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January 10, 2025

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

Attention: Jo-Anne Galarneau
Executive Director and Board Secretary

Re: Submission of Supplemental Information for the 2025 Capital Budget Application

On July 16, 2024, Newfoundland and Labrador Hydro ("Hydro") submitted its 2025 Capital Budget Application ("2025 CBA"), which included a capital project to replace the stator winding of Hinds Lake Hydroelectric Generating Station generating Unit 1.[1]

As part of its responses to requests for information for the 2025 CBA, Hydro indicated that retesting results on Unit 1 from September 2024 were inconclusive, so further testing was required. Hydro committed to providing the Board of Commissioners of Public Utilities with an update on the results once they were finalized.[2]

Enclosed, please find the report as provided by third-party consultant Qualitrol.

Combined with observed damage found during visual inspections, as well as loose end windings and wedges, the data provided in the report does not affect Hydro's recommendation to proceed with the replacement of the stator. Hydro will proceed with the project as approved.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

SWalsh

Shirley A. Walsh
Senior Legal Counsel, Regulatory
SAW/kd

Encl.

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[1] "2025 Capital Budget Application," Newfoundland and Labrador Hydro, July 16, 2024, sch. 7, proj. 1.
[2] Please refer to Hydro's response to PUB-NLH-067 of the 2025 CBA proceeding.

ecc:

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Partial Discharge Test Report

Qualitrol

Hinds Lake GS – Unit 1

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December 02, 2024

Newfoundland & Labrador Hydro

Partial Discharge Test Report

Hinds Lake GS
Unit 1

Attached please find a copy of our Partial Discharge Test Report for the tests carried out on October 31, 2024 Hinds Lake GS Unit 1 for the subject assets at the Hinds Lake GS plant.

The current Partial Discharge test on the subject generators suggests the following condition of the stator winding, partial discharge sources and recommendations:

Asset	PD Levels	PD Source(s)	Recommendations
Unit 1	*Fluctuations and Moderate to Typical. High PD observed in the past.*	Internal voids and surface coating issue in the slot area	Reduction of PD magnitudes from previous high levels may indicate the winding is still degrading. Visual inspections and off-line IR/PI tests, if these have not already occurred, should be performed.

While Moderate PD levels are observed in this most recent test, previously most couplers indicated High PD activity was present. Thus, it is possible the winding is still degrading even though the PD is decreasing. It would be prudent to perform visual inspections and off-line IR/PI tests if these have not already occurred.

At Iris, we are committed to providing you with superior products and service. We value all input. If you require further information or have any questions, please do not hesitate to contact us.

Sincerely,

Amith Menon

Amith Menon
Manager, Field Service

QUALITROL Defining Reliability

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QUALITROL - IRIS POWER L.P.

Interpretation of Partial Discharge Test Results

PDA Differential

Client:	**NEWFOUNDLAND & LABRADOR HYDRO**
Company:	**NEWFOUNDLAND & LABRADOR HYDRO**
Site:	Hinds Lake GS
Asset:	**Unit 1**
Test Date:	**October 31, 2024**

Client Reference	
IRIS Reference	50537405
Issue	1
Revision	0
Date	November 06, 2024
Issuing office	Toronto, Canada

Prepared by: **Signature**

Aravind Sampath **Date** November 06, 2024

Reviewed by: **Signature**

Howard Sedding **Date** November 30, 2024

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1 INTRODUCTION

IRIS Power LP was requested by **NEWFOUNDLAND & LABRADOR HYDRO – Hinds Lake GS** to carry out condition assessment of the **Unit 1** stator winding.

This assessment consisted of On-line Partial Discharge measurements. Further information regarding Partial Discharge Interpretation can be found in the attached appendix. These tests were carried out under IRIS Power LP task reference: **50537405.**

2 WINDING COMPARISON

2.1 Statistical Comparison

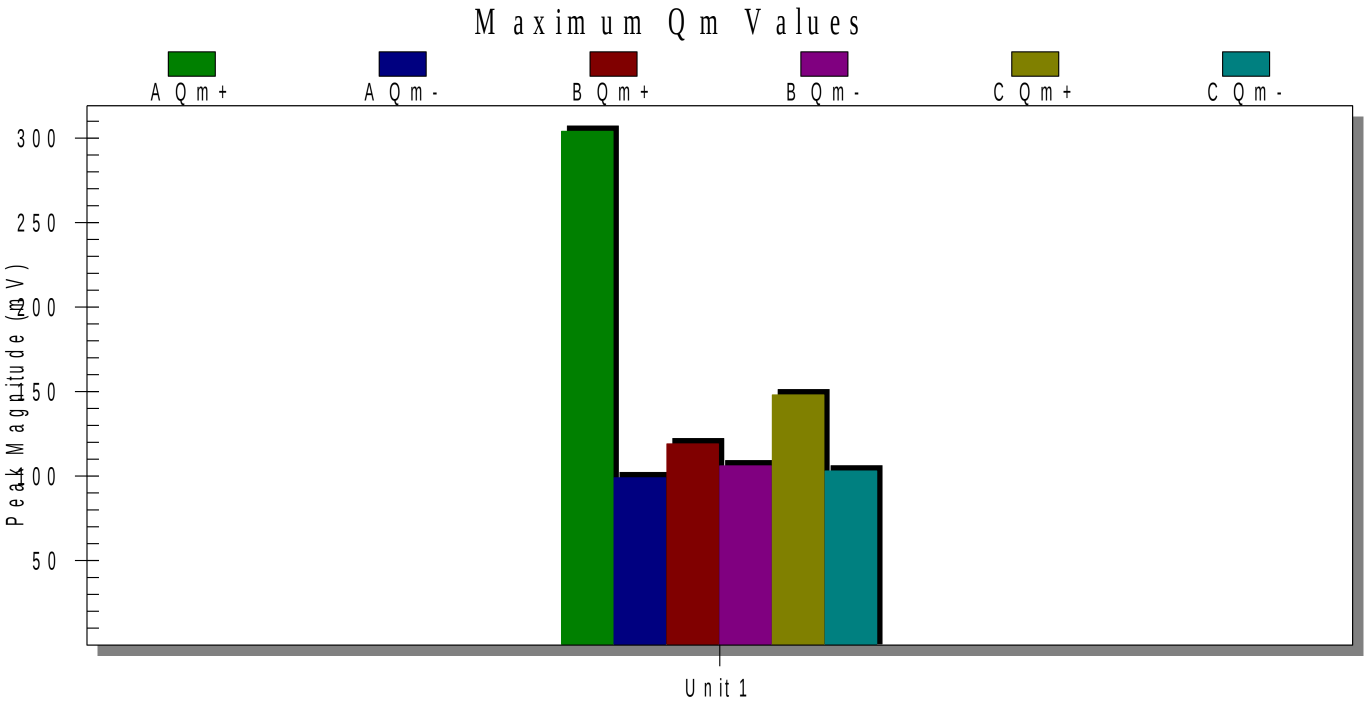
The table below provides a quick summary of relative winding insulation discharge activity when compared to other windings of this voltage class [ref. A-4.2].

Rank	Phase	Concern
Very High		**Moderate concern, should retest in 6 months if stable or in 2-3 months if rising or baseline test. If an upward trend exists, further investigation is recommended.**
High		
Moderate	**Phase A**	No concern unless an upward trend is present. Retest in 6 months.
Typical	**Phase B** **Phase C**	No concern unless an upward trend is present. Retest in 6-12 months.
Low		No concern, retest on regular schedule of 6-12 months.
Negligible		

Disclaimer: The above comparison to the statistical database assumes that the PD couplers are in the optimum location and the standard test method is utilized. If surge capacitors are present at the terminals, a sensitivity check may be needed to ensure that the surge capacitors do not affect the stator winding PD signals. Refer to A-4.2 of the attached Appendix for information regarding impedance mismatches, test method, zone of coverage, and other limitations with statistical ranking.

2.2 Asset/Phase Comparison

The plot displays the highest Q_m+ and Q_m- values for a given phase and/or asset [ref. A-4.3.1].



3 UNIT: Unit 1

3.1 Asset Design

Rated Voltage	*13.8 kV*	Machine Type	*Hydro Generator*
Rated Power	*70.0 MW*	Insulation	
Rated Frequency	*60 Hz*	PD Sensors	*Cable Capacitor (80pF)*
Rated Speed	*360 RPM*	Test Sequence	*7*
Manufacturer	*HITATCHI*	Test Type	*PDA Differential*
Date Manufactured/serial #	*1980 / N/A*	Winding Manufacturer	
Application		Rewind Year	*N/A*
		Data collected by:	*End User*

3.2 Partial Discharge Trends

While the PDView™ plots provide a visual indication of the Partial Discharge patterns in each phase, the summary numbers provide a means to trend and compare results from similar voltage class windings.

The table below lists the Qm summary numbers from the tests for this machine.

	Power (MW)	Reactive (MVar)	Voltage (kV)	Temp (°C)	Ambient		A-A-C1		A-A-C2		B-B-C1		B-B-C2		C-C-C1		C-C-C2	
					Temp (°C)	RH (%)	Qm+	Qm-	Qm+	Qm-	Qm+	Qm-	Qm+	Qm-	Qm+	Qm-	Qm+	Qm-
Apr 13	65.0	0.0	13.8	55	23	16	469	180	142	79	289	147	224	99	317	172	92	95
Feb 15	65.0	0.0	13.8	48	19	6	675	234	189	94	310	242	241	146	340	219	116	108
Jan 18	70.0	0.0	13.8	18	19	9	454	230	99	-	228	126	149	95	331	169	-	68
Jan 20	65.0	-9.5	13.8	40	28	35	455	249	67	48	446	263	66	49	455	256	69	48
Feb 24	80.0	0.0	13.8	40	25	24	535	209	82	58	340	142	173	99	290	181	75	76
Sep 24	70.0	0.0	13.8	45	23	65	271	99	57	25	110	71	94	72	183	174	46	33
Oct 24	74.0	-14.9	13.8	38	25	33	304	99	51	19	112	58	119	106	148	103	59	42

"-" is an indication that the value was not provided, or available at the time of the test.

Phase A-A-C1

There have been some fluctuations in the Partial Discharge, but it appears to be due to variances in operating and/or ambient conditions, not problems with the winding.

Phase A-A-C2

The Partial Discharge is stable (no more than 25% difference in Peak Magnitudes (+/-Qm), so there is no evidence of a change in winding condition.

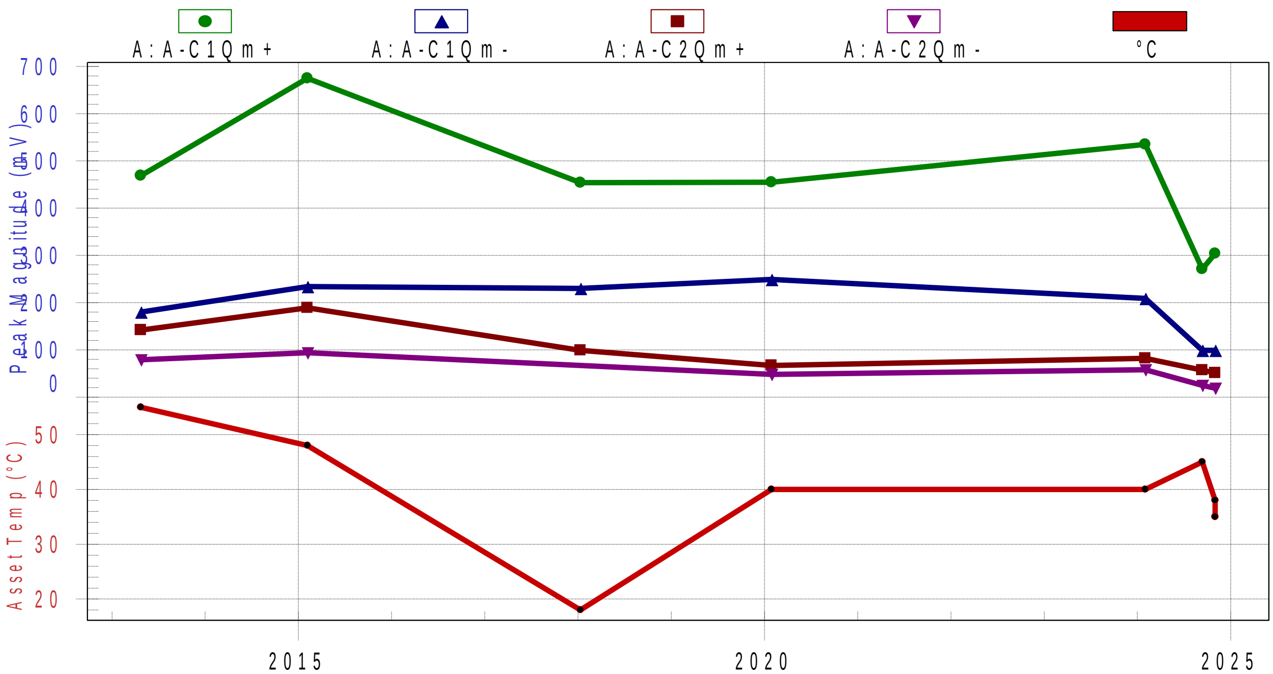


Figure 1 – Trend Plot for A Phase

Phase B-B-C1

There have been some fluctuations in the Partial Discharge, but it appears to be due to variances in operating and/or ambient conditions, not problems with the winding.

Phase B-B-C2

There have been some fluctuations in the Partial Discharge, but it appears to be due to variances in operating and/or ambient conditions, not problems with the winding.

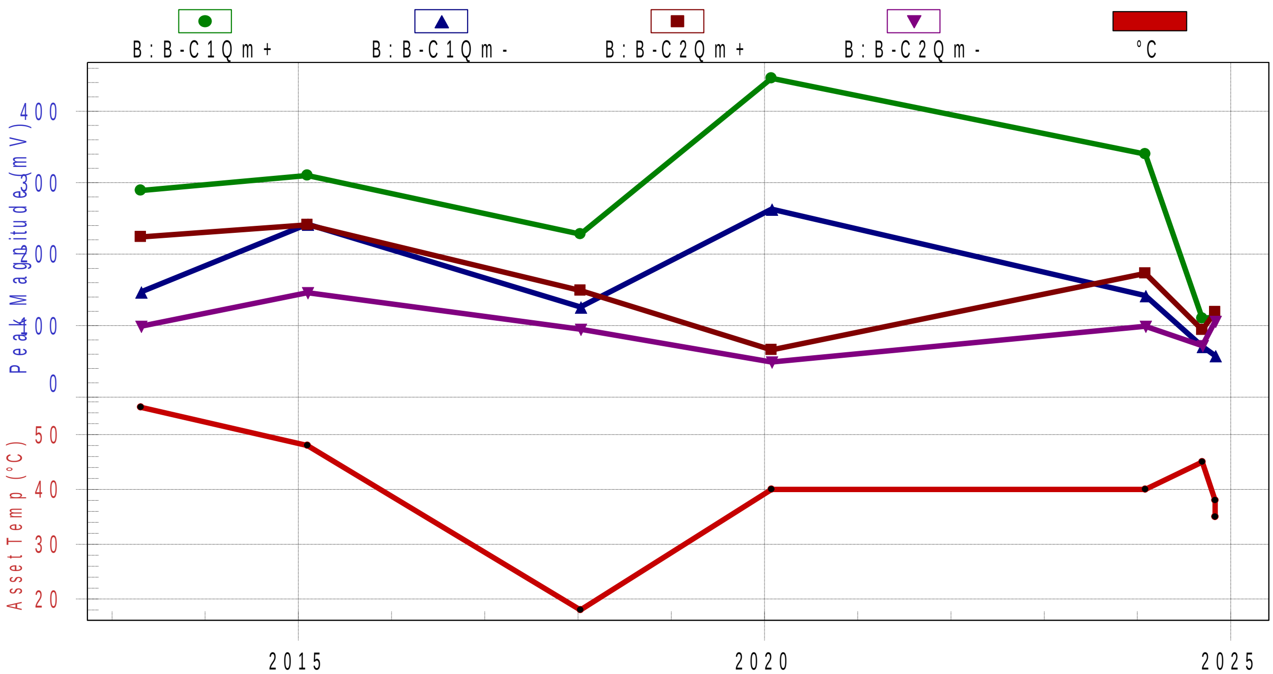


Figure 2 – Trend Plot for B Phase

Phase C-C-C1

There have been some fluctuations in the Partial Discharge, but it appears to be due to variances in operating and/or ambient conditions, not problems with the winding.

Phase C-C-C2

The Partial Discharge is stable (no more than 25% difference in Peak Magnitudes (+/-Qm), so there is no evidence of a change in winding condition.

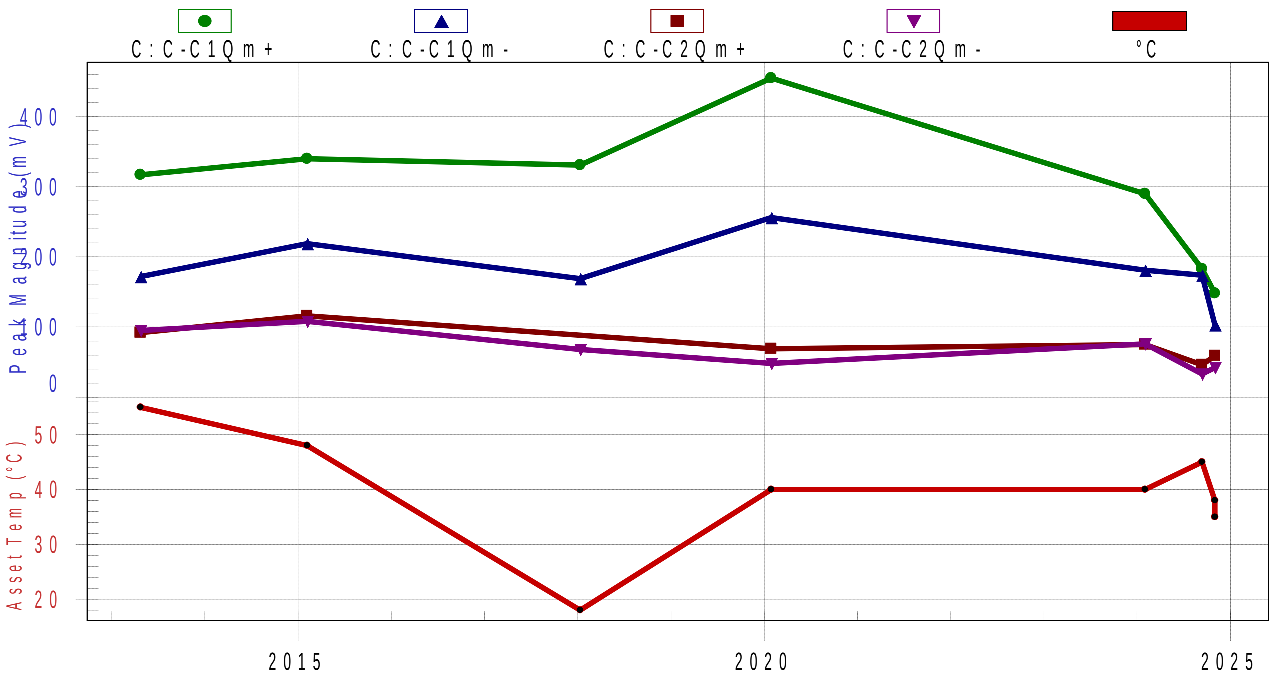


Figure 3 – Trend Plot for C Phase

3.3 Partial Discharge Results

Phase A	Date	Time	Test Range	K-factor	NQN+	NQN-	Qm+	Qm-
A1 - A-C1	10/31/2024	1:32:09 PM	50.0-850.0 mV	1.00	654	163	304	99
A1 - A-C2	10/31/2024	2:45:55 PM	10.0-170.0 mV	1.00	-	32	51	19

Phase B	Date	Time	Test Range	K-factor	NQN+	NQN-	Qm+	Qm-
B1 - B-C1	10/31/2024	1:40:30 PM	10.0-170.0 mV	1.00	245	125	112	58
B1 - B-C2	10/31/2024	1:40:30 PM	10.0-170.0 mV	1.00	245	142	119	106

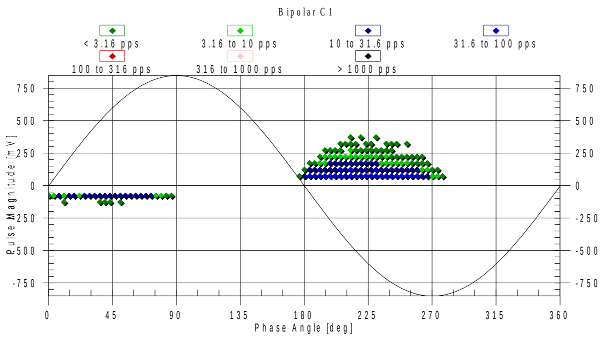
Phase C	Date	Time	Test Range	K-factor	NQN+	NQN-	Qm+	Qm-
C1 - C-C1	10/31/2024	1:54:58 PM	20.0-340.0 mV	1.00	305	208	148	103
C1 - C-C2	10/31/2024	1:52:55 PM	10.0-170.0 mV	1.00	107	83	59	42

3.4 Pulse Phase Analysis Plot

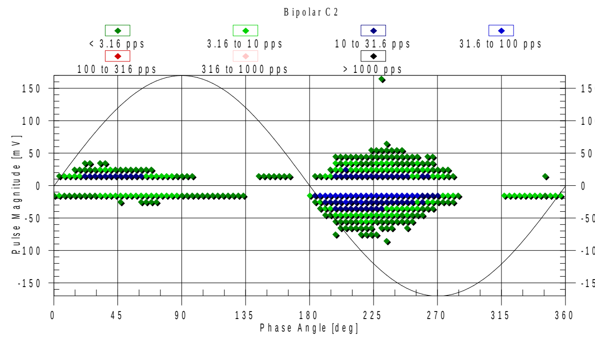
Based on the information known to date, an ABC rotation is assumed. The following plot shows the Linear Pulse density plot with the phases appropriately shifted to make it easier to observe the vertical alignment that occurs when detected pulses are from the same source, as with interphasal and cross-coupled pulses. Should the rotation selected disagree with your documentation, please let us know.

Pulse Phase Analysis (ABC rotation PRPD)
Folder: NEWFOUNDLAND & LABRADOR HYDRO
Asset Name: Unit 1

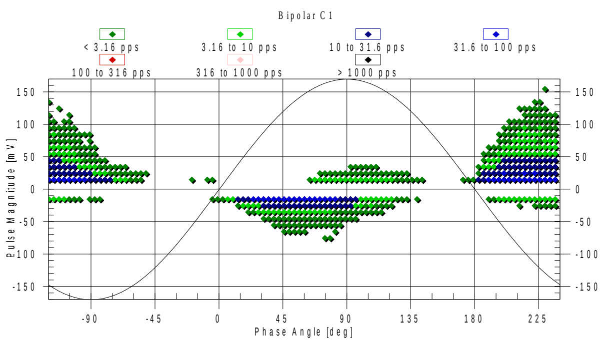
Asset Class: Hydro Generator, Sensor Type: Cable Capacitor (80pF)
Operating load: 74.0 MW, Reactive Load: -14.9 MVar, Operating Asset Temp 38 deg C, Operating Voltage 13.8 kV
Operating Gas Pressure: N/A, Ambient Temp 25 deg C, Ambient Humidity: 33 %, Freq. / Test Duration 60 Hz / 5 s
Manufacturer: HITATCHI, Year of Installation: 1980, Winding Manufacturer: , Re-Wind Year: N/A



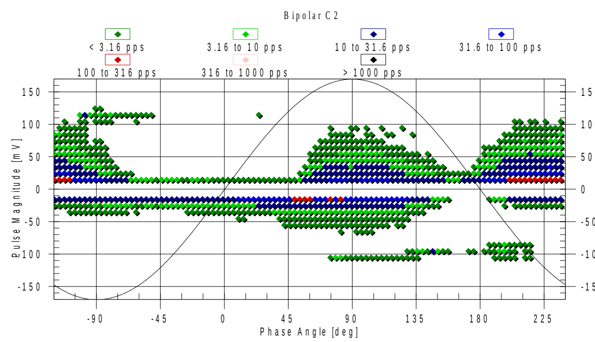
Phase: A, Sensor(s): A-C1,A-C2 Start Time: 10/31/2024 1:32:09 PM
C1: NQN+: 654, NQN-: 163, Qm+: 304, Qm-: 99, Status OVR



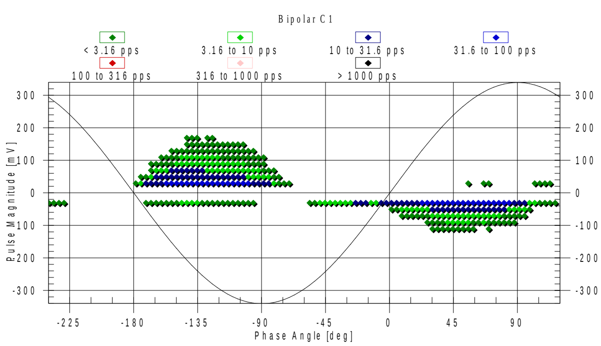
Phase: A, Sensor(s): A-C1,A-C2 Start Time: 10/31/2024 2:45:55 PM
C2: NQN+: -, NQN-: 32, Qm+: 51, Qm-: 19, Status OVR,HNPR



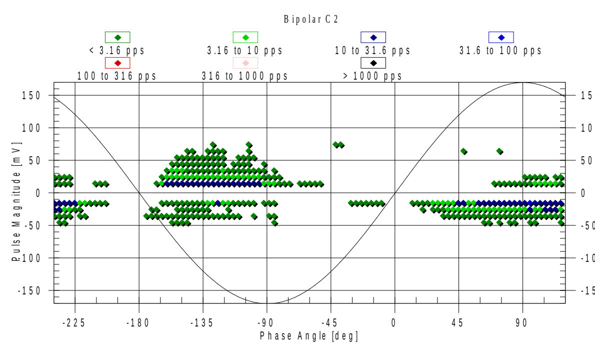
Phase: B, Sensor(s): B-C1,B-C2 Start Time: 10/31/2024 1:40:30 PM
C1: NQN+: 245, NQN-: 125, Qm+: 112, Qm-: 58, Status OVR



Phase: B, Sensor(s): B-C1,B-C2 Start Time: 10/31/2024 1:40:30 PM
C2: NQN+: 245, NQN-: 142, Qm+: 119, Qm-: 106, Status OVR



Phase: C, Sensor(s): C-C1,C-C2 Start Time: 10/31/2024 1:54:58 PM
C1: NQN+: 305, NQN-: 208, Qm+: 148, Qm-: 103, Status OVR



Phase: C, Sensor(s): C-C1,C-C2 Start Time: 10/31/2024 1:52:55 PM
C2: NQN+: 107, NQN-: 83, Qm+: 59, Qm-: 42, Status OVR

Note: - Data selected for C1 and C2 plots in a phase are not of same voltage ranges but same load.

3.5 Partial Discharge Analysis

The moderate level of Partial Discharge compared to other windings of this voltage class [ref. A-4.2] means the winding does not, as of yet, have significant problems.

The Partial Discharge magnitudes and patterns are not comparable suggesting an isolated problem in the winding, and not a uniform condition.

Appendix Reference	Parameter	Pair	Phase A		Phase B		Phase C	
			A-C1	A-C2	B-C1	B-C2	C-C1	C-C2
PD Trend								
A3.1.2	Comparison to previous measurement	1	Stable (+/-25%)	Stable (+/-25%)	Stable (+/-25%)	Stable (+/-25%)	Stable (+/-25%)	Stable (+/-25%)
A3.1.1	Long Term Trend	1	Fluctuation	Stable (+/-25%)	Fluctuation	Fluctuation	Fluctuation	Stable (+/-25%)
A3.4	Operating and/or ambient conditions effect	1	Unknown for: All	Unknown for: All	Unknown for: All	Unknown for: All	Unknown for: All	Unknown for: All
PD Comparison								
A3.2	Database comparison	1	Moderate	Low	Typical	Typical	Typical	Low
A3.3	Phase comparison	1	Isolated Problem	Isolated Problem	Isolated Problem	Uniform	Uniform	Uniform
A4.2	Polarity predominance	1	Positive	Positive	Positive	None	None	None
A3.5	System	1	Negligible		Negligible		Negligible	
PD in Slot		1	Yes	Yes	Yes	Yes	Yes	Yes
A4.2.1	Internal discharge	1	√	√	√	√	√	√
A4.2.1.3	Delamination from conductor	1						
A4.2.2.1	Loose coils	1						
A4.2.2.2	Electrical slot discharge	1	√	√	√			
Operating Conditions Effect								
A3.4.1	Load dependence	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
A3.4.2	Stator winding temperature dependence	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
A3.4.3	Hydrogen pressure effect	1	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

A3.4	Operating voltage effect	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
A3.4	Ambient temp. effect	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
A3.4.4	Ambient humidity effect	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
PD in Endwinding		1	Yes	Yes	Yes	Yes	Yes	Yes
A4.3.2	Inter-Phase	1						
A4.3.1	Stress control interface	1	√	√	√	√	√	√
A4.3.2.3	Gap type discharge	1						
A4.5.2	Cross-coupling*	1		√	√	√	√	√
A4.5.1	Excitation pulses*	1						
A4.5.4	Severe disturbance*	1						
A4.5.3	Broadband clusters	1						
A4.3.2.1	Contamination	1						
	Peak clusters	1						
Operating Conditions Effect								
A3.4.1	Load dependence	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
A3.4.2	Stator winding temperature dependence	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
A3.4.3	Hydrogen pressure effect	1	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
A3.4	Operating voltage effect	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
A3.4	Ambient temp. effect	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
A3.4.4	Ambient humidity effect	1	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

* Extraneous pulses: Cross-coupling, excitation pulses, broadband clusters and severe disturbances are not indicative of problems within the asset insulation system; however, their presence may obscure notable winding PD activity. Please refer to Section A-4.5 in the Appendix for more information.

4 STATOR WINDING ASSESSMENTS

4.1 Unit 1

Overall Concern:	Some concern since the PD levels have decreased on most couplers
Next Test	Within 6 months

Phase	Pair	C1 Assessment	C2 Assessment
A-Phase	1	Short Term: Stable (+/-25%); Long Trend: Fluctuation; Oper Conditions: Unknown for: All; Ranking: Moderate.	Short Term: Stable (+/-25%); Long Trend: Stable (+/-25%); Oper Conditions: Unknown for: All; Ranking: Low.
B-Phase	1	Short Term: Stable (+/-25%); Long Trend: Fluctuation; Oper Conditions: Unknown for: All; Ranking: Typical.	Short Term: Stable (+/-25%); Long Trend: Fluctuation; Oper Conditions: Unknown for: All; Ranking: Typical.
C-Phase	1	Short Term: Stable (+/-25%); Long Trend: Fluctuation; Oper Conditions: Unknown for: All; Ranking: Typical.	Short Term: Stable (+/-25%); Long Trend: Stable (+/-25%); Oper Conditions: Unknown for: All; Ranking: Low.

4.1.1 PD Patterns

- **A-3.1.2 SHORT-TERM MOVEMENT:** The PD levels of all three C1 & C2 sensors have shown stable PD levels from the last test, suggesting the stable condition of the subject stator winding. Minor deviations in the PD levels are expected and considered normal.
- **A-3.1.1 LONG-TERM TREND:** There have been significant decreases in PD activity in most couplers compared to the February 2024 results. Normally, this would be considered good and due to changes in operating conditions. However, as discussed in [4] there is anecdotal evidence from other machines that this may mean the winding is getting closer to failure.
- **A-3.2 and A-3.3 DATABASE AND PHASE COMPARISON:** The PD magnitudes are not similar among the phases, indicative of an isolated source of higher PD magnitudes in A-C1, B-C1 & C-C1 Phases. The TYPICAL to MODERATE levels of PD compared to other windings of this voltage class and other similar air-cooled windings in the Iris statistical database means this asset does not, as of yet, have significant problems but the regular PD monitoring is suggested to observe a possible accelerated deterioration of the worst phase.
- **A-3.4.1 LOAD EFFECT:** When operated at two different loads we do not see a difference in Qm level for partial discharge activity. On that basis there is no evidence of winding looseness.

Power (MW)	Temp (°C)	A-A-C1		A-A-C2		B-B-C1		B-B-C2		C-C-C1		C-C-C2	
		Qm+	Qm-	Qm+	Qm-	Qm+	Qm-	Qm+	Qm-	Qm+	Qm-	Qm+	Qm-
28	35	271	97	-	-	118	72	98	94	157	95	50	36
74	38	266	98	61	30	124	71	118	80	148	103	68	49

- **A-4.2.1.1 INTERNAL VOIDS:** A-C2, B-C2 & C-C2 Phases reveal characteristic clusters of pulses at the 45°/225° phase positions that are usually indicative of phase-to-ground voltage dependent PD sources in a slot portion of the stator winding. This pattern with uniform distribution of negative and positive pulses typically indicates the presence of micro-voids forming within the slot section of the coil or bar due to long-term thermal aging, and possibly in combination with voids that may have been present since manufacturing.
- **A-4.2.2 SLOT PARTIAL DISCHARGE:** If the discharge protective coating in the slot section of the stator winding fails to serve its purpose due to various reasons, then the possibility for the partial discharge develops here. The resulting PD pattern then could be seen predominantly at the 225° angular position in A-C1, B-C1 & C-C1 Phases.
- **A-4.5.2 CROSS-COUPLING:** Some of the patterns presented on all three phases have a significant cross-coupled component, that is, pulse clumps that are reversed in polarity and/or positioned outside of the first quadrant (0°-90°) and third quadrant (180°-270°) of the AC reference sine wave. These are not sources of PD or signs of problems on these phases but rather signals cross-coupled from other phases.

4.1.2 Recommendations

Although this winding now has Moderate PD activity, in the past most couplers indicated High PD activity was present. Thus it is possible the winding is still degrading even though the PD is decreasing, as discussed in [4]. It would be prudent to perform visual inspections and off-line IR/PI tests if these have not already occurred.

LIMITATIONS OF ASSESSMENT

Deterioration due to Partial Discharge is an extremely slow process; however, the prediction of failure is impossible. Eventual failure will occur during a switching surge, poor synchronization, load rejection or some other event causing a breakdown of the weakest point. On-line Partial Discharge tests should be conducted at regular intervals and, where appropriate or indicated, be supplemented with visual inspections and off-line testing. Consistent and regular testing will provide the means to assist plant personnel in determining the overall winding condition. Though some conclusions can be drawn from a single test, the trend at comparable ambient and operating conditions truly evaluates the condition of the winding. Doubling of Partial Discharge over a twelve-months interval often indicates a rapidly deteriorating winding. The plant's history of a machine could be beneficial in deciding the proper course of action.

5 PREVIOUS REPORTS

- Jan 10, 2018 [50362475]
- February 07, 2024 [50510267]
- September 24, 2024 [50532208-1]

6 ATTACHMENTS

- **Attachment 1 (40 pages)**
  Appendix - Interpretation of PD Results

7 REFERENCES

1) IEEE 1434, "IEEE Guide to the Measurement of Partial Discharges in Rotating Machinery"
2) IEC TS 60034-27-2:2012 Rotating electrical machines - Part 27-2: On-line partial discharge measurements on the stator winding insulation of rotating electrical machines
3) 2021 Iris Power Partial Discharge Severity Tables, available online: https://irispower.com/online-partial-discharge-severity-tables/.
4) G.C. Stone, et al, "Electrical Insulation for Rotating Machines, Second Edition, 2014, Wiley/IEEE Press., P411.