORMALEMENT OUVERT (2X)
143.3	ROBINET À TOURNANT SPHÉRIQUE, PLACÉ AU COUVERCLE, 1" NPT NORMALEMENT FERMÉ (1X)
143.4	ROBINET À TOURNANT SPHÉRIQUE, POUR TUYAUTERIE DE VIDANGE, 1 1/2" NPT NORMALEMENT OUVERT (1X)
144.1	BOUCHON DE PURGE 1" NPT DES RADIATEURS (17X)
160	ANNEAU DE LEVAGE DU COUVERCLE (4X)
161	ANNEAU DE LEVAGE DU NOYAU
162	CROCHETS DE LEVAGE DU TRANSFORMATEUR COMPLET. (NON-LIVRÉS, UTILISÉS À L'USINE SEULEMENT.)
164	TROU DE TRACTION (8X)
165	POINT D'APPLICATION DU VÉRIN (4X)
200	TROU D'HOMME (6X)
215.1	BORNE DE MISE À LA TERRE DU TRANSFORMATEUR (3X)
215.2	BORNE DE MISE À LA TERRE DU NOYAU ET DES PRESSE-CULASSES
220.1	TRAVERSÉE HT, ABB TYPE GOE 1175 / 2500 A, XV15079010-BA
220.2	TRAVERSÉE NEUTRE, ECI MODÈLE 250-012-T-081-02, 46 kV, 1200 A, XV15079010-BB
261	RADIATEUR GALVANISÉ, MENK, 1ZBA468007-GK (17X)
266.1	JOINT DE DILATATION 3" ABB # 1ZCV251101-18
301	PLAQUE AMOVIBLE NON PERCÉE POUR CONDUITS (LOCALISATION SUR DESSIN D'ENCOMBREMENT CIVIL XV15079004-C)
303.1-.4	BOÎTES À BORNES POUR TRANSFORMATEURS DE COURANT
400	SYSTÈME DE SÉCURITÉ, POTEAUX D'ANCRAGE (2X)
401	CONNEXION EVER-TITE 50 mm AVEC BOUCHON POUR CONSERVATEUR PRINCIPAL
403	BOUCHON 2 1/2" POUR REMPLISSAGE DES POUTRES AVEC DU SABLE
404	DISPOSITIF DE RETENUE DE L'ÉCHELLE.
405	BLOCS D'ANCRAGE POUR PANNEAUX ACOUSTIQUES.



POUR LE COUPLE DE SERRAGE DES BOULONS, VOIR LE DOCUMENT 1ZCV460001-B DANS LE MANUEL D'ENTRETIEN ET D'EXPLOITATION.



NO	NOTES

NO	DATE	RÉVISIONS	R. de T.	EMET.	HQ
A	2014/08/28	ITEM 85 ANNULÉ. ITEM 220.2 ECI MODÈLE ÉTAIT E81H. IDENTIFICATION ITEMS HYD, 49QI, 63GI, 63QI, 71QI MODIFIÉS.		DSH/PGR	

NO	RÉFÉRENCES	NO

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ____________________ DATE : ____-__-__

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

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Recommandation
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- ☐ Accepté tel que noté (doit être validé par un ingénieur si ça modifie le concept)
- ☐ Corriger et resoumettre avant les travaux
- ☐ Refusé

Signature ☐ Ingénieur ☐ Autre Date
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ABB Inc.
1600 Boul. Lionel Boulet
Varennes, Québec
J3X 1S4

DESSINÉ	D. ST-HILAIRE	DATE	2014/05/21
VÉRIFIÉ	P. GAUTHIER	DATE	2014/05/21
APPROUVÉ	P. LAMOTHE	DATE	

POSTE DE L'OUTAOUAIS

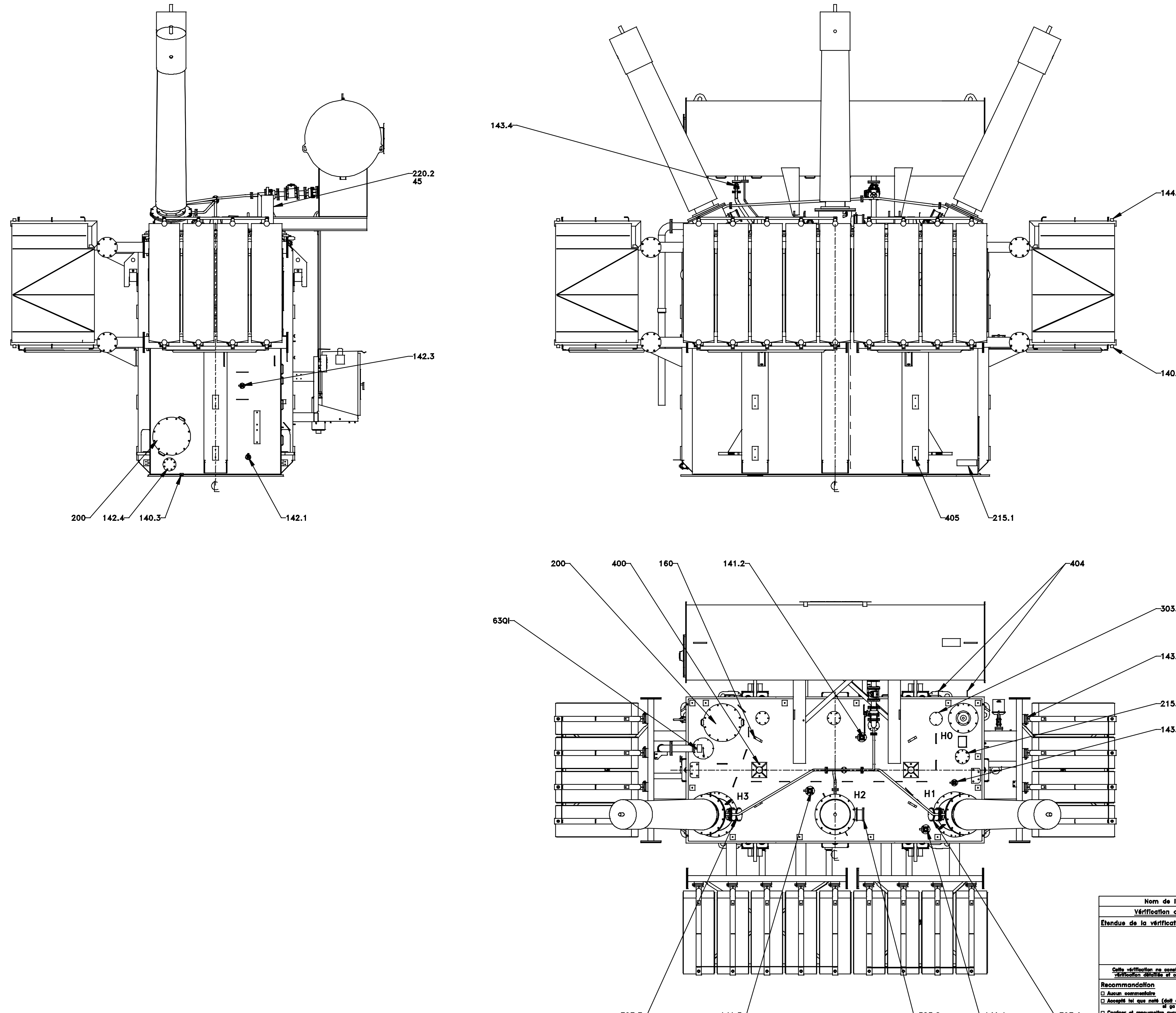
ENCOMBREMENT DÉTAILLÉ
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

RAPPORT 1:30
DIMENSIONS EN mm

FEUILLE SUIVANTE 02

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOR.
6403	40140	A000060	XV15079004-D	01	A	1

M. DRAPEAU (2009-03)



NO	NOTES

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
A	2014/08/28	ITEM 63QI ÉTAIT 63QT		DSH/PGR	

NO	RÉFÉRENCES	NO

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ________________ DATE : ____-__-__

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

Cette vérification ne constitue d'aucune façon une vérification détaillée et complète de la conception

Recommandation
☐ Aucun commentaire
☐ Accepté tel que noté (doit être validé par un ingénieur si ça modifie le concept)
☐ Corriger et resoumettre avant les travaux
☐ Refusé

Signature ☐ Ingénieur ☐ Autre Date
Nom No de membre de l'OIQ

La vérification est restreinte à celle indiquée et ne garantit pas que les données du document revu sont exactes ou exhaustives. Elle ne dégage nullement la personne ou la firme qui l'a préparé de ses obligations de quelque nature que ce soit.

ABB Inc.
1600 Boul. Lionel Boulet
Varennes, Québec
J3X 1S4

DESSINÉ	D. ST-HILAIRE	DATE	2014/05/21
VÉRIFIÉ	P. GAUTHIER	DATE	2014/05/21
APPROUVÉ	P. LAMOTHE	DATE	

POSTE DE L'OUTAOUAIS

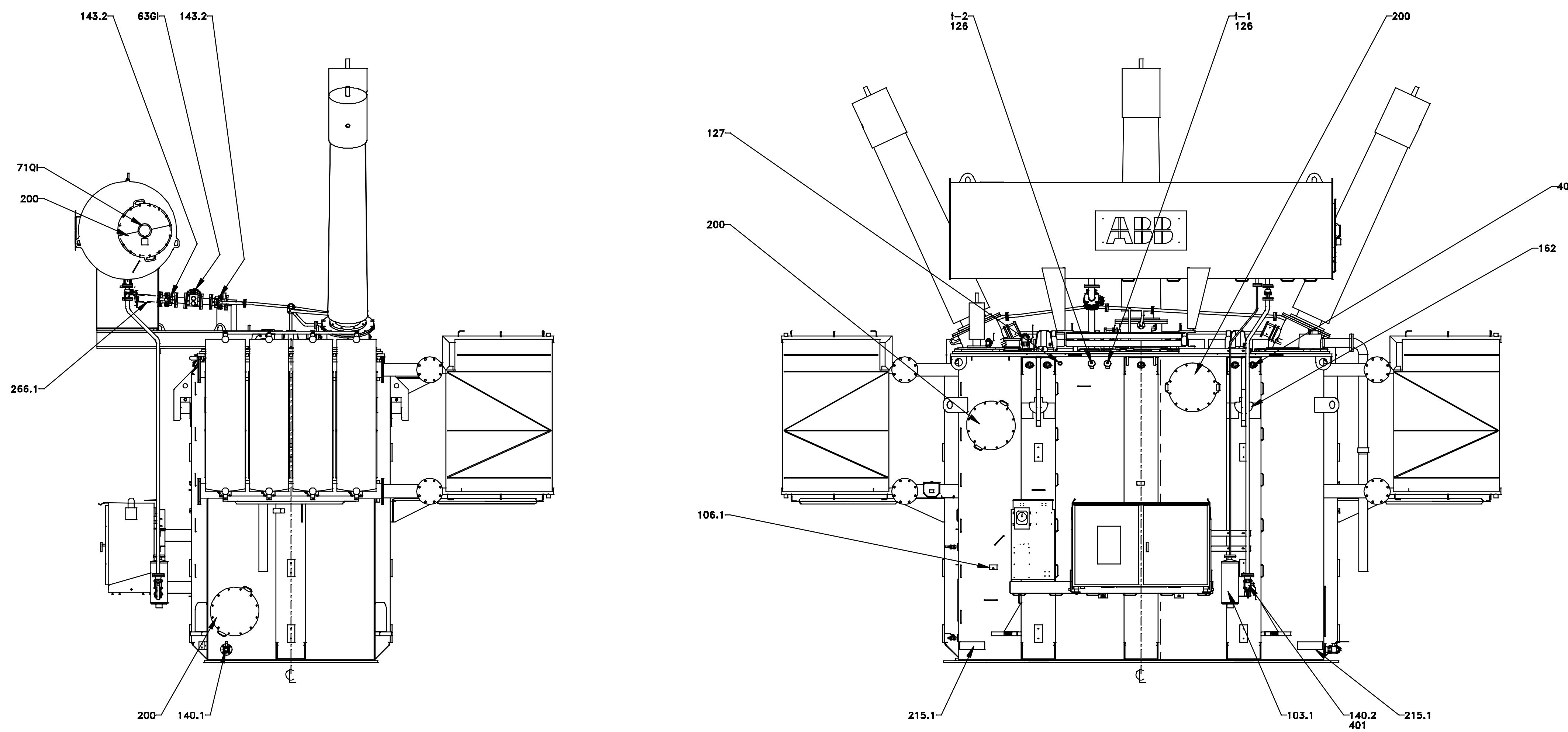
ENCOMBREMENT DÉTAILLÉ
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

RAPPORT 1:35
DIMENSIONS EN mm

FEUILLE SUIVANTE 03

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOR.
6403	40140	A000060	XV15079004-D	02	A	1

M. DRAPEAU (2009-03)



NO	NOTES

NO	DATE	RÉVISIONS	R. de T.	EMET.	HQ
A	2014/08/28	ITEMS 63GI, 71QI, ÉTAIENT 63GT, 71QT.		DSH/PGR	

NO	RÉFÉRENCES	NO

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ______________________ DATE : ____-__-__

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

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Signature ☐ Ingénieur ☐ Autre Date
Nom No de membre de l'OIQ

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Varennes, Québec
J3X 1S4

DESSINÉ	D. ST-HILAIRE	DATE	2014/05/21
VÉRIFIÉ	P. GAUTHIER	DATE	2014/05/21
APPROUVÉ	P. LAMOTHE	DATE	

POSTE DE L'OUTAOUAIS

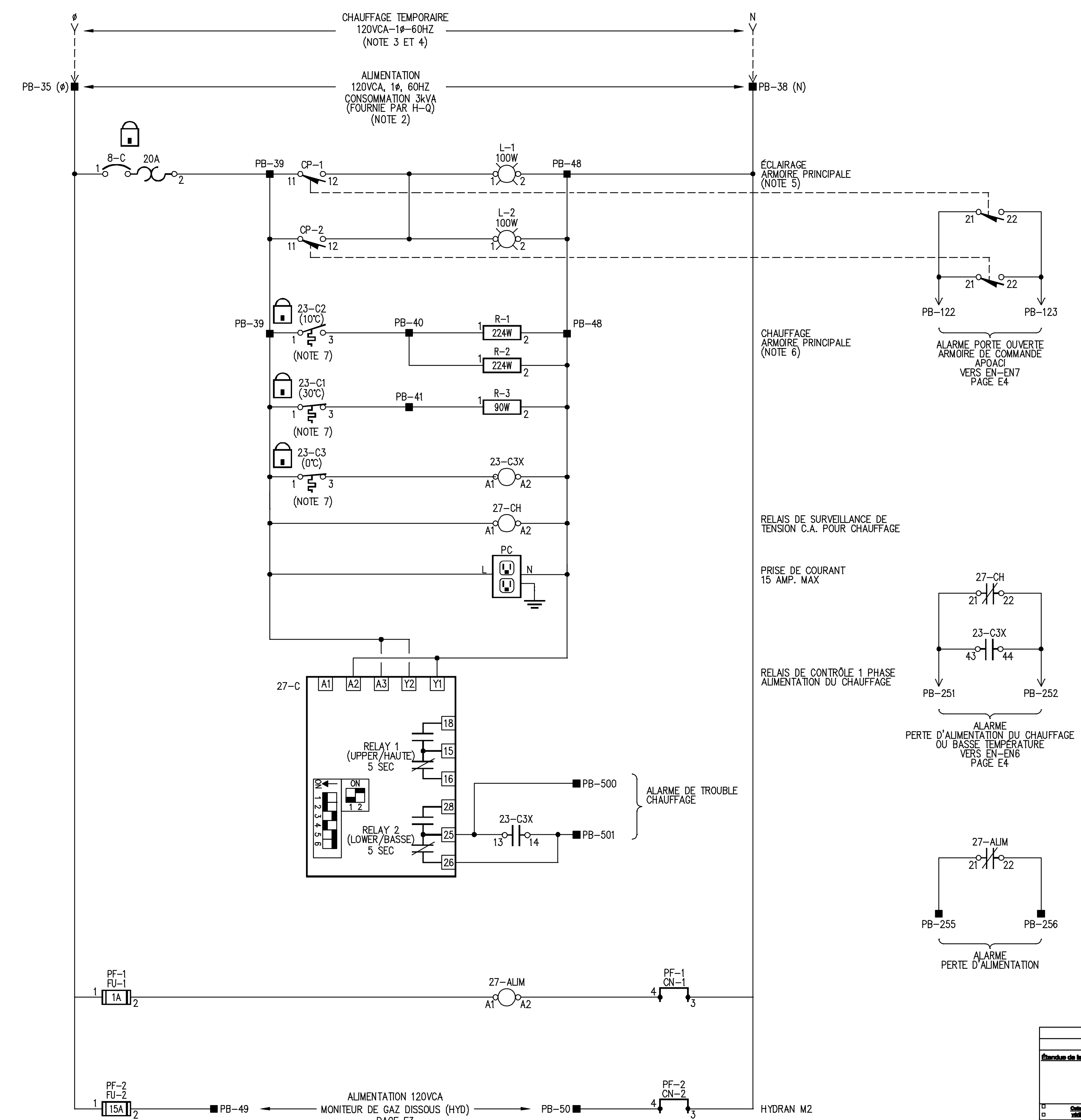
ENCOMBREMENT DÉTAILLÉ
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

RAPPORT 1:35
DIMENSIONS EN mm

FEUILLE SUIVANTE —

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOR.
6403	40140	A000060	XV15079004-D	03	A	1

M. DRAPEAU
(2009-03)



NO	NOTES
1	LE CIRCUIT EST MONTRÉ EN POSITION NON-ÉNERGISÉ ET LES COMMUTATEURS
	EN POSITION HORS CIRCUIT
2	HYDRO-QUÉBEC EST RESPONSABLE DE PROTÉGER ADÉQUATEMENT L'ENTRÉE
	ÉLECTRIQUE DE L'ARMOIRE
3	ENLEVER LE CORDON DE CHAUFFAGE TEMPORAIRE LORS DE LA MISE EN SERVICE DE
	L'INDUCTANCE
4	LE CHAUFFAGE TEMPORAIRE EST REQUIS POUR ÉVITER LA CONDENSATION LORS DE
	L'ENTREPOSAGE
5	LES INTERRUPTEURS DE PORTE SONT MONTRÉS LES PORTES FERMÉES
6	LA PUISSANCE DES ÉLÉMENTS 250W/127V EST DE 224W LORSQU'ILS SONT ALIMENTÉS À 120V
	ET LA PUISSANCE DE L'ÉLÉMENT 100W/127V EST DE 90W LORSQU'IL EST ALIMENTÉ À 120V
7	LES THERMOSTATS SONT MONTRÉS EN CONDITION NORMAL, SOIT 15°C À L'INTÉRIEURE

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
A	2014-05-16	AJOUT NUMÉRO CONTRAT H-Q / ABB		A. DA.	

NO	RÉFÉRENCES	NO
4	SCHÉMA DE CÂBLAGE	XV15079004-G
3	LISTE DE MATÉRIEL	XV15079004-E04
2	SCHÉMA DE FILERIE	XV15079004-BS
1	PLAN DE L'ARMOIRE DE COMMANDE	XV15079004-BR

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
ABB / NOMOS	15079 / 5108289	4500601577	2014/03/14
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ____ DATE : ____

SCEAUX

ABB Inc.
1600 Boul. Lionel-Boulet
Varennes, Québec
J3X 1S4

NOMOS
1480, rue Provinciale
Québec (Québec)
G1N 4A2

DESSINÉ	A. DALLEAU	DATE	2014/04/17
VÉRIFIÉ	J. CARTIER	DATE	2014/04/18
APPROUVÉ	N. BLAIS Ing.	DATE	

POSTE DE L'OUTAOUAIS

SCHÉMA DE PRINCIPE - AUXILIARES ET CIRCUIT DE PROTECTION 125VCC

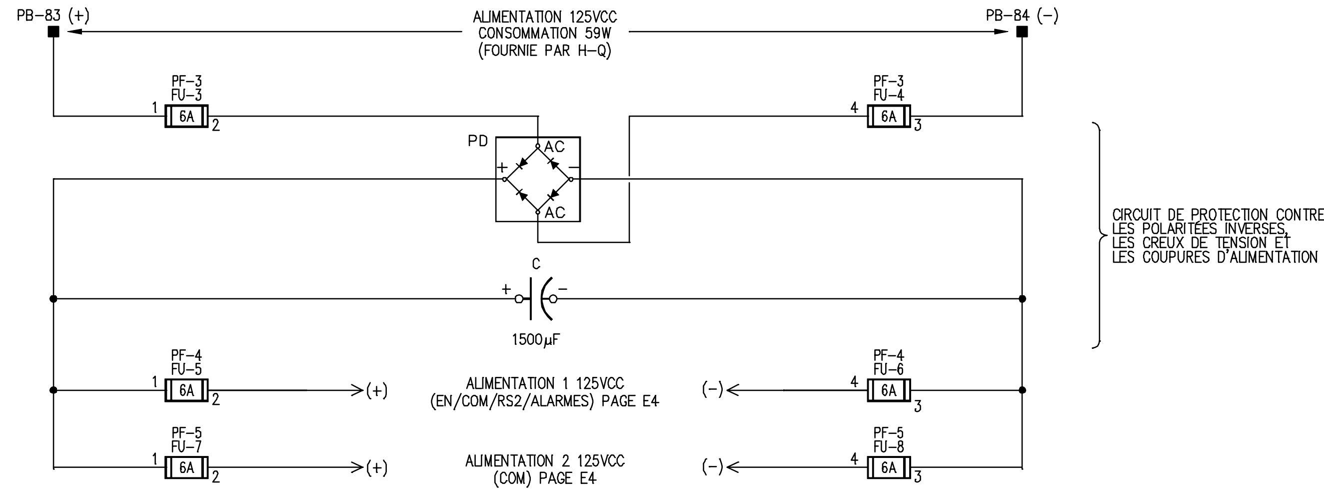
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

ÉCHELLE 0 RAPPORT 1:
DIMENSIONS EN mm

FEUILLE SUIVANTE 02

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOL.
6403	40140	A000060	XV15079004-E	01	A	1

M. DRAPEAU (2009-05)



NO	NOTES
1	LE CIRCUIT EST MONTRÉ EN POSITION NON-ÉNERGISÉ ET LES COMMUTATEURS EN POSITION HORS CIRCUIT
2	HYDRO-QUÉBEC EST RESPONSABLE DE PROTÉGER ADÉQUATEMENT L'ENTRÉE ÉLECTRIQUE DE L'ARMOIRE
3	ENLEVER LE CORDON DE CHAUFFAGE TEMPORAIRE LORS DE LA MISE EN SERVICE DE L'INDUCTANCE
4	LE CHAUFFAGE TEMPORAIRE EST REQUIS POUR ÉVITER LA CONDENSATION LORS DE L'ENTREPOSAGE
5	LES INTERRUPTEURS DE PORTE SONT MONTRÉS LES PORTES FERMÉES
6	LA PUISSANCE DES ÉLÉMENTS 250W/127V EST DE 224W LORSQU'ILS SONT ALIMENTÉS À 120V ET LA PUISSANCE DE L'ÉLÉMENT 100W/127V EST DE 90W LORSQU'IL EST ALIMENTÉ À 120V
7	LES THERMOSTATS SONT MONTRÉS EN CONDITION NORMAL, SOIT 15°C À L'INTÉRIEURE

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
A	2014-05-16	AJOUT NUMÉRO CONTRAT H-Q / ABB		A. DA.	

NO	RÉFÉRENCES	NO
4	SCHÉMA DE CÂBLAGE	XV15079004-G
3	LISTE DE MATÉRIEL	XV15079004-E04
2	SCHÉMA DE FILERIE	XV15079004-BS
1	PLAN DE L'ARMOIRE DE COMMANDE	XV15079004-BR

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
ABB / NOMOS	15079 / 5108289	4500601577	2014/03/14
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ____________ DATE : ____ __ __

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

ABB Inc.
1600 Boul. Lionel-Boulet
Varennes, Québec
J3X 1S4

NOMOS
1480, rue Provinciale
Québec (Québec)
G1N 4A2

DESSINÉ	A. DALLEAU	DATE	2014/04/17
VÉRIFIÉ	J. CARTIER	DATE	2014/04/18
APPROUVÉ	N. BLAIS ing.	DATE	

POSTE DE L'OUTAOUAIS

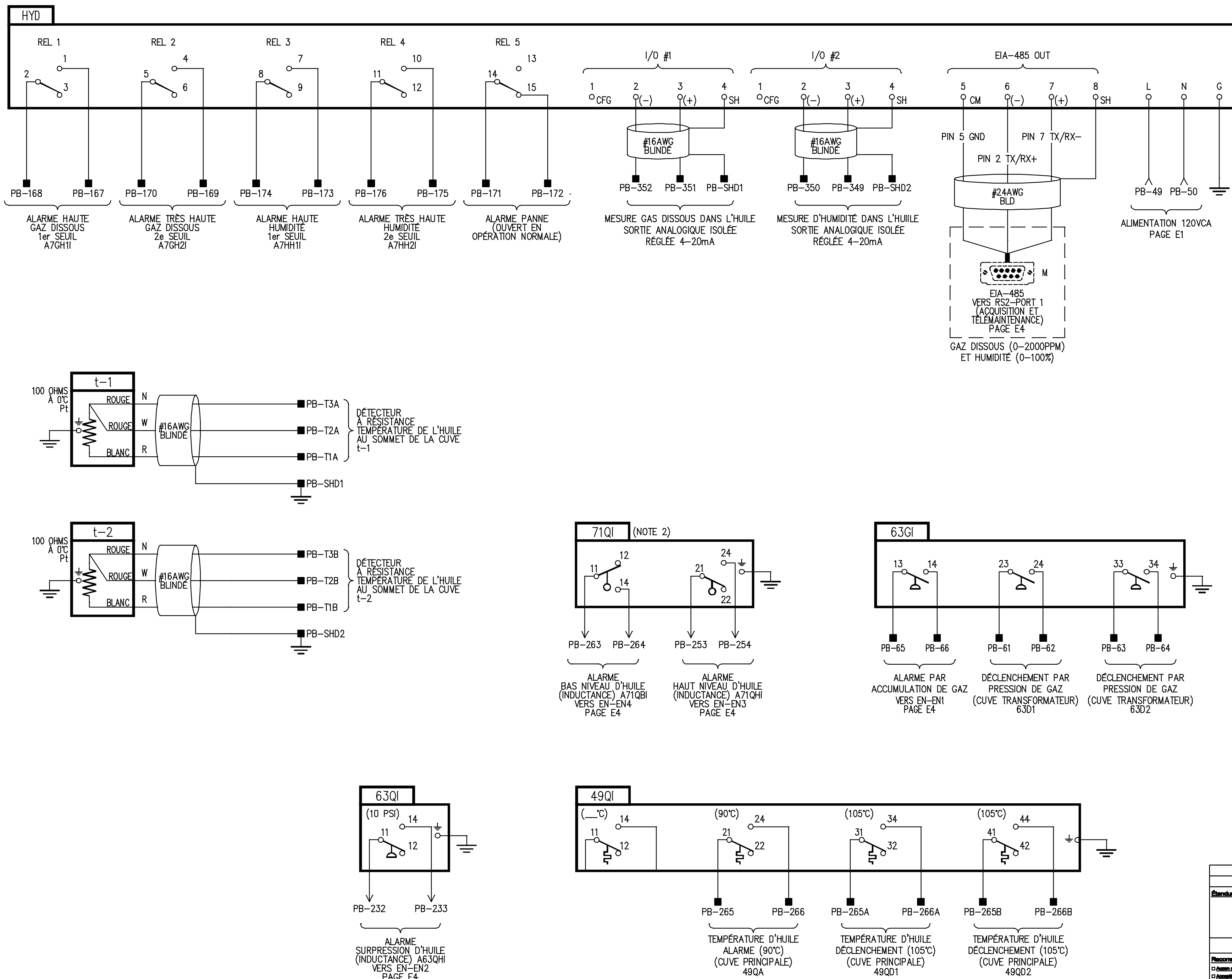
SCHÉMA DE PRINCIPE - AUXILIARES ET CIRCUIT DE PROTECTION 125VCC
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

ÉCHELLE 0 RAPPORT 1:
DIMENSIONS EN mm

FEUILLE SUIVANTE 03

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOL.
6403	40140	A000060	XV15079004-E	02	A	1

M. DRAPEAU (2009-05)



NO	NOTES
1	LE CIRCUIT EST MONTRÉ EN POSITION DÉSALIMENTÉ ET LES COMMUTATEURS EN POSITION HORS-CIRCUIT
2	LE DÉTECTEUR DE NIVEAU D'HUILE 71QI EST REPRÉSENTÉ EN NIVEAU NORMAL D'OPÉRATION

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
A	2014-05-16	AJOUT NUMÉRO CONTRAT H-Q / ABB		A. DA.	

NO	RÉFÉRENCES	NO
4	SCHÉMA DE CÂBLAGE	XV15079004-G
3	LISTE DE MATÉRIEL	XV15079004-E04
2	SCHÉMA DE FILERIE	XV15079004-BS
1	PLAN DE L'ARMOIRE DE COMMANDE	XV15079004-BR

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
ABB / NOMOS	15079 / 5108289	4500601577	2014/03/14
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ______ DATE : ____ __ __

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification

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Recommandation
☐ Aucun commentaire
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☐ Corriger et resoumettre avant les travaux
☐ Refusé

Signature ☐ Ingénieur ☐ Autre Date
Nom No de membre de l'OIQ

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Varennes, Québec
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NOMOS
1480, rue Provinciale
Québec (Québec)
G1N 4A2

DESSINÉ	A. DALLEAU	DATE	2014/04/17
VÉRIFIÉ	J. CARTIER	DATE	2014/04/18
APPROUVÉ	N. BLAIS ing.	DATE	

POSTE DE L'OUTAOUAIS

SCHÉMA DE PRINCIPE - INSTRUMENTS

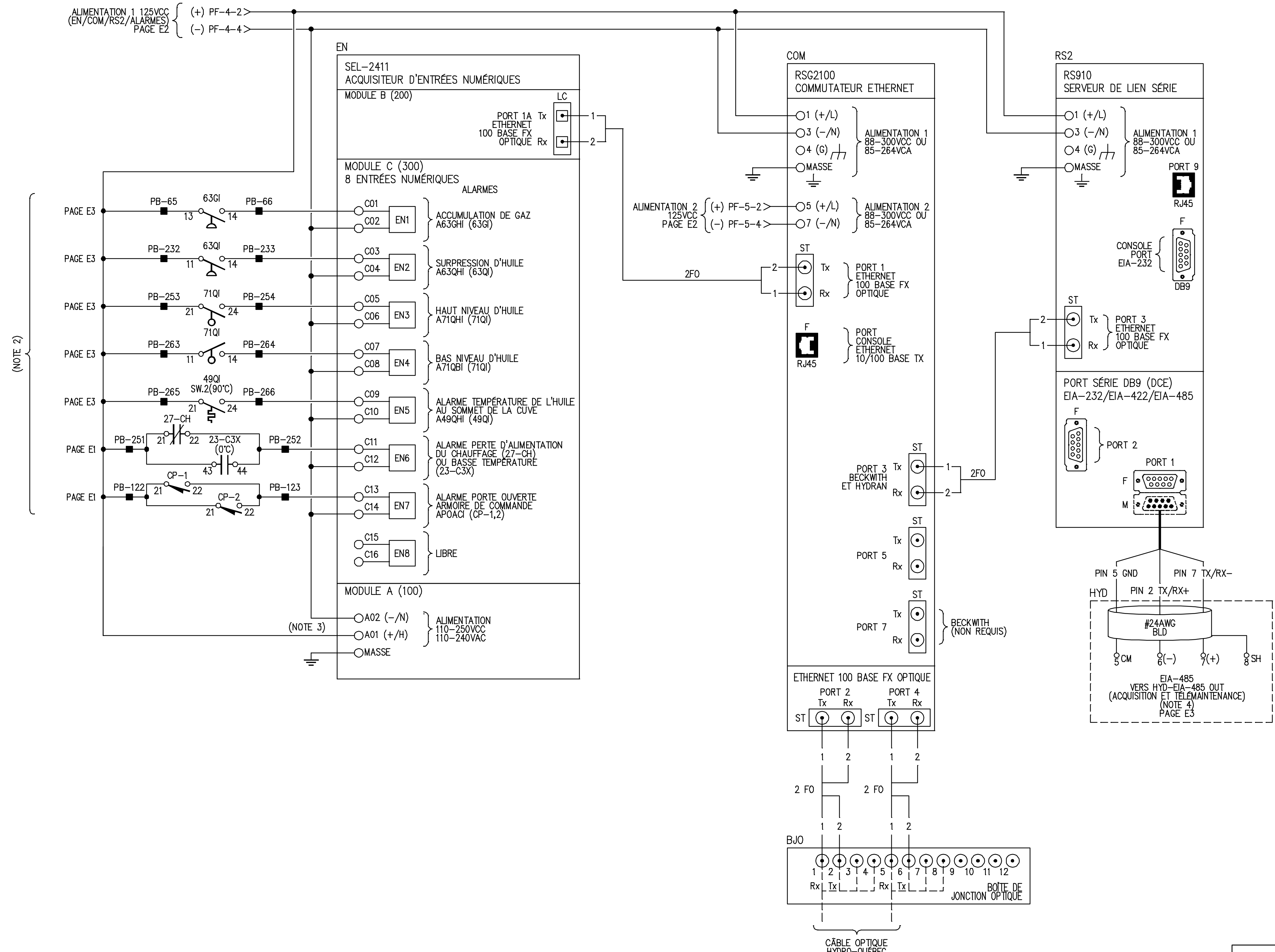
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

ÉCHELLE 0 RAPPORT 1: DIMENSIONS EN mm

FEUILLE SUIVANTE 04

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOL.
6403	40140	A000060	XV15079004-E	03	A	1

M. DRAPEAU (2008-03)



NO	NOTES
1	LE CIRCUIT EST MONTRÉ EN POSITION DÉSALIMENTÉ ET LES COMMUTATEURS EN POSITION
	HORS-CIRCUIT
2	VOIR LES SCHÉMAS DE FILERIE POUR LA NUMÉROTATION DES ENTRÉES NUMÉRIQUES
3	L'ALIMENTATION DE EN (SEL-2411) EST À LA FIN DE LA BOUCLE (+) ET (-) DES ALARMES
4	LA POLARITÉ DE HYDRAN EST INVERSÉE

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
A	2014-05-16	AJOUT NUMÉRO CONTRAT H-Q / ABB		A. DA.	

NO	RÉFÉRENCES	NO
4	SCHÉMA DE CÂBLAGE	XV15079004-G
3	LISTE DE MATÉRIEL	XV15079004-E04
2	SCHÉMA DE FILERIE	XV15079004-BS
1	PLAN DE L'ARMOIRE DE COMMANDE	XV15079004-BR

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
ABB / NOMOS	15079 / 5108289	4500601577	2014/03/14
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ____ DATE : ____

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification
Recommandation
Signature
Nom

ABB Inc.
1600 Boul. Lionel-Boulet
Varennes, Québec
J3X 1S4

NOMOS
1460, rue Provinciale
Québec (Québec)
G1N 4A2

DESSINÉ	A. DALLEAU	DATE	2014/04/17
VÉRIFIÉ	J. CARTIER	DATE	2014/04/18
APPROUVÉ	N. BLAIS ing.	DATE	

POSTE DE L'OUTAOUAIS

SCHÉMA DE PRINCIPE - SYSTEME DE COMMUNICATION

INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

ÉCHELLE 0
RAPPORT 1:
DIMENSIONS EN mm

FEUILLE SUIVANTE 05

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	RÉV.	FOL.
6403	40140	A000060	XV15079004-E	04	A	1

M. DRAPEAU (2009-05)

MATÉRIEL ARMOIRE DE COMMANDE

ID	DESCRIPTION	NUMÉRO	MANUFACTURIER	NOTES
8-C	DISJONCTEUR 1 PÔLE 20A 120V 10kA RMS ADAPTATEUR DE CADENASSAGE POUR DISJONCTEUR	S201-K20 SA1-E	ABB ABB	
23-C1,C2,C3	THERMOSTAT DE CHAUFFAGE -35 À +45°C CONTACT FORME C BOÎTIER CADENASSABLE POUR THERMOSTAT JOHNSON	A19-BBC-4C F29-0143	JOHNSON WHITE-ROGERS	
23-C3X	RELAIS AUXILIAIRE 2NO/2NF BOBINE 120V	NF22E-13	ABB	
27-ALIM	RELAIS AUXILIAIRE 2NO/2NF BOBINE 120V	NF22E-13	ABB	
27-C	RELAIS DE CONTRÔLE 1 PHASE BASSE TENSION	DUC 01 D B23 500V	CARLO-GAVAZZI	
27-CH	RELAIS AUXILIAIRE 2NO/2NF BOBINE 120V	NF22E-13	ABB	
82	BOÎTIER NEMA 3R 1100H X 1800L X 610P VERT ISOLÉ + SURFACE PROTECTRICE			
91	BARRE DE MISE À LA TERRE			
C	CONDENSATEUR 450V 1500µF SOCLE DE FIXATION	DCMC152T450BC2B 125565-09	CDE CORNELL DUBLIER CDE CORNELL DUBLIER	
CN-1,2	CARTOUCHE DE NEUTRE	NTN-R-30	BUSSMANN	
CP-1,2	INTERRUPTEUR DE PORTE 2NF	LS35P51B02	ABB	
FU-1	FUSIBLE CLASSE RK1 250V 1A	A2D1R	FERRAZ SHAWMUT	
FU-2	FUSIBLE CLASSE RK1 250V 15A	A2D15R	FERRAZ SHAWMUT	
FU-3,4,5,6,7,8	FUSIBLE CLASSE RK1 250V 6A	A2D6R	FERRAZ SHAWMUT	
L-1,2	SOCLE D'ÉCLAIRAGE 100W 120V AMPOULE 100W 120V	VAKS100CG 100ARSVSBR120130V	RAB PHILIPS	
BJO	BOÎTE DE JONCTION OPTIQUE CONNECTEUR DE FIBRE OPTIQUE MULTI MODE TYPE ST (12X)	SPH-01P CCH-CP12-19T	CORNING CABLE CORNING CABLE	
COM	COMMUTATEUR ETHERNET (6 PORTS OPTIQUES)	RSG2100-B-DP-HI-HI-FX01-FX01-FX01- XXXX-XXXXX-XXXX-XXXX-XXXX-XXXX-XXXX-XX	SIEMENS	
EN	ACQUISITEUR D'ENTRÉES NUMÉRIQUES (28 ENTRÉES ET 4 SORTIES NUMÉRIQUES)	241101A3A3A3A1A0430	SCHWEITZER	
PB	BLOC DE JONCTION 70A 600V (M10/10.1) SÉPARATEUR (SCF6) FIN DE SECTION (FEM6) SÉPARATEUR (SCFM6) COUVERCLE DE PROTECTION (CPM)	11526120 11870703 11836816 11482505 18731214	ABB ABB ABB ABB ABB	
PC	PRISE DE COURANT 15A 120V PROTECTION DE FUITE À LA TERRE COUVERCLE ÉTANCHE EN ALUMINIUM	GFR5262WTR 4992	HUBBELL LEVITON	
PD	PONT DE DIODE 1000VDC 35A	MB3510	DIVERS	
PF-1,2,3,4,5	PORTE FUSIBLE 250V 30A 2 PÔLE COUVERCLE POUR PORTE-FUSIBLE 250V 30A	R30A2ST-HQ (2X) CHR230	MARATHON MARATHON	
R-1,2	ÉLÉMENT CHAUFFANT 250W 127V	F050410	OHS	
R-3	ÉLÉMENT CHAUFFANT 100W 127V	F054886	OHS	
RS2	SERVEUR DE LIENS SÉRIE	RS910-HI-D-S1-FX01-TX-XX	SIEMENS	

MATÉRIEL INDUCTANCE

ID	DESCRIPTION	NUMÉRO	MANUFACTURIER	NOTES
49QI	INDICATEUR DE TEMPÉRATURE DE L'HUILE	AKM345-00220106 CS-44052	QUALITROL	
63GI	RELAIS DE GAZ, TYPE BUCHHOLZ	BF80/10-2-K	EMB	
63QI	RELAIS DE SURPRESSION + DÉFLECTEUR	LPRD00-00007345 + SLD000-00030028	QUALITROL	
71QI	INDICATEUR DE NIVEAU D'HUILE	032-302-01 CS-41616	QUALITROL	
303.1,2,3,4	BOITE DE JONCTION POUR TRANSFORMATEURS DE COURANT			
HYD	TRANSMETTEUR DE GAZ DISSOUS ET D'HUMIDITÉ	HYDRAN M2	GENERALE ELECTRIQUE DU CANADA	
t-1,2	DÉTECTEUR DE TEMPÉRATURE À RÉSISTANCE 100 OHMS Pt	RA11-D100A3-007.0-YB1.5-U0-SP-TW	THERMO-KINETICS	

NO	NOTES

NO	DATE	RÉVISIONS	R. de T.	ÉMET.	HQ
A	2014-05-16	AJOUT NUMÉRO CONTRAT H-Q / ABB		A. DA.	

NO	RÉFÉRENCES	NO
4	SCHÉMA DE CÂBLAGE	XV15079004-G
3	SHÉMA DE PRINCIPE	XV15079004-E
2	SCHÉMA DE FILERIE	XV15079004-BS
1	PLAN DE L'ARMOIRE DE COMMANDE	XV15079004-BR

SOCIÉTÉ / FOURNISSEURS	No DE RÉF. INTERNE	No DU CONTRAT	DATE
ABB / NOMOS	15079 / 5108289	4500601577	2014/03/14
HYDRO-QUÉBEC / ABB	QPCAJ / 15079	4510181832	2014/01/16

CE DOCUMENT EST CONFORME : ☐ AU MATÉRIEL FOURNI ☐ AU MATÉRIEL INSTALLÉ
FOURNISSEUR : ____ DATE : ____

SCEAUX

Nom de l'entreprise
Vérification de conformité
Étendue de la vérification
Recommandation

ABB Inc.
1600 Boul. Lionel-Boulet
Varennes, Québec
J3X 1S4

NOMOS
1480, rue Provinciale
Québec (Québec)
G1N 4A2

DESSINÉ A. DALLEAU DATE 2014/04/17
VÉRIFIÉ J. CARTIER DATE 2014/04/18
APPROUVÉ N. BLAIS ing. DATE

POSTE DE L'OUTAOUAIS

SCHÉMA DE PRINCIPE - LISTE DE MATÉRIEL
INDUCTANCE TRIPHASÉ 140 Mvar
315 kV
No DE SÉRIE 15079-01
POSITION XL73

ÉCHELLE 0 RAPPORT 1:
DIMENSIONS EN mm

INSTALLATION	CLASSE	CODE D'ÉMETTEUR	No DU DESSIN DU FOURNISSEUR	FEUILLE	REV.	FOL.
6403	40140	A000060	XV15079004-E	05	A	1

M. DRAPEAU (2009-09)

newfoundland labrador hydro
a nalcor energy company

TECHNICAL NOTE

LABRADOR ISLAND LINK (LIL) HVDC MONOPOLE TRANSFER LIMITS – OPERATION PRIOR TO AVAILABILITY OF MFA GENERATION (MFAGS)

INTRODUCTION

The purpose of this technical note is to provide guidance with respect to the operation of a single pole of the Labrador Island HVdc Link (LIL) prior to the completion of the first hydro unit at the Muskrat Falls (MFA) generating facility under winter loading conditions with no high inertia synchronous condensers at Soldiers Pond (SOP). The results of this power system study provide operating restrictions and determine the maximum firm and non-firm power order limitations for all system loading conditions between December 2017 and March 2018. For the purposes of this study the 1021 and 1033 PSS®E base cases were used as a starting point due to the LIL monopole configuration. These cases represent the 2017 winter peak and intermediate loading scenarios for the Island and Labrador Interconnected Systems.

It is anticipated that the first pole (Pole 1) of the LIL HVdc could go into operation as early as December of 2017 with the intent to bring power and energy to the Island Interconnected System and offset fuel burn at the Holyrood Thermal Generating Station. In an effort to obtain first power over the LIL for this upcoming winter, there has been a requirement to minimize scope. In essence, this results in the requirement to commission a minimum amount of equipment to achieve the schedule and fuel savings benefits while ensuring reliable system operation through the winter.

Due to delays with the CD0534 package the high inertia synchronous condensers (HISC) to be installed at Soldiers Pond (SOPSC) are not expected to be commissioned until March of 2018. In addition, the electrode sites at L'anse-au-Diable (Labrador) and Dowden's Point (Island) are not expected to be ready for operation this winter. This would force the HVdc into a metallic return monopole configuration which will utilize the Pole 2 high voltage overhead line (OHL) conductor as a return path rather than the electrode lines. To further reduce complexity and reduce construction time, it has been determined that the transition compounds at Forteau and Shoal Cove will not be fully commissioned. In particular the high speed switching equipment required for the 2.0 pu monopole overload for ten minutes will not be completed for first power. The minimum requirement for LIL operation is a single subsea cable per HVdc OHL which would result in the connection of Cable 1 (CBL1-North) and Cable 2 (CBL2-South) to Pole 1 and Pole 2 OHLs respectively. Operation of the LIL monopole in metallic return without the support of the HISCs has implications on the Island Interconnected System. This study will determine the impact of delaying the installation of the HISCs at SOPSC until late February, early March 2018.

newfoundland labrador hydro
a nalcor energy company

TECHNICAL NOTE

HISTORY

Due to schedule delays with construction of the Muskrat Falls Generating Station (MFAGS), it is expected that the Labrador Transmission Assets (LTA), Muskrat Falls Terminal Station (MFATS2), LIL HVdc, Soldiers Pond Terminal Station (SOPTS) and Converter Station (SOPCS) will be available prior to first power at MFAGS. As a result, there is corporate incentive to operate the LIL and import power and energy from Labrador to the Island of Newfoundland to offset generation at the Holyrood Thermal Generating Station. The strategy is to replace more expensive energy generated from oil with low cost hydroelectric energy from the Churchill Falls Hydroelectric Generating Facility.

LTA 315 kV SYSTEM OVERVOLTAGES

Power system studies were completed by the Ready for Integration (RFI) section of the Transition to Operations (TTO) Department to determine if the LIL could operate at a low power transfer prior to commissioning of the first unit at MFAGS without exceeding ac system voltage criteria. Early load flow and switching studies identified the need for a 140 MVAR, 315 kV shunt reactor to eliminate overvoltages on the MFA 315 kV bus following switching of the HVdc filter banks prior to deblock of the converter. The CD0501 project team have placed a Purchase Order (PO) for a 150 MVAR, 315 kV, three-phase, oil filled ABB unit to be installed prior to operation of the LIL HVdc link[1]. The reactor is required to be in service until a minimum of two MFA generators have been commissioned. At that point, the reactor is no longer required for LIL operation. However, it will remain a project asset and be available for use in the event of a long-term plant outage.

FIRM POWER TRANSFERS ON THE LIL PRIOR TO MUSKRAT FALLS GENERATION

RFI completed a power system study to determine the maximum firm transfer limit on the LIL Bipole HVdc scheme prior to commissioning of generation at MFAGS. It was determined that with the installation of a 150 MVAR shunt reactor at MFATS2, a maximum of 220 MW could be transferred from MFACS to SOPCS. The defining contingency was a loss of a single 315 kV transmission line (L3101 or L3102) between CHFTS2 and MFATS2. Power transfers above 220 MW would result in an unacceptably low 315 kV voltage at MFATS2 (below 0.90 pu or 283.5 kV). Therefore, it was determined that the LIL shall be limited to a maximum power order of 220 MW at MFACS until the first unit at MFAGS is commissioned.

[1] The 150 MVAR 315 kV shunt reactor is a standard size used by Hydro-Québec and acceptable for the LTA application.

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TECHNICAL NOTE

NEWFOUNDLAND HYDRO (NLH)/NEWFOUNDLAND POWER (NP) UNDER-FREQUENCY LOAD SHEDDING

NLH and NP utilize an under-frequency load shedding scheme (UFLS) which is designed to trip blocks of customer load in the event demand exceeds supply. Under-frequency protection is extremely important on small isolated ac power systems due to the capacity and limited system inertia provided by generators on the system.

NLH system operators follow a Maximum Unit Loading Guideline which determines the maximum output from an online generator for a specified power system load. In effect, the guideline helps operators schedule the appropriate inertia on the system such that loss of the largest machine does not exceed reliability parameters. NLH System Operators monitor and limit the maximum output of generators on the system to ensure that loss of the largest supply contingency does not result in excessive customer load loss and operation of the 58 Hz load shedding block. For example, for *NLH System Generation* equal to 700 MW a maximum of 150 MW of generation/supply can be lost and stay within the UFLS guidelines. The maximum generator output is further reduced to 110 MW for light system loads during the summer months. This would be relevant for *NLH System Generation* of around 500 MW as shown in Figure 1.

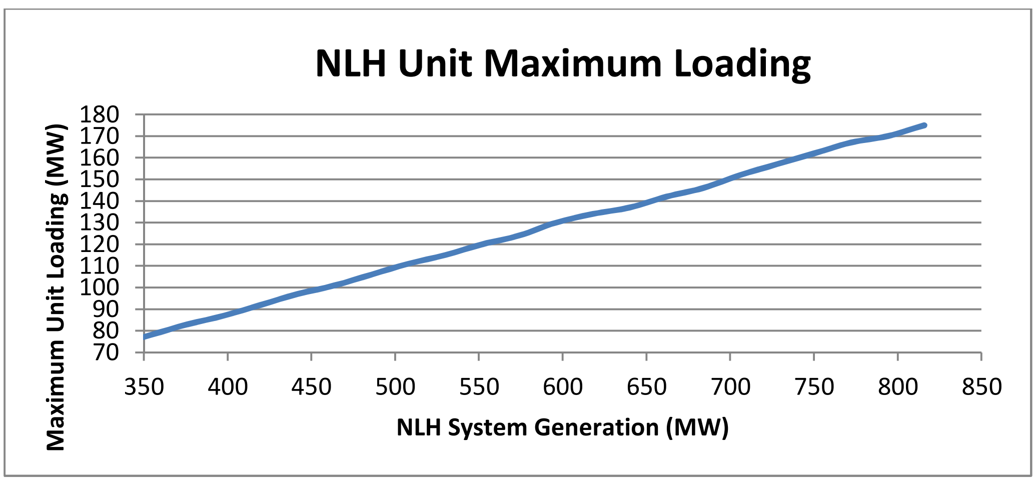

Figure 1: NLH Unit Maximum Loading Guideline (Isolated Island)

During the winter months over peak the *NLH System Generation* is in excess of 816 MW, however there are no restrictions on NLH's existing fleet of generating units as the largest unit and single contingency supply loss is 175 MW. Operating restrictions for the loss of larger blocks of supply have not been studied to date. NLH will complete power system studies later in 2017 to identify larger supply contingency losses of up to the new single supply contingencies.

Today, with typical operational dispatch and spinning reserves the Island Interconnected System can withstand the loss of approximately 60 MW of generation over peak without triggering UFLS. In the

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TECHNICAL NOTE

summer months at lower system loads, that value is reduced to roughly 40 MW. During the summer less generation is required to meet the customer load, therefore machines are removed from service resulting in lower system inertia.

NLH SPINNING RESERVE CRITERIA

NLH System Operators monitor generator dispatch levels and ensure that there is sufficient spinning reserve to cover the loss of the largest generation/supply contingency plus an additional 70 MW. For example, if HRP unit G1 is online for 170 MW of generation, operators would ensure at a minimum that 240 MW of spinning reserve is online to improve customer restoration time.

SOLDIERS POND HIGH INERTIA SYNCHRONOUS CONDENSERS

The requirement for HISCs was determined by NLH System Planning early during the design phase of the Lower Churchill Project. Due to the relative size of the Island Interconnected System load (1800 MW) and the LIL HVdc rated power (900 MW), tripping of the bipole would lead to a large rate of frequency decay on the Island Interconnected System.

Today, the largest generators on the Island Interconnected System are Units G1 and G2 at Holyrood with a maximum continuous rating of 170 MW. The next largest loss of supply is a trip of unit G7 at Bay d'Espoir (BDE), which has a maximum continuous rating of 154 MW. It should also be noted that BDE units G1/G2, G3/G4 and G5/G6 are connected to common 230 kV buses B1, B2 and B3 respectively which can trip up to two 75 MW units for a loss of 150 MW of supply.

Today, the Island Interconnected System will experience under-frequency load shedding for any of the above contingencies. The Soldiers Pond Synchronous Condensers (SOPSC) were specified to ensure the Island Interconnected System could withstand the loss of a single pole on the LIL HVdc scheme or a temporary bipole fault of 900 MW. Many factors including the frequency response of the Island Interconnected System and the bus voltages at SOPTS were reviewed to ensure they met NLH System Planning criteria. One of the criterion involved the acceptable performance of the HVdc scheme with respect to commutation failures. It was determined that following a fault, the HVdc would experience successive commutation failure once the fault was removed, which was contrary to the criteria. It became clear that voltage recovery at the SOP 230 kV bus was important to the performance of the LIL.

The final SOPSC specification was determined assuming an inertia constant of 7.84 MWs/MVA per machine with a minimum of two machines in service assuming one out of service for maintenance. The capacity was determined by assuming the shutdown of Holyrood (HRP) Units G1 and G2 with G3 converted permanently to a synchronous condenser and a new combustion turbine installed at HRP with synchronous condenser capability. The final design was the installation of three (3) 175 MVAR units to meet all system performance criteria.

TECHNICAL NOTE

The HISCs at SOP have three (3) main functions to support the Island Interconnected System following interconnection of the Labrador Island Link HVdc:

1. Provide ac system inertia – 7.84 MWs/MVA per machine or 1372 MWs
    a. HRP G1 and G2 have an inertia of 1.182 MWs/MVA or 196 MWs
    b. BDP G6 has an inertia of 5.24 MWs/MVA or 445MWs
    c. Hydro generators, due to the design of the rotor (low speed, more poles, large diameter) generally have higher inertia than thermal machines which operate at high speed, have fewer pole and smaller diameter rotors.
2. Provide voltage control at the SOP 230 kV bus for variations in system load, LIL power order, during fault recovery and filter switching events.
3. Strengthen the short circuit level at SOP – 613 MVA 3Φ per machine

Overall, the removal of the SOP HISCs from operation during the 2017/2018 winter will reduce the power system inertia, voltage control and short circuit level. It should be noted however, that the Holyrood Thermal Generating Station will remain in service during monopole operation and will aid in providing short circuit strength, voltage control and inertia. Eventually the LIL monopole operations could see both HRP Units G1 and G2 removed from service once NLH is comfortable with the operation and reliability of the HVdc link and there is sufficient reliable capacity on the power system.

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TECHNICAL NOTE

POWER SYSTEM STUDY ASSUMPTIONS

For the purpose of this study, the following assumptions have been made regarding the operation of the LIL and the ac power systems in Labrador and on the Island:

- The Muskrat Falls Hydroelectric Development (MFAGS) is unavailable
- All ac equipment is in service at Churchill Falls Terminal Station 2 (CHFTS2)
  - Six 315/735 kV single phase transformers (two 3Φ banks) are in service at CHFTS2
- All ac equipment is in service at Muskrat Falls Terminal Station 2 (MFATS2)
  - Two 315 kV transmission lines are in service between Churchill Falls and Muskrat Falls
  - Two 315/138/25 kV transformers in service at MFATS2 to provide station service
  - Happy Valley is supplied from CHF at 138 kV (L1301/L1302 are in service)
- It is assumed that the Labrador Island Link HVdc system (LIL) will switch in a minimum of two filters at MFACS and one filter at SOPCS before deblocking the monopole scheme.
  - Power orders up to 113 MW will require 2x72 MVAR (SOPCS) and 1x75 MVAR filter (SOPCS).
  - Power orders above 113 MW will require an additional 1x75 MVAR filter at SOPCS.
- The monopole scheme is operated in metallic return configuration as the electrode line and electrode grounding sites are unavailable (R_{dc}= 38.19 Ω)
- The cable switching stations at Forteau Point (FTPCABLE) and Shoal Cove (SOCCABLE) are unavailable with one submarine cable connected to each pole.
- The frequency controller is not available at SOP which will not allow the LIL to respond to frequency excursions for contingencies.
  - Frequency recovery relies strictly on hydroelectric and thermal machine governor systems and droop settings.[2]
- A 150 MVAR, 315 kV shunt reactor is installed on the MFA 315 kV bus for voltage control. It will remain in service at all times.
- The Muskrat Falls Terminal Station (MFATS) has two 72 MVAR rated harmonic filters installed
- The Soldiers Pond Terminal Station (SOPTS) has two 75 MVAR rated harmonic filters installed
- All three (3) 230 kV transmission lines (TL217, TL242 and TL201) have been re-terminated at SOPTS.
  - TL266 (SOP/HWD) will maintain old TL201 ratings
- The high inertia synchronous condensers (HISCs) are not available at Soldiers Pond (SOPTS).
- Holyrood (HRP) Units G1, G2 and G3 are available for generation (170/170/150)
- Holyrood (HRP) Combustion Turbine is available for generation (40-123.5 MW)
- 230 kV Transmission Line TL267 is in service between Bay d'Espoir (BDE) and Western Avalon

[2] Potential use of the Maritime Link once it is in service for frequency control will be reviewed separately and may enhance system reliability.

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Terminal Station (WAVTS)

- All ac work related to the Maritime Link has been completed
    - Transmission lines TL211 and TL233 re-terminated in new station (BBKTS2)
    - Transformers BBK T1 and BBKT3 re-terminated in new station (BBKTS2)
    - Transmission line TL263 between Upper Salmon (USL) and Granite Canal (GCL) has been re-terminated at Granite Canal Tap Terminal Station (GCTTS)
    - Transmission Line TL269 between GCTTS and BBKTS2 is in service
- The Maritime Link (ML) HVdc scheme between Bottom Brook and Woodbine is out of service and unavailable.
- NLH's existing under-frequency load shedding scheme (UFLS) will be used
    - The 58 Hz UFLS block of load shall not be shed
    - The 59 Hz UFLS 15 second block of load shall not be shed
    - Newfoundland Power's df/dt relays have been removed from service
- NLH spinning reserve criteria shall be equal to the loss of the largest generator or supply plus 70 MW.
- No consideration has been given to the limitations of recall power available at MFA.

In addition, the following NLH System Planning Criteria for dynamic stability analysis was used to determine adequate system performance for all operating modes:

- System response shall be stable and well damped following a disturbance;
    - System disturbances include:
        - Three phase faults except a three phase fault on the Bay d'Espoir 230 kV bus with tripping of a 230 kV transmission line;
        - Loss of the largest generator on line on the Island System with and without fault;
        - Permanent pole fault; and
- Post fault recovery voltages on the ac system shall be as follows:
    - Transient under voltages following fault clearing should not drop below 70%;
    - The duration of the voltage below 80% following fault clearing should not exceed 20 cycles;
- There shall be no commutation failures of the HVdc link during post fault recovery for ac system faults.

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TECHNICAL NOTE

POWER SYSTEM STUDY

The operational study completed in this report provides insight into the frequency response of the Island Interconnected System for loss of supply of the LIL monopole and large generators without the support of HISCs at SOPSC. The overlying principle during this study is to ensure stable operation following disturbances of the NLH's ac system, acceptable fault recovery and to ensure limits of the UFLS scheme are not exceeded.

The analysis was completed using PSS®E Base Cases 1021 and 1033, which were provided to GE Grid for use in their system studies for the LIL HVdc system. Base case 1021 was chosen as it simulates a heavily loaded power system during the winter peak. Base case 1033 was chosen to study the impact of an intermediate loaded (Spring/Fall) power system in which case there is less system inertia. These two cases were modified from their original bases cases to permit 220 MW of power on the LIL in a monopolar metallic return configuration. In addition the SOP HISCs and ML were removed from service. The resultant cases MP-WP1 and MP-IN1 are shown in Table 1 and cover all operating conditions from December 2017 to March 2018.

Table 1: Original and Modified 1011 and 1033 Base Case Dispatches

Case	LIL Power Order (MW)	LIL Config.	Filters		SOP HISCs	HRP Generation (MW)					HWD CT (MW)	PRV (MW)	BDE Generation (MW)				USL (MW)	GCL (MW)	SVL CT (MW)	HLK (MW)	CAT (MW)		ML Power Order (MW)
			MFA	SOP		CT	G1	G2	G3	TOTAL			G1	G2-G6	G7	TOTAL					G1	G2	
1011	900	BP ER	4	5	2	OFFLINE	OFFLINE	OFFLINE	SC	0	SC	8.0	59.4	299.0	135.0	493.4	75.0	23.0	SC	65.0	35	35	158
MP-WP1	220	MP MR	2	2	0	40	100	100	100	340	10	8.0	64.6	325.0	154.0	543.6	84.0	40.0	10.0	75.0	67	67	OFFLINE
1033	300	MP ER	3	3	2	SC	OFFLINE	OFFLINE	SC	0	SC	8.0	75.3	379.5	154.0	608.8	84.0	40.0	SC	75.0	63.5	63.5	160
MP-IN3	220	MP MR	2	2	0	OFFLINE	70	70	SC	140	SC	8.0	55.3	278.2	135.0	468.4	73.0	23.0	SC	67.0	35	35	OFFLINE

For the purposes of this power system study, base cases MP-WP1 and MP-IN1 were analyzed in PSS®E using dynamic stability study methods. All simulations were completed using Siemens PTI PSS®E version 32.

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Short Circuit Strength (SCL) – MFATS2/SOPTS

The modified base cases without operation of the HISCs at SOPSC and the use of Holyrood thermal generation had an impact on the short circuit level experienced at SOPTS. Table 2 outlines the resultant three-phase short circuit levels at SOP and MFA given the new generation dispatch. These values can be compared to the CD0501 contract values given to GE Grid for the HVdc design in Table 3.

Table 2: Modified Base Case 3Φ Short Circuit Level

Winter 2017/2018 Fault Level Study		
March 15, 2016		
PSS®E Model	**MFA 3Φ SCL**	**SOP 3Φ SCL**
Winter Peak (MP-WP1)	1670	3323
Intermediate (MP-IN1)	1670	2901

Table 3: GE Grid HVdc Design Fault Levels

Converters and Transition Compounds General Technical Requirements (ILK-SN-CD-8000-EL-DB-0002-01)		
Nov 26, 2015 (APPENDIX E/F)		
PSS®E Model	**MFA 3Φ SCL**	**SOP 3Φ SCL**
Max. Foreseeable	4137	4208
Maximum	4116	4208
Minimum	2847	3462
Extreme Minimum	2236	2849
Special Considerations	1625	2237

It is clear from Tables 2 and 3 that the Labrador Island Link HVdc monopole will be operating near the *Special Considerations* fault level at MFATS2 and near the *Extreme Minimum* fault level at SOPTS as stated in the CD0501 General Technical Requirements.

The *Extreme Minimum* fault level was established for GE Grid to design the ac and dc equipment for their rating, up to 900 MW bipole transfer. Operating at this SCL does not require the equipment to meet performance criteria as stated in the contract.

The *Special Considerations* value was determined to be used for low power testing and commissioning of the LIL HVdc system. GE Grid is to design the ac and dc systems to provide up to 225 MW of power transfer over the LIL without exceeding equipment ratings. Operating at this SCL does not require the equipment to meet performance criteria as stated in the contract.

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TECHNICAL NOTE

ISLAND INTERCONNECTED SYSTEM SPINNING RESERVE (WINTER 2017/2018)

The modified base cases were dispatched such that there was adequate spinning reserve available for the largest generation/supply contingency on the Island Interconnected System. For both cases, the largest supply loss would be a trip of the LIL monopole at 220 MW (less losses equals 205 MW at SOP). This would result in a spinning reserve requirement of 275 MW. Table 4 outlines the NLH spinning reserve criteria and Island Interconnected System spinning reserve for each case. There is more than sufficient spinning reserve on Island generation to support the loss of the 205 MW at SOP.

Table 4: Modified Base Case Spinning Reserve

Case	LIL (MW)	LIL Config.	NLH Spinning Reserve Criteria (MW)	Island Spinning Reserve (MW)
MP-WP1	220	MP MR	275	363.9
MP-IN1	220	MP MR	275	435.6

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Winter Peak System Load: Base Case MP-WP1

Base case MP-WP1 simulates the Winter 2017/2018 peak loading conditions during operation of the LIL in monopole metallic return configuration. Figure 2 shows the steady state load flow solution for the winter peak case for LTA and LIL.

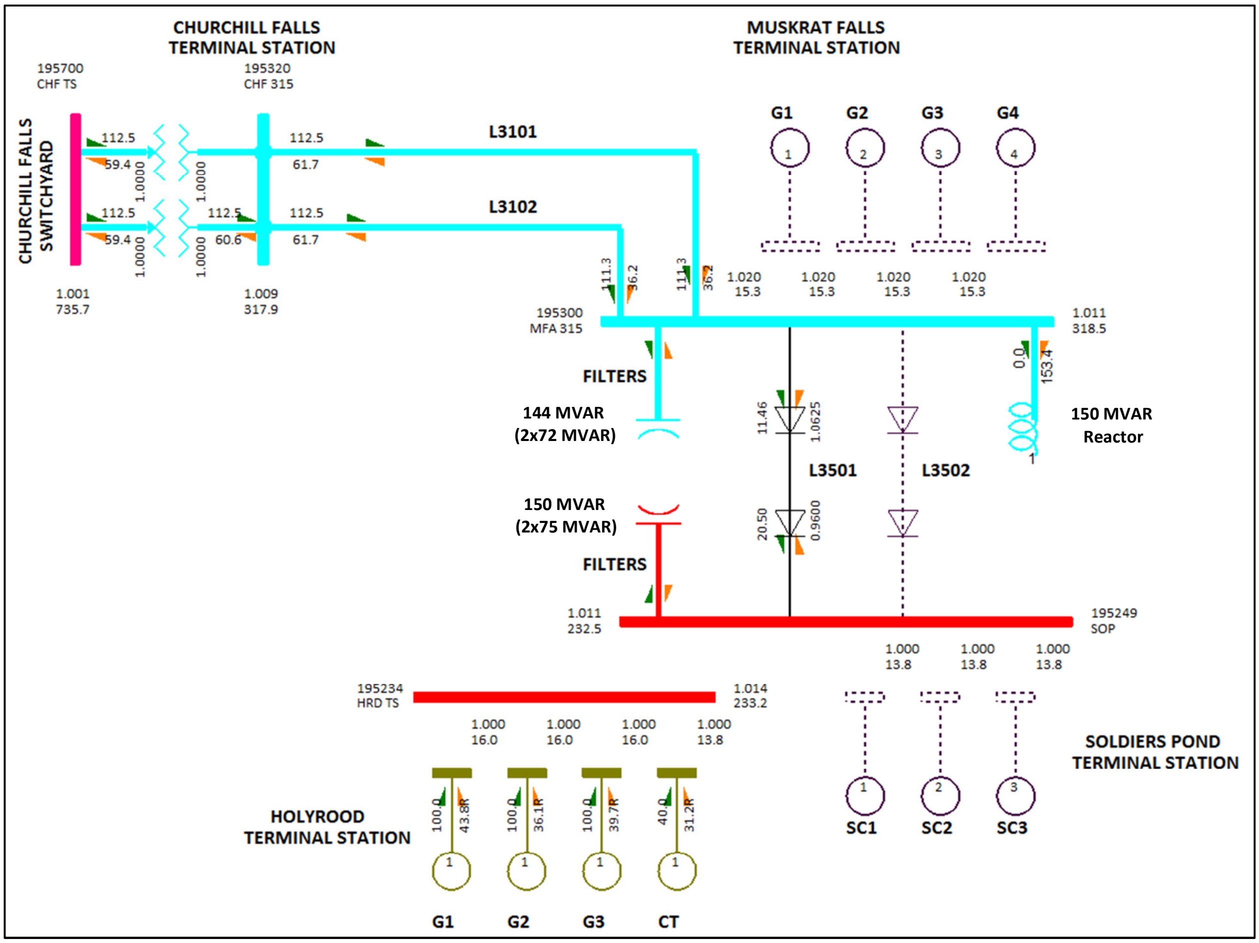

Figure 2: Base Case MP-WP1 - Simple LIL HVdc Single Line Diagram

The LIL is configured in monopole metallic return with an R_{dc} of 38.19 Ω and power order of 220 MW scheduled at MFA. The transmission losses in this case will be on the order of 15 MW for an injection of 205 MW at SOPTS. A 150 MVAR, three-phase, oil-filled shunt reactor is connected to the MFA 315 kV bus to limit overvoltages in the event of a pole trip, as the generating facility at MFA is not commissioned to provide voltage control. Two filters are online at both MFACS (144 MVAR) and SOPCS (150 MVAR) to absorb both background and converter harmonics.

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TECHNICAL NOTE

The dynamic analysis of this base case involved the simulation and study of 53 contingencies which are listed below in Table 5. All transmission line contingencies listed were stable, had acceptable post fault recovery voltages and did not result in any UFLS. The most important contingencies for this study were the permanent loss of Pole 1 on the LIL and large capacity generators on the Island Interconnected System.

Table 5: System Study Contingencies

Contingency List - 3Φ Faults					
Line	**End**	**Line**	**End**	**Gen**	**HVdc**
L3101	CHF	TL233	BBK	BDE G7	Pole 1
L3101	MFA	TL233	BUC	USL G1	
L7053	CHF	TL234	BDE	CAT G1	
L7053	MTG	TL234	USL	SVL CT	
TL201	SOP	TL236	HWD	HRD CT	
TL201	WAV	TL236	OPD	HRD G3	
TL202	BDE	TL237	CBC	GCL G1	
TL202	SSD	TL237	WAV	CHF A3	
TL203	SSD	TL247	CAT		
TL203	WAV	TL247	DLK		
TL207	SSD	TL248	MDR		
TL207	CBC	TL248	DLK		
TL209	BBK	TL263	USL		
TL209	SVL	TL263	GCL		
TL211	MDR	TL266	SOP		
TL211	BBK	TL266	HWD		
TL218	HRD	TL267	BDE		
TL218	OPD	TL267	WAV		
TL228	BUC	TL268	SOP		
TL228	MDR	TL268	HRD		
TL231	STB	TL269	BBK		
TL231	STB	TL269	GCL		
TL232	STB				
TL232	STB				

A pole dc fault resulting in a permanent loss of LIL Pole 1 was simulated to trigger the UFLS protection system and shed 130 MW of customer load. It should be noted that the load shed is within the spinning reserve requirement which will result in quick restoration of customer loads. The Island Interconnected System frequency was suppressed to 58.19 Hz before recovering above 59 Hz. The frequency recovered above 59 Hz over the 20 second simulation period without tripping the 59 Hz 15 second UFLS block.

The next largest supply loss was a three-phase fault at the 230 kV bus at BDE followed by a trip of BDP Unit 7 which is dispatched at 154 MW prior to the fault. This contingency shed 78 MW of customer load and prevented the system frequency from depressing below 58.53 Hz. Similarly, the customer load can be quickly restored as the load shed is within the spinning reserve requirements.

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The last contingency to activate the UFLS scheme was a three-phase fault at the HRDTS 230 kV bus with a subsequent trip of HRP G3 at 100 MW. This resulted in 36 MW of customer load shed for this contingency and prevented the system frequency from depressing below 58.78 Hz. The frequency recovered above 59 Hz over the 20 second simulation without tripping the 59 Hz 15 second UFLS block. Again, customers can expect a quick restoration of power and energy due to amount of spinning reserve on the Island Interconnected System.

The detailed results of the UFLS protection system simulation is provided in Table 6.

Table 6: Supply Loss Contingencies – UFLS Summary MP-WP1

Winter Peak Case - 220 MW LIL Transfer						
Bus #	Simulation Time (s)	% of Load Block Shed	Total Load Shed		Bus Voltage (pu)	Bus Freq. (Hz)
			MW	MVAR		
220 MW Pole Trip - 205 MW @ SOP						
196221	2.689	67.0	10.04	2.30	0.98	58.74
195624	2.693	30.6	26.06	5.76	1.01	58.71
195432	2.978	100.0	5.99	1.15	1.05	58.53
196546	3.015	94.2	27.92	6.21	1.01	58.49
196571	3.019	42.0	8.21	1.87	1.00	58.48
195144	3.431	47.6	27.94	6.41	0.99	58.35
196566	3.465	35.5	17.71	4.01	1.01	58.35
195407	4.544	100.0	3.72	0.84	1.01	58.19
195408	4.561	100.0	1.68	0.39	0.98	58.19
195409	4.562	100.0	0.69	0.15	1.03	58.19
Total Load Shed/Min V./Min Freq.			**129.96**	**29.09**	**0.98**	**58.19**
154 MW BDP G7 3Ø Fault + Trip						
195624	3.412	30.5	26.06	5.76	1.03	58.74
196221	3.433	67.0	10.04	2.30	1.01	58.69
196571	3.659	42.0	8.21	1.87	1.01	58.61
195432	3.934	100.0	5.99	1.15	1.08	58.57
196546	4.027	94.2	27.92	6.21	1.04	58.53
Total Load Shed/Min V./Min Freq.			**78.22**	**17.29**	**1.01**	**58.53**
100 MW HRP G3 3Ø Fault + Trip						
196221	6.393	67.0	10.04	2.30	0.98	58.78
195624	6.404	30.5	26.06	5.76	1.02	58.78
Total Load Shed/Min V./Min Freq.			**36.10**	**8.06**	**0.98**	**58.78**

It should be noted here that the LIL frequency controller at SOP is not activated for this study. The enabling of this feature will greatly improve the overall system performance for loss of generation on the Island. Although the LIL is limited to 220 MW for normal operation, with both 315 kV transmission lines in service the LIL frequency controller could operate up to its rated monopole limit of 450 MW. This limit is imposed by the submarine cables rather than the Labrador Interconnected System which can transfer up to a non-firm value of 500 MW to MFATS2.

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TECHNICAL NOTE

Intermediate System Load: Base Case MP-IN1

Base case MP-IN1 simulates the Island Interconnected System intermediate loading conditions during mild winter day operation of the LIL in monopole metallic return configuration. Figure 3 shows the steady state load flow solution for the intermediate power system load case for LTA and LIL.

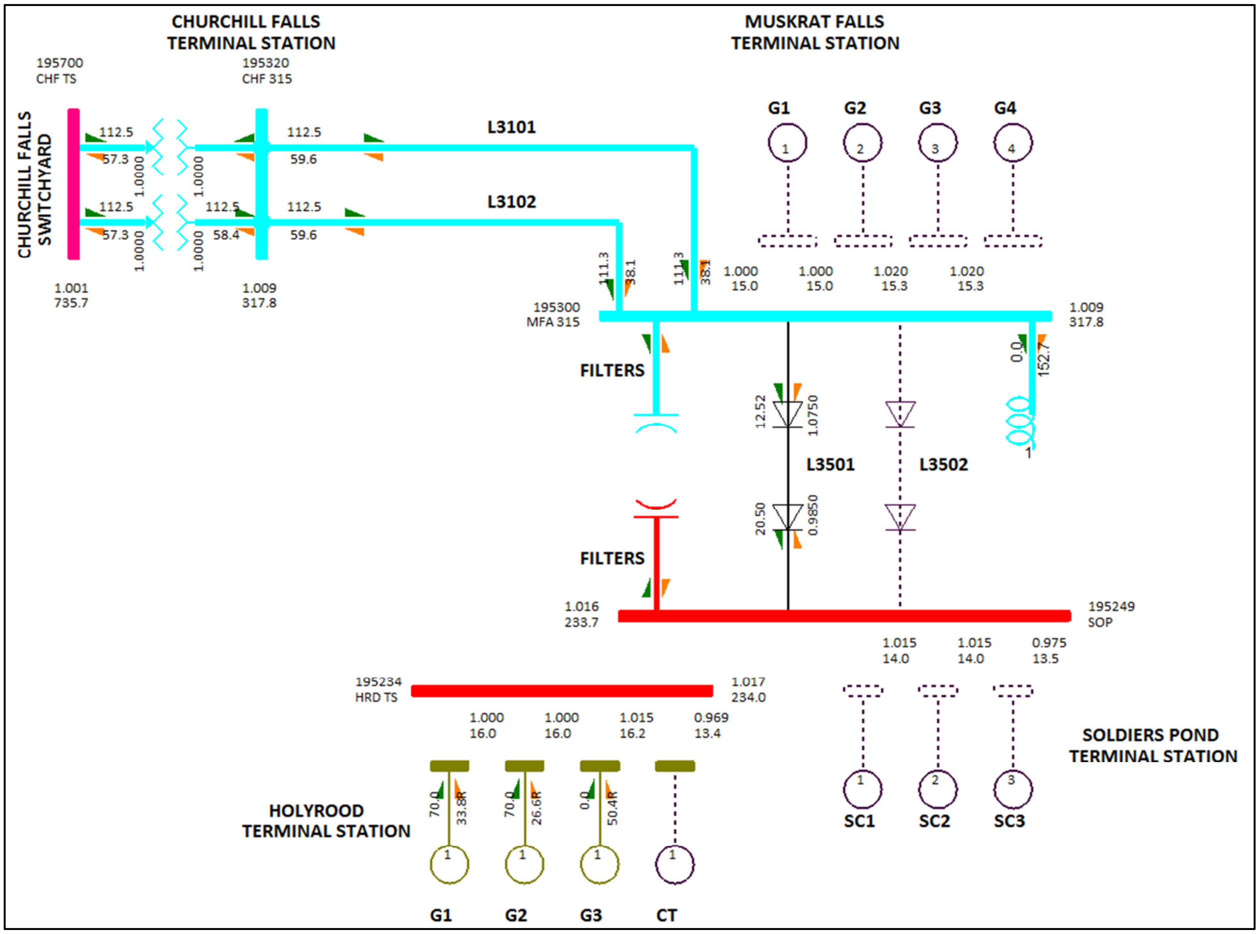

Figure 3: Base Case MP-IN1 - Simple LIL HVdc Single Line Diagram

The LIL is configured in monopole metallic return with an R_{dc} of 38.19 Ω and power order of 220 MW scheduled at MFA. The transmission losses in this case will be on the order of 15 MW for an injection of 205 MW at SOPTS. A 150 MVAR, three-phase, oil-filled shunt reactor is connected to the MFA 315 kV bus to limit overvoltages in the event of a pole trip, as the generating facility at MFA is not commissioned to provide voltage control. Two filters are online at both MFACS (144 MVAR) and SOPCS (150 MVAR) to absorb both background and converter harmonics.

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TECHNICAL NOTE

The dynamic analysis of this base case involved the simulation and study of 53 contingencies which are listed below in Table 7. All transmission line contingencies listed were stable, had acceptable post fault recovery voltages and did not result in any UFLS. The most important contingencies for this study were the permanent loss of Pole 1 on the LIL and large capacity generators on the Island Interconnected System.

Table 7: System Study Contingencies

Contingency List - 3Φ Faults					
Line	**End**	**Line**	**End**	**Gen**	**HVdc**
L3101	CHF	TL233	BBK	BDE G7	Pole 1
L3101	MFA	TL233	BUC	USL G1	
L7053	CHF	TL234	BDE	CAT G1	
L7053	MTG	TL234	USL	SVL CT	
TL201	SOP	TL236	HWD	HRD CT	
TL201	WAV	TL236	OPD	HRD G2	
TL202	BDE	TL237	CBC	GCL G1	
TL202	SSD	TL237	WAV	CHF A3	
TL203	SSD	TL247	CAT		
TL203	WAV	TL247	DLK		
TL207	SSD	TL248	MDR		
TL207	CBC	TL248	DLK		
TL209	BBK	TL263	USL		
TL209	SVL	TL263	GCL		
TL211	MDR	TL266	SOP		
TL211	BBK	TL266	HWD		
TL218	HRD	TL267	BDE		
TL218	OPD	TL267	WAV		
TL228	BUC	TL268	SOP		
TL228	MDR	TL268	HRD		
TL231	STB	TL269	BBK		
TL231	STB	TL269	GCL		
TL232	STB				
TL232	STB				

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A pole dc fault resulting in a permanent loss of LIL Pole 1 was simulated to trigger the UFLS protection system and shed 100 MW of customer load. The Island Interconnected System frequency was suppressed to 58.51 Hz before recovering above 59 Hz. The frequency recovered above 59 Hz over the 20 second simulation period without tripping the 59 Hz 15 second UFLS block. Customers can expect quick restoration of power due to amount of spinning reserve on the Island Interconnected System.

The next largest supply loss was a three-phase fault at the 230 kV bus at BDE followed by a trip of BDP Unit 7 which is dispatched at 135 MW prior to the fault. This contingency shed 66 MW of customer load and prevented the system frequency from depressing below 58.56 Hz. Similarly, the load shed can be quickly restored due to the spinning reserve requirements.

The detailed results of the UFLS protection system simulation is provided in Table 8.

Table 8: Supply Loss Contingencies – UFLS Summary MP-IN1

Intermediate Case - 220 MW LIL Transfer						
Bus #	Simulation Time (s)	% of Load Block Shed	Total Load Shed		Bus Voltage (pu)	Bus Freq. (Hz)
			MW	MVAR		
220 MW Pole Trip – 205 MW @ SOP						
196573	2.434	12.9	6.87	2.72	0.97	58.86
196565	2.445	33.6	13.37	5.25	0.98	58.86
196563	2.456	59.9	20.08	7.93	0.98	58.86
195624	2.680	30.5	19.71	8.11	1.03	58.72
196221	2.749	67.0	7.56	1.72	1.00	58.70
196571	2.954	42.0	6.25	2.47	0.98	58.51
196546	2.962	94.2	21.21	8.17	1.00	58.52
195432	2.978	100.0	4.51	1.67	1.05	58.54
Total Load Shed/Min V./Min Freq.			**99.56**	**38.04**	**0.97**	**58.51**
135 MW BDP G7 3Ø Fault + Trip						
196221	3.429	67.0	7.56	1.72	1.01	58.73
195624	3.473	30.5	19.71	8.11	1.03	58.74
196573	3.477	12.9	6.87	2.72	1.00	58.7
196571	3.976	42.0	6.25	2.47	1.00	58.56
196546	3.985	94.2	21.21	8.17	1.03	58.56
195432	4.002	100.0	4.51	1.67	1.08	58.58
Total Load Shed/Min V./Min Freq.			**66.11**	**24.86**	**1.00**	**58.56**

It should be noted here that the LIL frequency controller at SOP is not activated for this study. The enabling of this feature will greatly improve the overall system performance for supply loss contingencies of Island generation. Although the LIL is limited to 220 MW for normal operation, with both 315 kV transmission lines in service the LIL frequency controller could operate up to its rated monopole limit of 450 MW. This limit is imposed by the submarine cables rather than the Labrador Interconnected System which can transfer up to a non-firm value of 500 MW to MFATS2.

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CONCLUSIONS AND RECOMMENDATIONS

The results of this power system study indicate that the Labrador Island Link HVdc scheme can be successfully operated in monopole metallic return for the upcoming 2017/2018 winter season without availability of the SOP HISC Plant (SOPCS). However, it should be noted that the cases studied are not valid for operation into the spring/summer timeframe. During this time customer loads will drop and force NLH system operators into reducing the system inertia and short circuit levels at SOP by removing thermal generation at Holyrood. As a result, the outcome of this study relies on the reliable operation of the Holyrood Thermal Plant from December 2017 until the end of February 2018.

In the event that the Synchronous Condenser Contract (CD0534) falls behind schedule and at least two HISCs are not fully commissioned and available by the first week of March, the Labardor Island Link may have to be shut down or restricted to low power orders to avoid damage to equipment and risk of prolonged customer outages. Additional power system studies are required to determine the operating restrictions of such a scenario.

The detailed single line diagrams for the PSS®E cases used in this report can be found in Appendix A. Appendix B includes a copy of the dynamic analysis for each contingency.

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APPENDIX A

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APPENDIX B