Q. **i**. Why did Hydro use a third-party expert and not the OEM to conduct an on-site inspection during the 2024 annual outage?

ii. Please provide the name of the third-party expert used by Hydro, and copies of any reports provided to Hydro, in the assessment of the runners in 2024.

A. **i.** The on-site inspection of the runners during the 2024 annual outage was intended to confirm the findings of the original equipment manufacturer ("OEM"), and provide additional analysis on the recommended solution. The OEM did not submit a bid on the tender issued by Newfoundland and Labrador Hydro ("Hydro") for the on-site inspection and Hydro selected the third-party expert in Pelton runners from the bid proponents as best suited to complete this assessment.

ii. Hydro engaged GE Vernova Inc. to complete the third-party runner assessment at Cat Arm Hydroelectric Generating Station. Please refer to PUB-NLH-007 for the associated report.

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Subject/Project: **CAT ARM RUNNER INSTALLATION ASSESSMENT**

Title: **TURBINE AND GENERATOR U1, U2, AND SPARE RUNNER INSPECTION REPORT**

Ref. number: **27293400MEP00-PA00DC-05**

Summary:

REFERENCE DOCUMENTS :

CONTRACT NUMBER: 272934

CLIENT: NEWFOUNDLAND HYDRO

CLIENT DISTRIBUTION: YES ☒

NO ☐

Rev.	Date	Established	Checked	Approved	Modification
A	2024.11.12	MAHDI GHOURCHI	J. COMTOIS GOULET	D. AUGER-HABEL	REVISION
-	2024.10.17	MAHDI GHOURCHI	MAHDI GHOURCHI	D. AUGER-HABEL	First issue

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TABLE OF CONTENTS

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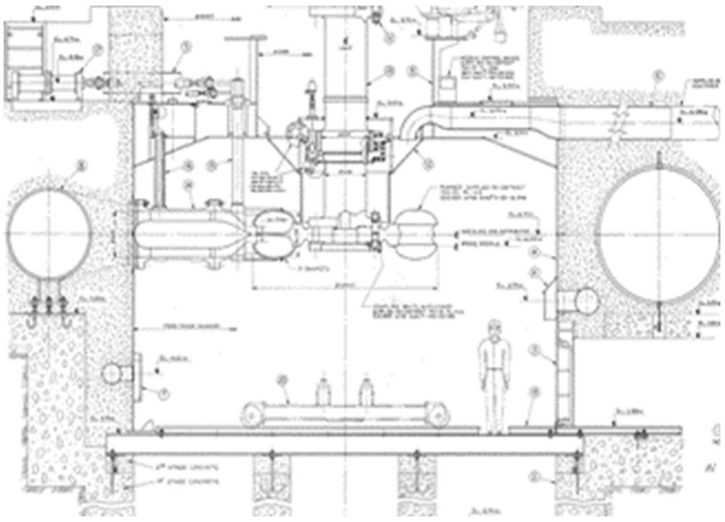
1 PROJECT INTRODUCTION

Location:	Newfoundland and Labrador, Canada NL Hydro
Turbine:	Pelton Type-Vertical configuration
Total:	2 units
Turbine	Synch speed –327 .3rpm
Runner Dia:	3045mm
Rated Flow:	20.14m3/sec
Rated output:	68.2MW
QTY of Jets:	6pcs



2 FOREWORD

This document report results following inspection:

- The turbine runner and shaft, including a visual inspection and magnetic particle testing (MT) of these components described in 27293400MEP00-PA00 DC-02
- The rotor pole height relative to the stator core was measured in both Unit 1 and Unit 2as described in 27293400MKA00-PA00 DC-01.

The inspection of Unit 1 was conducted from September 3rd to September 6th, while the inspection of Unit 2, including the spare runner, was carried out from September 23rd to September 26th.

3 EHS

This technical document outlines the scope of work to be performed. Environmental, Health, and Safety (EHS) aspects will be managed by NLH. Special attention must be given to hazards such as lead-based paint, asbestos, confined spaces, and Lockout/Tagout (LOTO) requirements. In alignment with the customer's safety protocols, Fall Protection and Confined Space training has been completed at the NL workplace, comprising a total of 32 hours.

All safety requirements were reviewed and followed prior to traveling to the project site and performing tasks, ensuring full compliance with GE and the customer's safety regulations, including the following:

Kickoff Meeting:

- Conducted a kickoff meeting with GE Safety Officer, Christopher Witkop, to discuss specific safety. Advice and comments based on the general conditions of the project.

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Fit Test: Proceeded with the fit test for respiratory usage to ensure compliance with safety requirements.

Hazardous Material Check:

- Checked for the presence of lead and asbestos in the inspection zones. Due to insufficient information, the working area has been assumed to contain both lead and asbestos as a precaution.

LOTO Procedure:

- Reviewed the Lockout/Tagout (LOTO) procedure with the customer and conducted a walkthrough of the LOTO process.

Grounding System:

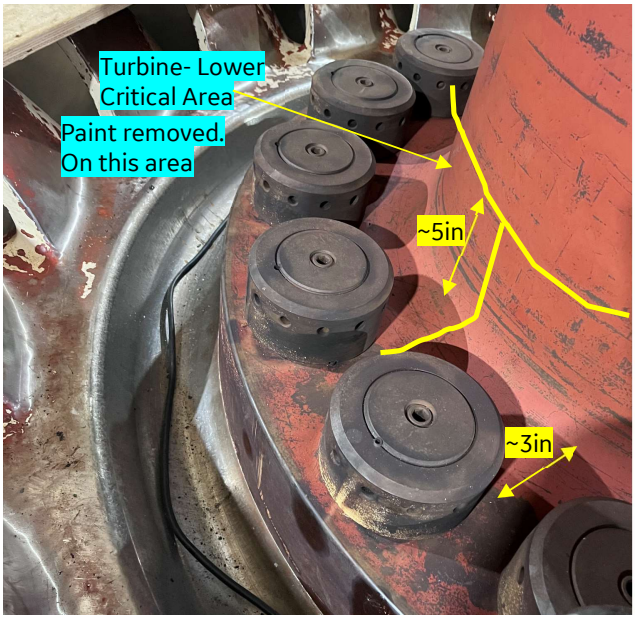
- Double-checked the grounding system to ensure proper safety measures were in place.

Mandatory Training:

- Completed mandatory confined space and fall protection training provided by Workplace NL (32 hours).

4 TURBINE SHAFT INSPECTION PREPARATION AND NON DESTRUCTIVE TESTS

To allow access for the shaft inspection, the bearing support extension was dismantled and removed. It was required to remove the paint from the shaft's high-stress zone in order to conduct the visual and magnetic particle (MT) tests. The high-stress zones at both the top and bottom, which were cleaned and tested, are located at the interface between the flange and the journal. The image below shows the cleaned area prepared for testing.



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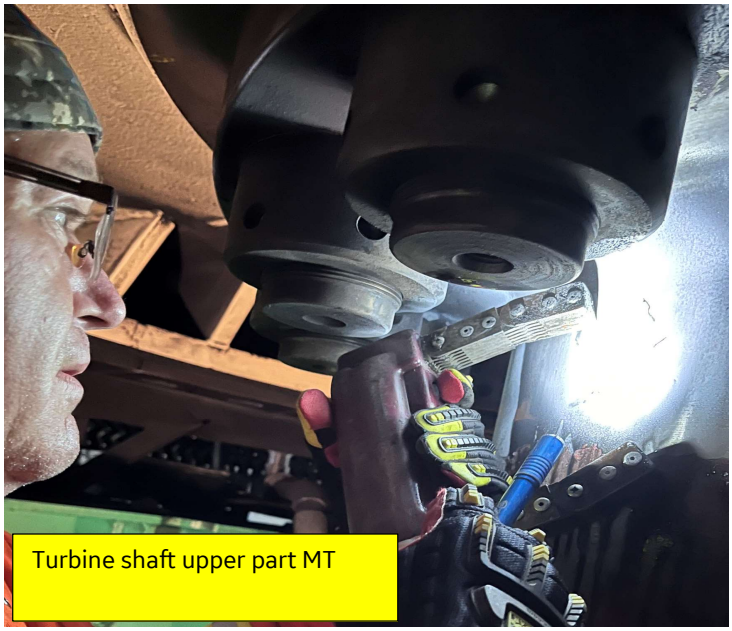
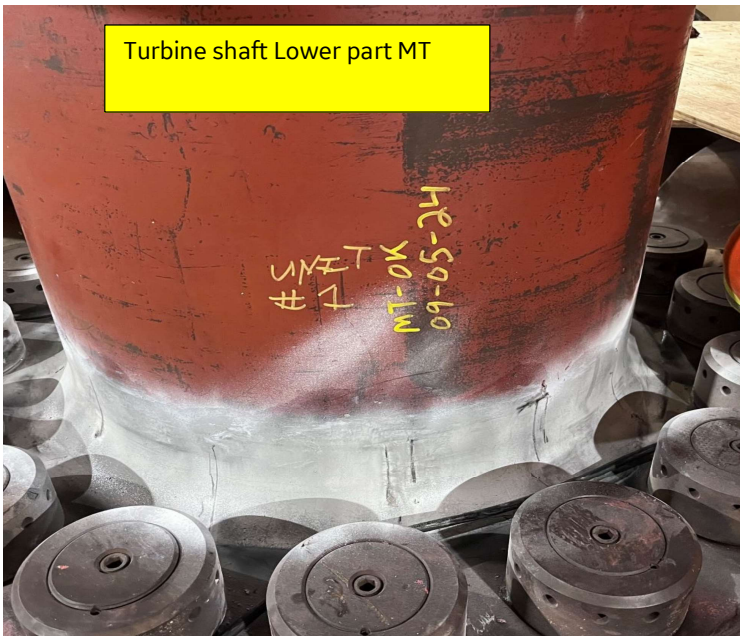
4.1 NDT-MAGNETIC PARTICLE TEST(MT)

After cleaning the turbine shaft and removing the paint, both the top and bottom critical zones were visually inspected, with no indications of defects observed. Following the visual inspection (VT), magnetic particle testing (MT) was performed on both the top and bottom areas of the shaft. No indications were found during the MT inspection. The MT test procedure and results are shown in the following pictures.





Turbine Shaft MT Result- U1

CFM

430 Bayside Dr. Unit SJ2,
Saint John, NB E2J 1A8
Tel: (506)648-2226

27 Clyde Ave.
Mount Pearl NL A1N 4R8
Tel: (709)728-2687

MAGNETIC PARTICLE EXAMINATION REPORT			NDE REPORT No.: MT- 9/09/24-GK-2
PROJECT No.	CUSTOMER: GE	CUSTOMER'S PO NO.	PAGE: 1 of 1
IDENTIFICATION: Turbine flange upper/lower on Unit #1		DRAWING NO.: See Below	DATE OF EXAMINATION: Sept.5 & 6 /2024
LOCATION: Cat Arm station	PART/WELD NO.: See Below	EQUIPMENT USED / SERIAL NO.: Magnaflux Yoke/ SN: N2042	CAL. DUE DATE: Nov.25, 2024
METHOD: Amps: ____ Ampere Turns: ____ [√] Wet [√] AC [√] Yoke [ ] Direct [ ] Central Conductor [ ] Dry [ ] DC [ ] Prods [ ] Coil [ ] Other: ____		EXAMINATION: [√] Initial [ ] Repair No. ____	NDE PROCEDURE NO.: SOP 520.13; CODE/SPEC: Client Info
VIEWING CONDITIONS: Good	LIFTING FORCE: 10 Lbs.	DEMAGNETIZATION REQUIRED: [ ] YES [√] NO	
RESULTS: [ ] Acceptable [ ] Rejectable [√] N/A (for information only)			

Scope:
This report covers the Magnetic Particle Examination of Turbine upper and lower flanges.

Results:
At the time of examination, no relevant or rejectable indications were found.

TECHNICIAN	Certified	Level	CUSTOMER'S REPRESENTATIVE
Name: GUY KETTLE	CGSB #4348	II	Date:
Signature:	Date: Sept.6,2024		AUTHORIZED INSPECTOR
Reviewed By:	Date:		Date:

CFM-011 Rev 1

Turbine Shaft MT Result- U2

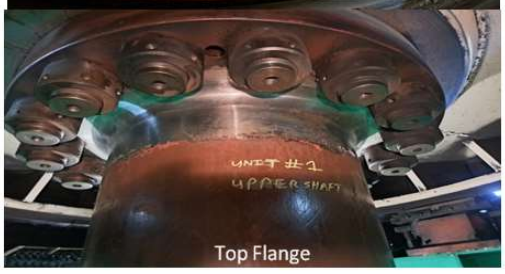
CFM

430 Bayside Dr. Unit SJ2,
Saint John, NB E2J 1A8
Tel: (506)648-2226

27 Clyde Ave.
Mount Pearl NL A1N 4R8
Tel: (709)728-2687

MAGNETIC PARTICLE EXAMINATION REPORT			NDE REPORT No.: MT- 24/09/24-GK-1
PROJECT No.	CUSTOMER: GE	CUSTOMER'S PO NO.	PAGE: 1 of 1
IDENTIFICATION: Turbine flange upper/lower on Unit #2		DRAWING NO.: See Below	DATE OF EXAMINATION: Sept.24 /2024
LOCATION: Cat Arm station	PART/WELD NO.: See Below	EQUIPMENT USED / SERIAL NO.: Magnaflux Yoke/ SN: N2042	CAL. DUE DATE: Nov.25, 2024
METHOD: Amps: ____ Ampere Turns: ____ [√] Wet [√] AC [√] Yoke [ ] Direct [ ] Central Conductor [ ] Dry [ ] DC [ ] Prods [ ] Coil [ ] Other: ____		EXAMINATION: [√] Initial [ ] Repair No. ____	NDE PROCEDURE NO.: SOP 520.13 CODE/SPEC: Client Info
VIEWING CONDITIONS: Good	LIFTING FORCE: 10 Lbs.	DEMAGNETIZATION REQUIRED: [ ] YES [√] NO	
RESULTS: [ ] Acceptable	[ ] Rejectable	[√] N/A (for information only)	

Scope:
This report covers the Magnetic Particle Examination of Turbine upper and lower flanges. Unit # 2



Results:
At the time of examination, no relevant or rejectable indications were found on upper and lower flanges area inspected.

TECHNICIAN	Certified	Level	CUSTOMER'S REPRESENTATIVE
Name: GUY KETTLE	CGSB #4348	II	Date:
Signature:	Date: Sept.24,2024		AUTHORIZED INSPECTOR
Reviewed By:	Date:		Date:

CFM-011 Rev 1

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4.2 RUNNER BUCKETS NDT

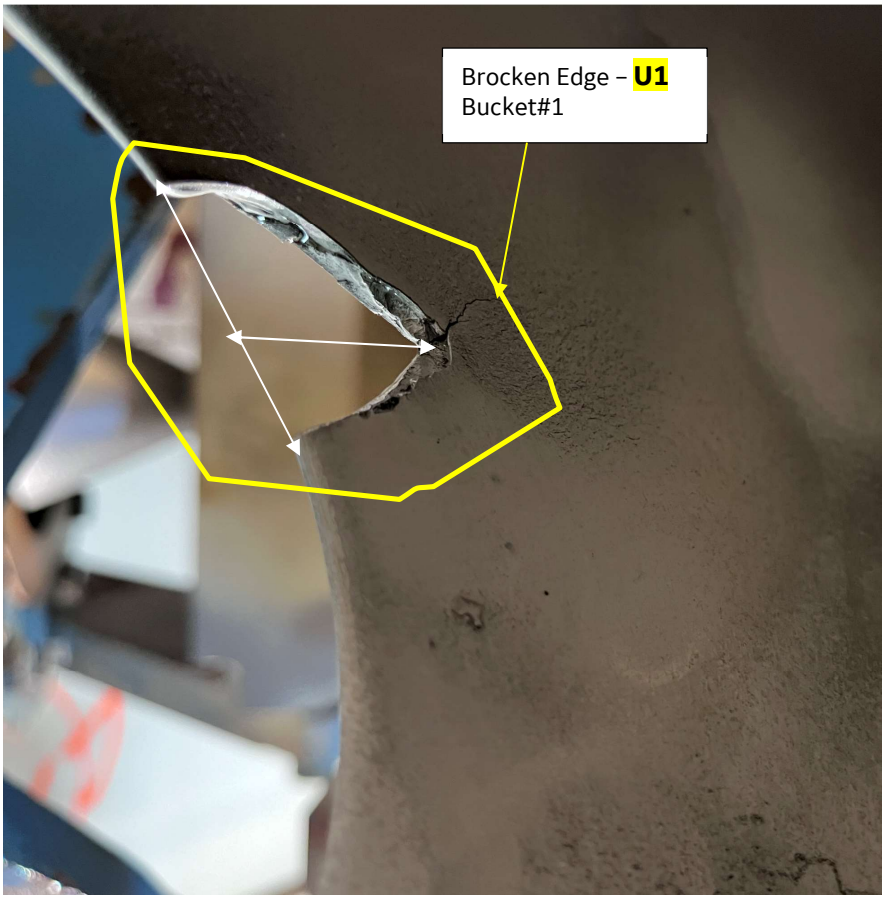
The runner buckets in both Unit 1 and Unit 2 exhibited several defects in various areas, particularly along the outer diameter of the buckets. Deep cavitation defects were observed on the edges of nearly all buckets.

5 UNIT #1

Following is Unit #1 inspection and measuring sections along with relative description.

5.1 RUNNER VISUAL AND MT INSPECTION

During the visual inspection of Bucket #1, in addition to the deep cavity on the bucket outlet edge, it was observed that approximately 50mm by 50mm of material was missing from the edge, with a crack propagating about 15mm along the length of the bucket. Aside from the major mechanical cavitation defects, visible near the outer edges of all buckets, no other issues were identified in the tested buckets. Buckets #1, #6, #8, and #12 underwent magnetic particle testing (MT). The following are pictures of the damaged spots on the buckets identified during the visual inspection (VT).



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Buckets Cavitation

The depth of cavitation in the buckets outer part measured 1 to 3mm. in this area the bucket thickness is around 5mm. Repair should be performed in the short.

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Unit #1 Runner MT Result

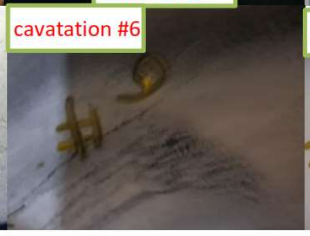
CFM

430 Bayside Dr. Unit SJ2,
Saint John, NB E2J 1A8
Tel: (506)648-2226

27 Clyde Ave.
Mount Pearl NL A1N 4R8

MAGNETIC PARTICLE EXAMINATION REPORT				NDE REPORT No.: MT- 5/09/24-GK-1
PROJECT No.	CUSTOMER: GE		CUSTOMER'S PO NO.	PAGE: 1 of 1
IDENTIFICATION: Runner buckets # 1, 6, 8,and 12 on Unit #1			DRAWING NO.: See Below	DATE OF EXAMINATION: Sept.5/2024
LOCATION: Cat Arm Station	PART/WELD NO.: See Below	EQUIPMENT USED / SERIAL NO.: Magnaflux Yoke/ SN: N2042		CAL. DUE DATE: Nov.25, 2024
METHOD: Amps: ____ Ampere Turns: ____ [√] Wet [√] AC [√] Yoke [ ] Direct [ ] Central Conductor [ ] Dry [ ] DC [ ] Prods [ ] Coil [ ] Other: ____			EXAMINATION: [√] Initial [ ] Repair No. ____	NDE PROCEDURE NO.: SOP 520.13; CODE/SPEC: Client Info
VIEWING CONDITIONS: Good	LIFTING FORCE: 10 Lbs.		DEMAGNETIZATION REQUIRED: [ ] YES [√] NO	
RESULTS: [ ] Acceptable	[ ] Rejectable	[√] N/A (for information only)		

Scope:
This report covers the Magnetic Particle Examination of Runner buckets # 1, 6, 8, and 12 as directed by GE.



Results:
At the time of examination, a crack was found at mechanical damaged area approximately 15MM long on bucket #1 at mechanical damage area. See attached pictures.
Number 1 bucket was totally MT inspected inside and outside
Buckets number 6, 8, and 12 croutch area only was MT inspected.
Areas inspected on number 6, 8, and 12 had no indications present.
Cavatation damage exists on all buckets inspected. MT was also performed on these areas with no linear indications found.

TECHNICIAN	Certified	Level	CUSTOMER'S REPRESENTATIVE
Name: GUY KETTLE	CGSB #4348	II	Date:
Signature:	Date: Sept.5,2024		AUTHORIZED INSPECTOR
Reviewed By:	Date:		Date:

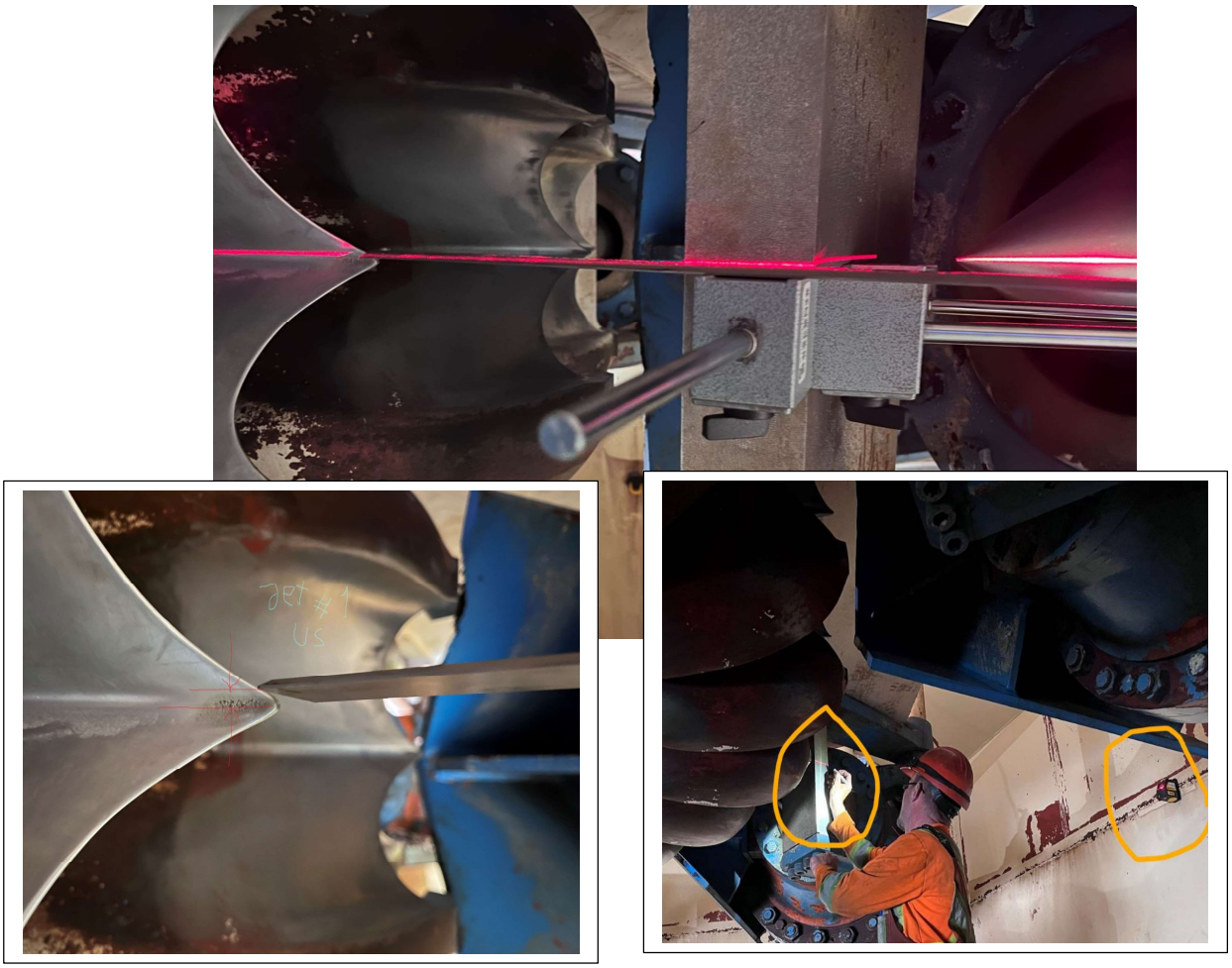
CFM-011 Rev 1

5.2 RUNNER ELEVATION CHECK AND MEASUREMENT

The runner elevation measurements relative to the injector tips were taken. A discrepancy of a few millimeters was found between the bucket tips and injector tips, exceeding the acceptable tolerance levels. The average deviation for the six injectors was 3.5mm, while the tolerance limit is 1.7mm. Several factors contributed to this deviation, such as:

1. **Tool Accuracy:** The measuring tool used was a self-leveling laser, which may lack the precision required for accurate measurements.
2. **Injector Elevation:** The deviation may stem from the misalignment of the injectors relative to one another.
3. **Runner Manufacturing:** Variations in the manufacturing process may have led to discrepancies in the tips of the runner buckets.
4. **Initial Machine Settings:** Since all readings indicated that the bucket tips were below the injectors, this could be attributed to the initial settings of the machine.
5. **Excessive Deflection:** The upper bracket may experience excessive deflection due to the weight of the rotating parts.

Following are some pictures and check sheets of runner elevation reading.



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Runner Elevation Reading

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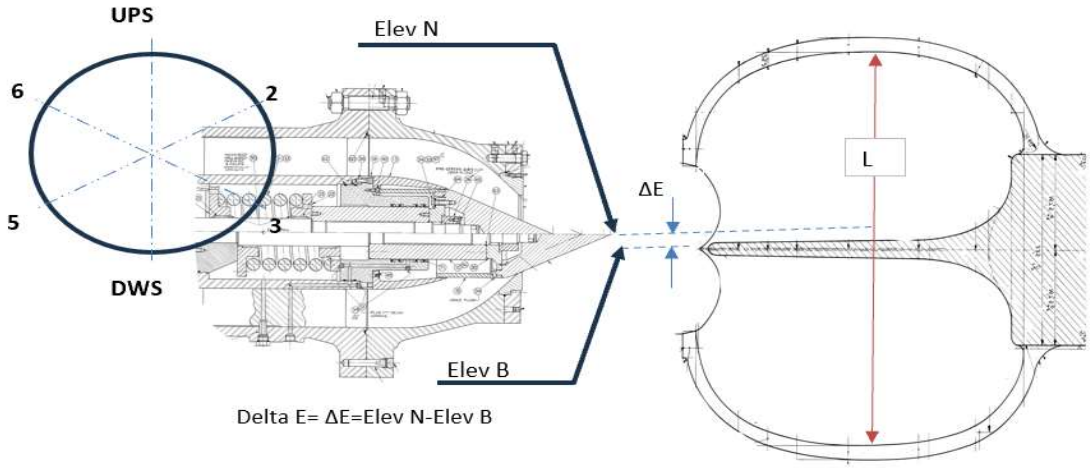
RELEVÉ DE MONTAGE / INSPECTION SHEET

27293401 - MEP00-EQR102	Rev. -

Titre / Title:	**Runner Center Line Elevation measuring**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	1 de/of 3
		1	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	
Projet / Project:	**Cat Arm**		Reading Date	**9/6/2024**

Narrative: the nazel jet elevation should check with runner bucket tip for measuring the devation



Delta E= ΔE=Elev N-Elev B

Nozel No.	1-UPS	2	3	4-DWS	5	6	AVG
Delta E(mm)	5.52	1.02	2.41	4.9	2	4.27	3.35
Delta E Tolerance= 0.25% of L			**0.0025*690=1.72mm**			**AVG-PD= 1.81mm**	

Note: Elev N= Nozel(jet) elevation and Elev B= Runner Bucket Centerline Elevation.
PD: Permissible Deviation

Measuring device(s)

Tool	**Caliper 8in**	**straight bar**	**laser beam**	**....**
Calibration#	**N/A**	**N/A**	**N/A**	
Cal. Due Date				

Taken	Checked	Confirmed	Witnessed(client)
Chad Smith	**Mahdi. Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
Date: 9/6/2024	Date 9/6/2024	Date: 9/6/2024	Date

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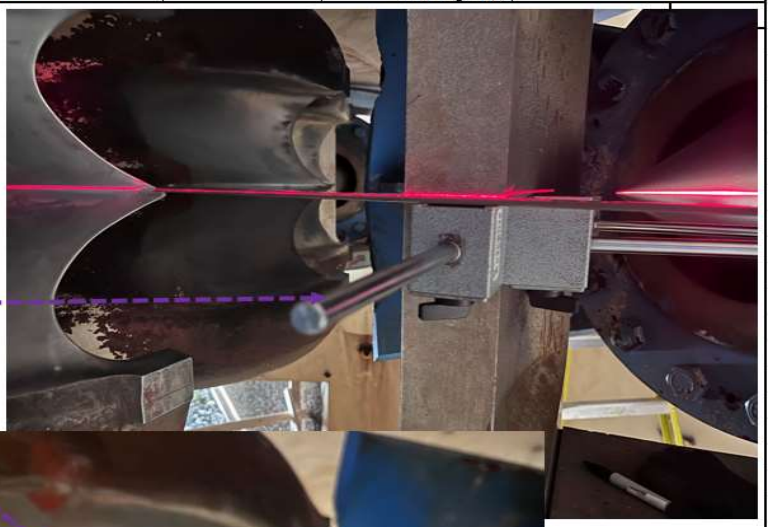
RELEVÉ DE MONTAGE / INSPECTION SHEET

27293401 - MEP00-EQR102	Rev. -

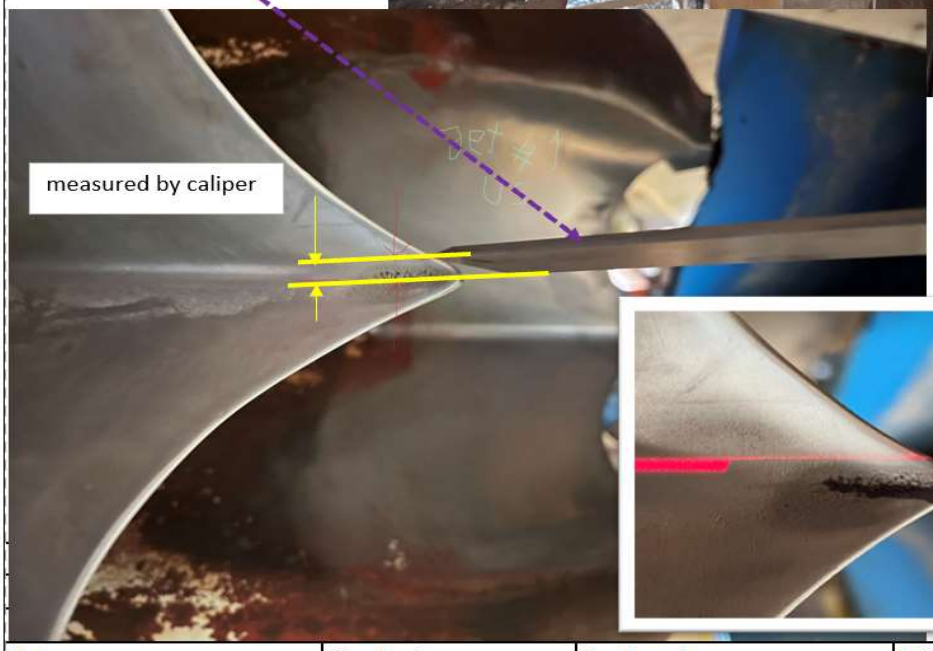
Titre / Title:	**Runner Center Line Elevation measuring**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	2 de/of 3
		1	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	
Projet / Project:	**Cat Arm**		Reading Date	**9/6/2024**

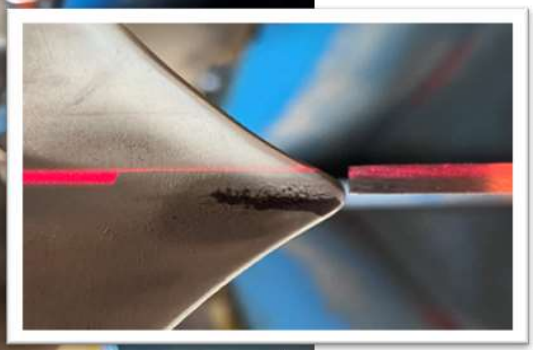
stright edge and magnatic support used along with laser beam to achive percise method for checking the runner center with Jets.



Magnetic Support

Machined Bar





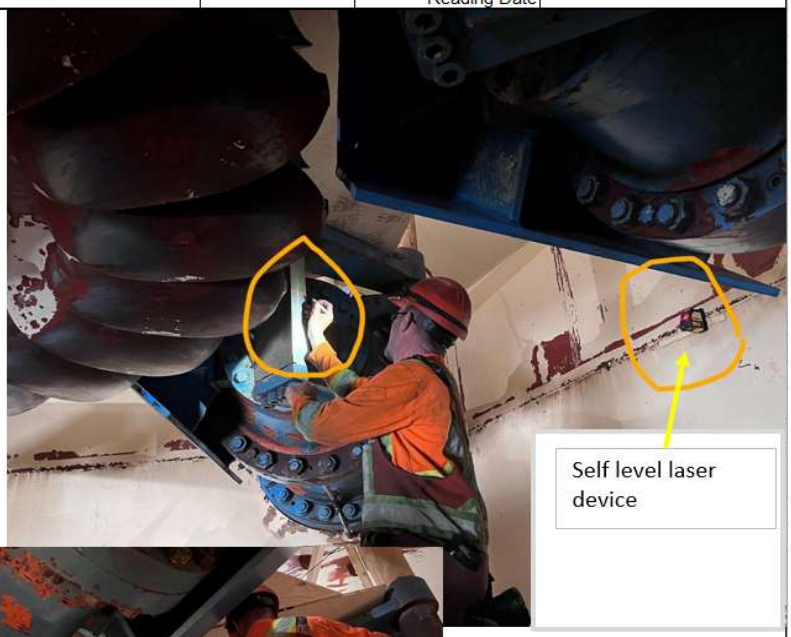
Taken	Checked	Confirmed	Witnessed(client)
Chad Smith	**Mahdi. Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
.....			
Date: 9/6/2024	Date 9/6/2024	Date: 9/6/2024	Date 9/6/2024

RELEVÉ DE MONTAGE / INSPECTION SHEET

GE VERNOVA

27293401 - MEP00-EQR102	Rev. -

Titre / Title:	**Runner Center Line Elevation measuring**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	3 de/of 3
		1	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	
Projet / Project:	**Cat Arm**		Reading Date	**9/6/2024**



Taken	Checked	Confirmed	Witnessed(client)
Chad Smith	**Mahdi. Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
..... Date: 9/6/2024	Date 9/6/2024	Date: 9/6/2024	Date 9/6/2024

5.3 ROTOR POLE HEIGHT READING

In addition to the turbine inspection and measurements, the generator's magnetic center was checked and measured. It was initially requested to remove the upper and lower shrouds to access the top and bottom of the poles. However, due to resource and schedule constraints, only one shroud on the upstream side and one on the downstream side, from both the top and bottom, were removed. This provided access to approximately 1.5 poles for measurement.

Although measurements of the air gap at the top and bottom of the generator were requested, it could not be taken due to a lack of proper tooling. Nevertheless, the 2023 air gap measurements were available, and it was determined that updated readings for 2024 were not technically mandatory.

Based on readings from 4 poles on both the upstream and downstream sides, at the top and bottom (as shown in the following pictures and check sheet), the poles appear to be positioned too high. To align them with the stator core center, each pole will need to be readjusted and lowered to match the center of the stator core.

Several root causes are associated with the deviation in pole height readings from the stator core center, including the following:

1. **Initial Misalignment of Poles:** The poles were not properly adjusted during the initial setup, contributing to the current deviation.

2. **Surface Waviness in Measuring Areas:** Surface irregularities on both the pole and core were observed, with an expected impact of 5 to 10% of the air gap. This factor cannot be corrected and should remain "as is."

3. **Deviation in Stator Core Elevation:** There is a discrepancy between the calculated and actual stator core elevation. If this is the case, the modification should focus on adjusting the rotor pole position, as no changes can be made to the stator core elevation.

To address these issues, all air shields on both the top and bottom must be removed to allow full access to the measurement areas.

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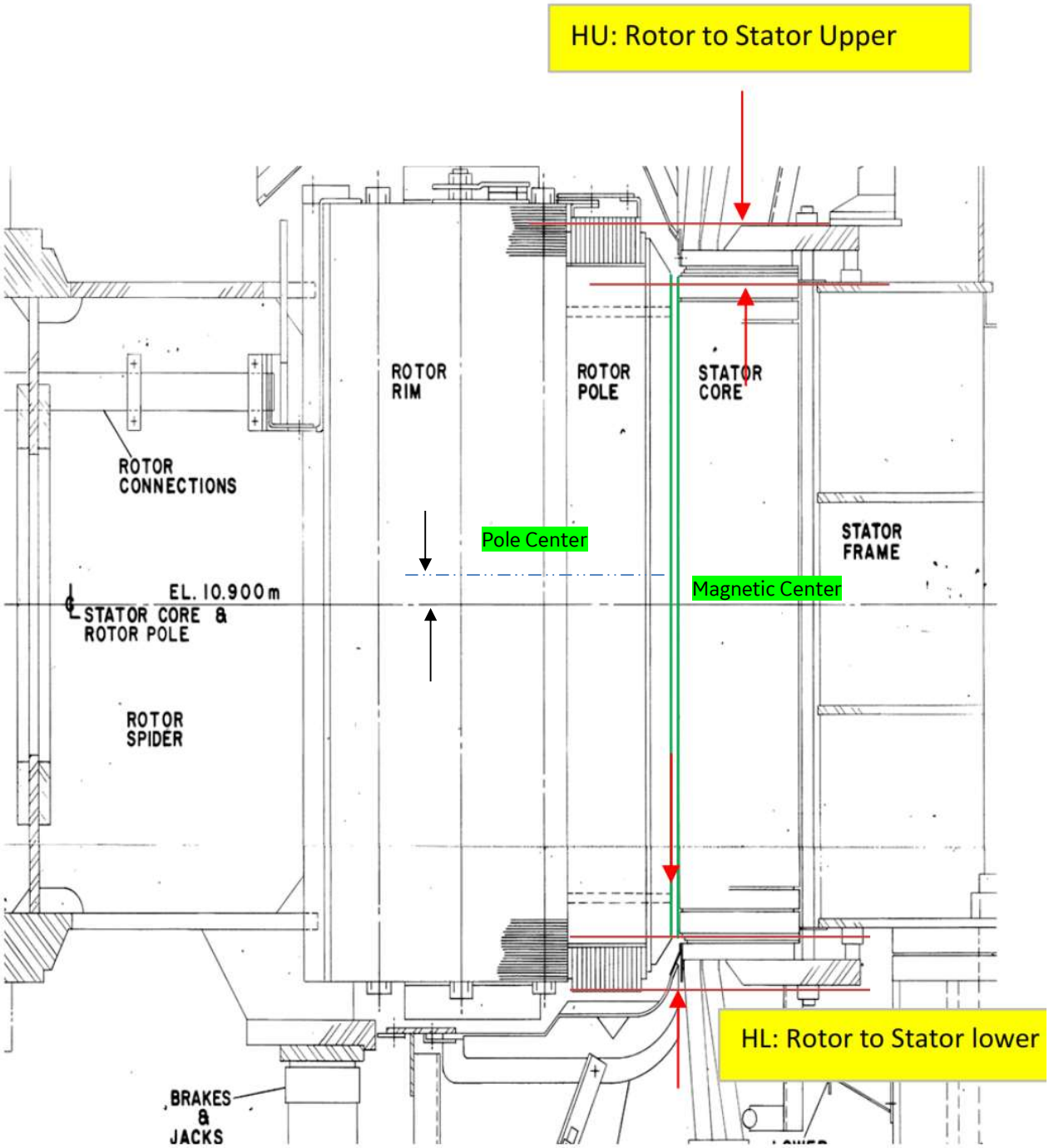

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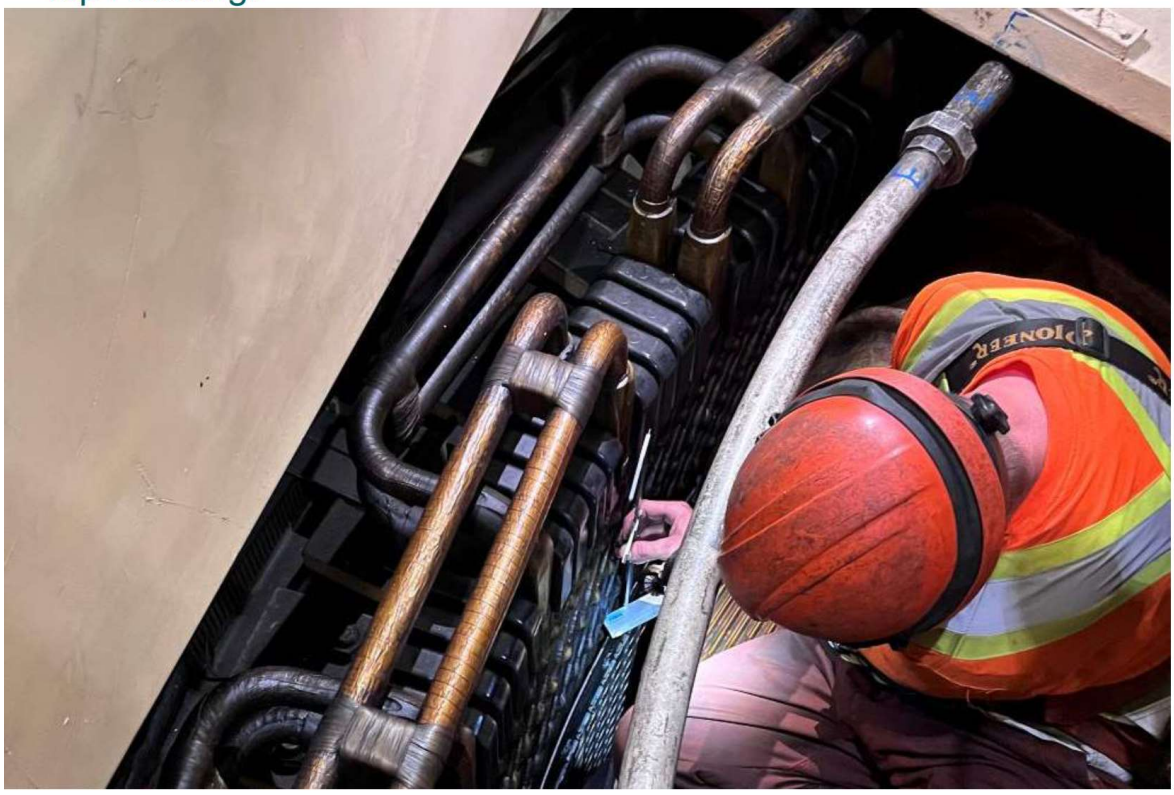
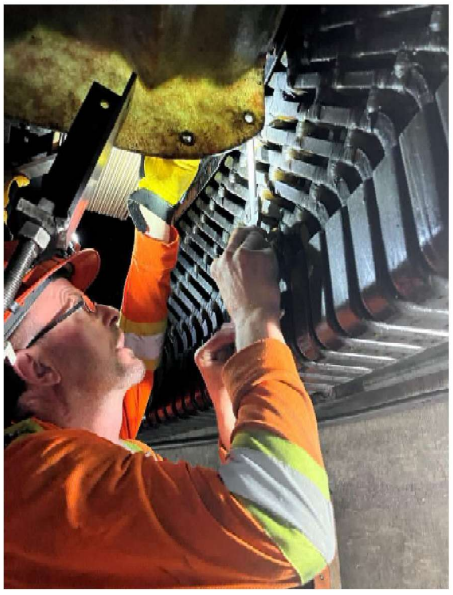
Rotor pole to stator heigh reading.

Top Reading.



Bottom Height Reading



Rotor pole height measuring check sheet.

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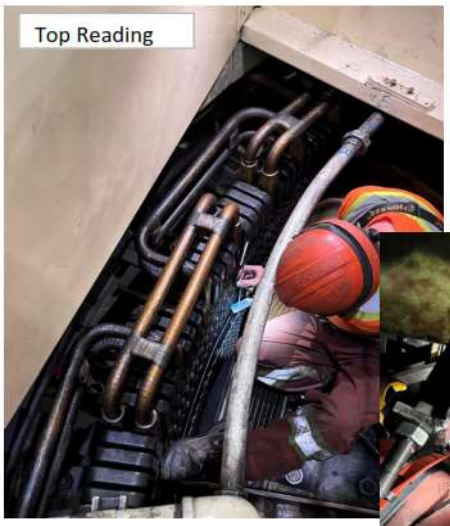
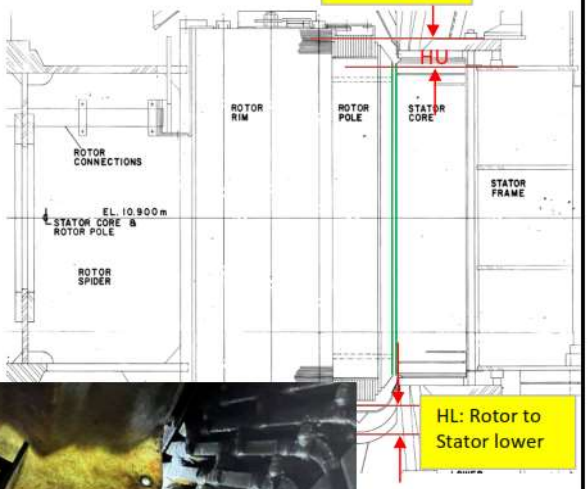
RELEVÉ DE MONTAGE / INSPECTION SHEET

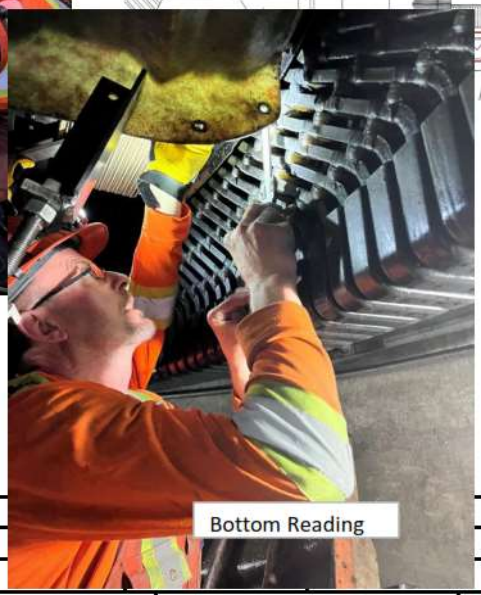
27293401 - MKBxx-EQR101	Rev. -

Titre / Title:	Rotor Pole to Stator Height(Mag. Center)			
Client:	NL Hydro	Groupe / Unit #	Feuille / Sheet:	1 de/of 2
		1	Produit / Product:	
#Projet / Project:	272934		Doc. Reference:	M-1602-170-007
Projet / Project:	Cat Arm		Reading Date	#REF!

value in inch		Top(HU)	Bott(HL)	T-B
Pole #	10	5.805	4.026	1.779
	11	5.65	3.96	1.69
	18	5.56	4.307	1.253
	19	5.558	4.225	1.333
CEATI accepted tolerance: 25% airgap ~0.25in				
AVG Measured deviation: 1.51in				







Measuring device(s)

Tool	**Caliper**		
Calibration#			
Cal. Due Date			

Taken	Checked	Confirmed	Witnessed(client)
Chad Smith	**Mahdi Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
Date: 9/6/2024	Date 9/6/2024	Date: 9/6/2024	Date 9/6/2024

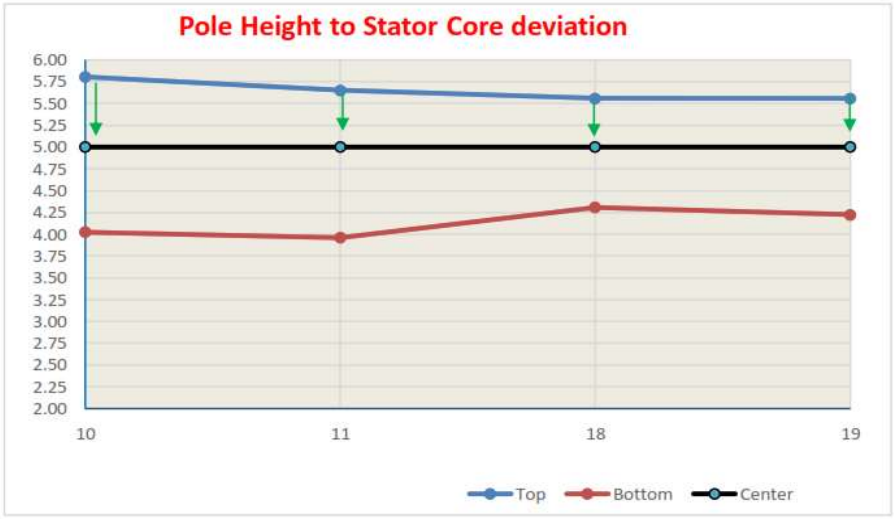
HN PS 1 P T 001 Rev.B

GE VERNOVA

RELEVÉ DE MONTAGE / INSPECTION SHEET

27293401 - MKBxx-EQR101	Rev. -

Titre / Title:	**Rotor Pole to Stator Height(Mag. Center)**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	2 de/of 2
		1	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	**M-1602-170-007**
Projet / Project:	**Cat Arm**		Reading Date	**9/6/2024**



Note: One shroud removed on UPS of stator and one on DWS of statoe on top and bottom. Reading has been taken on one and half pole each side on top and bottom on poles 10, 11, 18, and 19

Based on initial measuring on 3poles hieght to stator core it seems the poles should move down around 3/4 inch
Regarding to this observation, it is required to remove all the air shields on top and bottom of rotor and provide proper tooling and take the measurement on all of the poles and readjust in proper elevation.

Measuring device(s)

Tool	**Caliper**	…	…	….
Calibration#				
Cal. Due Date				

Taken	Checked	Confirmed	Witnessed(client)
Chad Smith	**Mahdi Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
Date: 9/6/2024	Date 9/6/2024	Date: 9/6/2024	Date 9/6/2024

HN PS 1 P T 001 Rev.B

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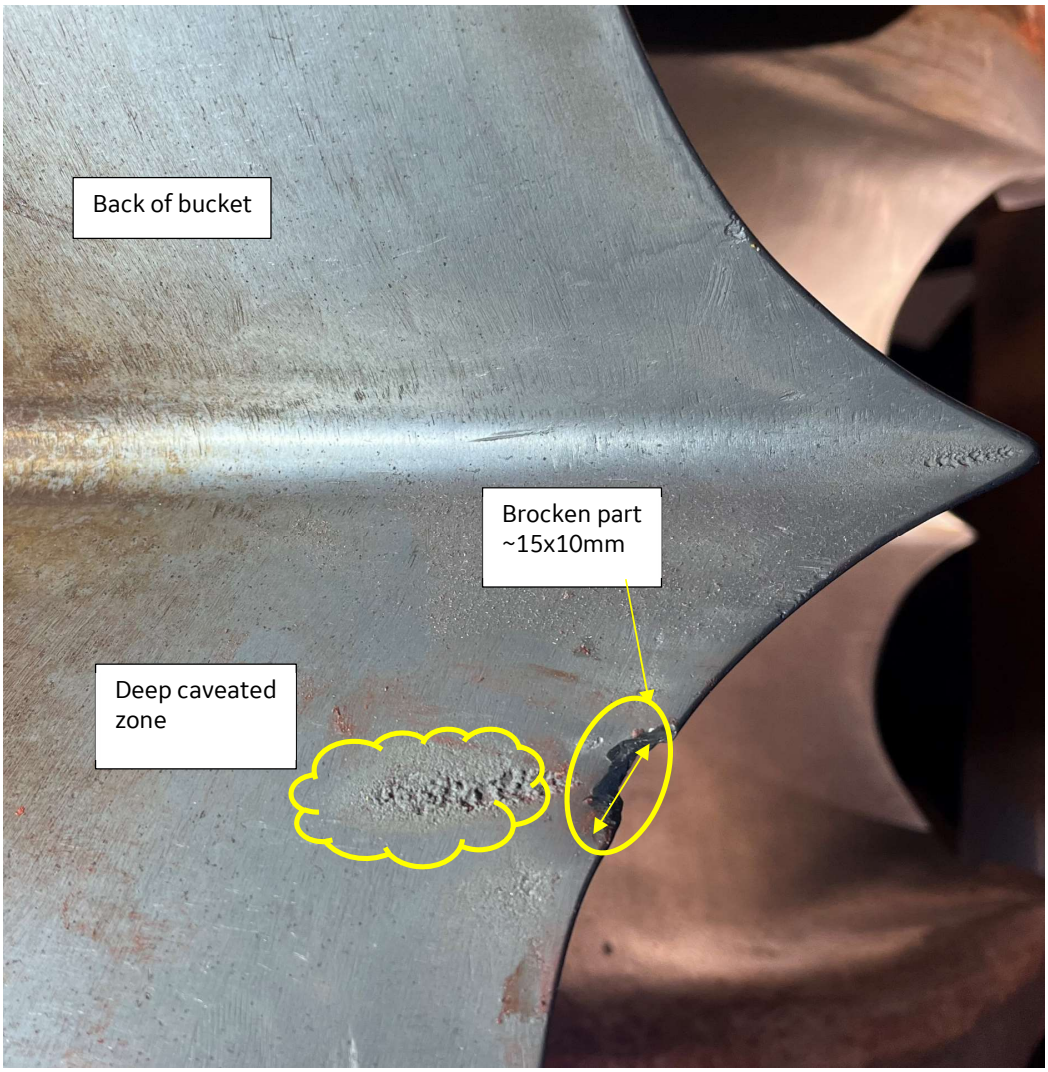
6 UNIT #2

In this section the Unit two inspection and measuring will be described, and the deviations root causes will be analysed.

6.1 RUNNER VISUAL AND MT INSPECTION

During the visual inspection of Bucket #2, in addition to the cavity on the bucket outlet edge, it was observed that approximately15mm by 10mm of material was missing from the bucket's edge, but it did not cause any crack in that bucket. Like unit #1, aside from the major mechanical cavitation defects, visible near the outer edges of all buckets, no other issues were identified in the tested buckets. Buckets #2, #5, #8, and #11, #14, #19, and back of bucket #21 underwent magnetic particle testing (MT). The following are pictures of the damaged spots on the buckets identified during the visual inspection (VT).

Bucket #2 Picture



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Buckets Cavity

The depth of cavitation in the buckets outer part measured 1 to 3mm. in this area the bucket thickness is around 5mm. Repair should be performed in the short-term

Unit #2 Runner MT Result

CFM

430 Bayside Dr. Unit SJ2,
Saint John, NB E2J 1A8
Tel: (506)648-2226

27 Clyde Ave.
Mount Pearl NL A1N 4R8
Tel: (709)728-2687

MAGNETIC PARTICLE EXAMINATION REPORT			NDE REPORT No.: MT- 25/09/24-GK-1
PROJECT No.	CUSTOMER: GE	CUSTOMER'S PO NO.	PAGE: 1 of 1
IDENTIFICATION: Runner buckets # 2,5, 8, 11, 14 , 19 and back of # 21 Unit # 2		DRAWING NO.: See Below	DATE OF EXAMINATION: Sept.25/2024
LOCATION: Cat Arm Station	PART/WELD NO.: See Below	EQUIPMENT USED / SERIAL NO.: Magnaflux Yoke/ SN: N2042	CAL. DUE DATE: Nov.25, 2024
METHOD: Amps: ____ Ampere Turns: ____ [√] Wet [√] AC [√] Yoke [ ] Direct [ ] Central Conductor [ ] Dry [ ] DC [ ] Prods [ ] Coil [ ] Other: ____		EXAMINATION: [√] Initial [ ] Repair No. ____	NDE PROCEDURE NO.: SOP 520.13 CODE/SPEC: Client Info
VIEWING CONDITIONS: Good	LIFTING FORCE: 10 Lbs.	DEMAGNETIZATION REQUIRED: [ ] YES [√] NO	
RESULTS: [ ] Acceptable	[ ] Rejectable	[√] N/A (for information only)	

Scope:

This report covers the Magnetic Particle Examination of Runner buckets # 2,5,8,11,14,19,& 21 as directed by GE.

Results:

Bucket # 2 has mechanical damage (broken edge), no linear indications were found
At the time of examination, 6 bucket croutch areas were inspected. No linear indications were found.
Cavatation damage exists on all buckets inspected. MT was also performed on these areas with no linear indications found.
See attached pictures.

TECHNICIAN	Certified	Level	CUSTOMER'S REPRESENTATIVE
Name: GUY KETTLE	CGSB #4348	II	Date:
Signature:	Date: Sept.25,2024		AUTHORIZED INSPECTOR
Reviewed By:	Date:		Date:

CFM-011 Rev 1

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6.2 RUNNER ELEVATION CHECK AND MEASUREMENT

The runner elevation measurements relative to the injector tips were taken. Runner to jet alignment is within IEC 60193.

Runner Elevation measurement by self-leveling laser beam

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Unit #2 Runner elevation Reading Check Sheet.

RELEVÉ DE MONTAGE / INSPECTION SHEET

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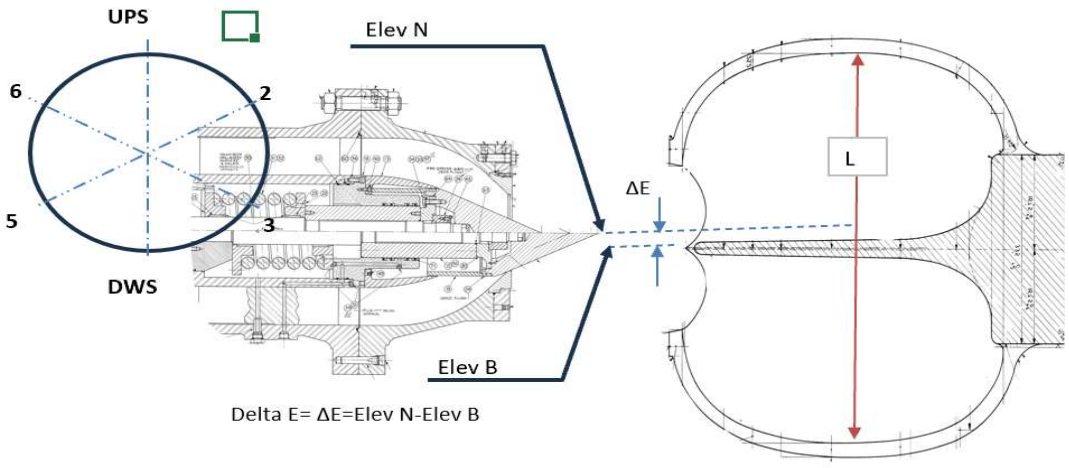
27293402 - MEP00-EQR102	Rev. -

Titre / Title:	**Runner Center Line Elevation measuring**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	1 de/of 2
		2	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	
Projet / Project:	**Cat Arm**		Reading Date	**9/25/2024**

Narrative: the nazel jet elevation should check with runner bucket tip for measuring the devation



Delta E= ΔE=Elev N-Elev B

Nozel No.	1-UPS	2	3	4-DWS	5	6	AVG
Delta E(mm)	0	0	1.5	0	0	0	0.25
Delta E Tolerance= 0.25% of L	**0.0025*690=1.72mm**						

Note: Elev N= Nozel(jet) elevation and Elev B= Runner Bucket Centerline Elevation.
PD: Permissible Deviation

Measuring device(s)

Tool	Caliper 8in	straight bar	laser beam	....
Calibration#	N/A	N/A	N/A	
Cal. Due Date	N/A	N/A	N/A	

Taken	Checked	Confirmed	Witnessed(client)
Adam	**Mahdi. Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
Date: 9/25/2024	Date 9/25/2024	Date: 9/25/2024	Date

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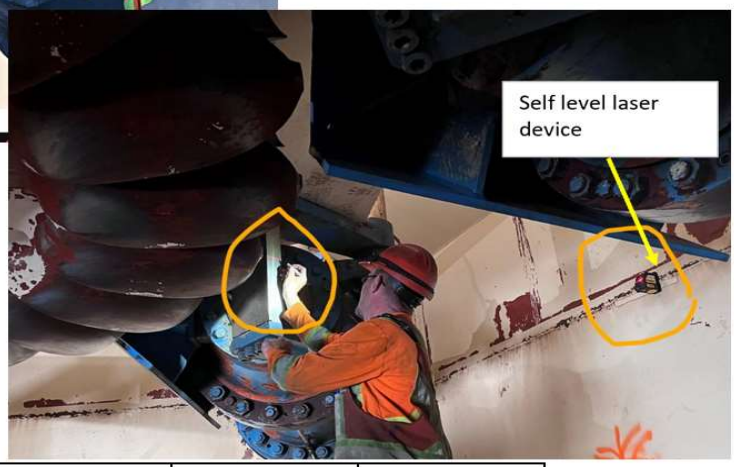
RELEVÉ DE MONTAGE / INSPECTION SHEET

27293402 - MEP00-EQR102	Rev. -

Titre / Title:	**Runner Center Line Elevation measuring**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	2 de/of 2
		2	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	
Projet / Project:	**Cat Arm**		Reading Date	**9/25/2024**



Measuring device(s)

Tool		…	…	….
Calibration#				
Cal. Due Date				

Taken	Checked	Confirmed	Witnessed(client)
Adam	**Mahdi. Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
…..			
Date: 9/25/2024	Date 9/25/2024	Date: 9/25/2024	Date 9/25/2024

6.3 ROTOR POLE HEIGHT READING

the generator's magnetic center was checked and measured. However, due to resource limitations and scheduling constraints, only one shroud on the UPS side and one shroud on the DWS side, both top and bottom, were removed. This allowed access to 1.5 poles on each side.

By 4 poles elevation reading, magnetic axis alignment exceeded the CEATI tolerance. . However, based on the readings from these four poles in Unit 1, the poles are generally better positioned relative to Unit 1. As shown in the attached check sheet, two of the poles are within the acceptable tolerance range according to CEATI standards, while the other two require repositioning. For a more accurate analysis and precise measurements, the removal of all shrouds on both the top and bottom is essential. The root causes of the misalignment are consistent with those observed in Unit #1, including:

Initial Misalignment of Poles: The poles were not properly adjusted during the initial setup, contributing to the current deviation.

1. **Surface Waviness in Measuring Areas:** Surface irregularities on both the pole and core were observed, with an expected impact of 5 to 10% of the air gap. This factor cannot be corrected and should remain "as is."

2. **Deviation in Stator Core Elevation:** There is a discrepancy between the calculated and actual stator core elevation. If this is the case, the modification should focus on adjusting the rotor pole position, as no changes can be made to the stator core elevation.

In next outage of the machine, it is recommended to check all poles height and readjusted with magnetic center.

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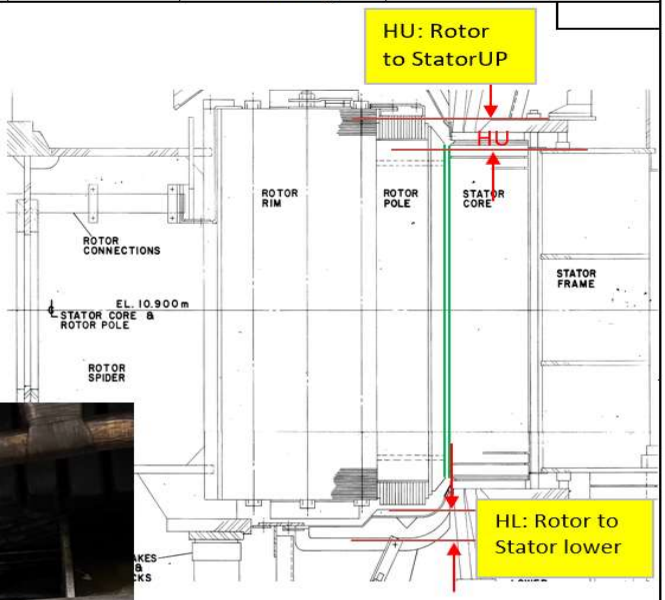
RELEVÉ DE MONTAGE / INSPECTION SHEET

27293402 - MKB00-EQR101	Rev. -

Titre / Title:	**Rotor Pole to Stator Height(Mag. Center)**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	1 de/of 2
		2	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	**M-1602-170-007**
Projet / Project:	**Cat Arm**		Reading Date	**24-Sep-24**

value in inch			Top(HU)	Bott(HL)	T-B
Pole #	UPS	16	127.5	123	4.5
		17	129	124	5
	DWS	5	132.25	121.75	10.5
		6	133	118.5	14.5
CEATI accepted tolerance: 25% airgap ~5.5mm					
AVG Measured deviation: 9mm					



Measuring device(s)

Tool	**Caliper**	…	…	….
Calibration#				
Cal. Due Date				

Taken	Checked	Confirmed	Witnessed(client)
Sid Lilly	**Mahdi Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
Date: 9/24/2024	Date 9/24/2024	Date: 9/24/2024	Date 9/24/2024

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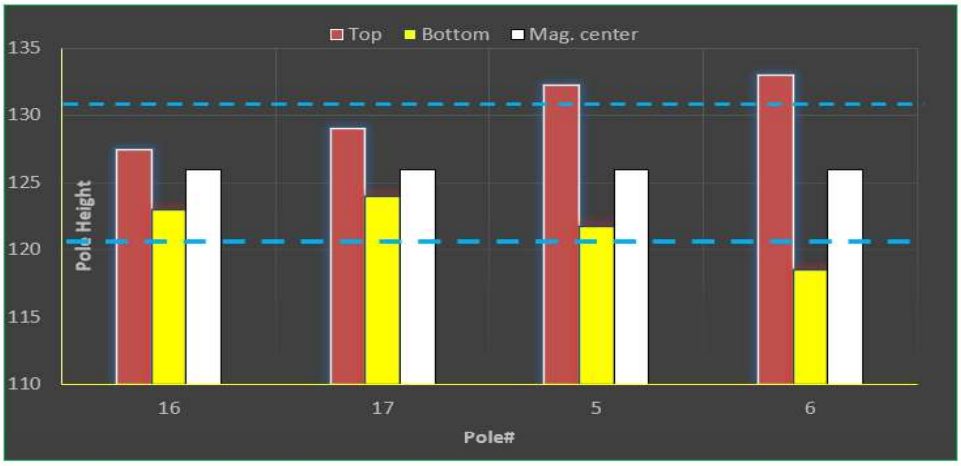
RELEVÉ DE MONTAGE / INSPECTION SHEET

27293402 - MKB00-EQR101	Rev. -

Titre / Title:	**Rotor Pole to Stator Height(Mag. Center)**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	2 de/of 2
		2	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	**M-1602-170-007**
Projet / Project:	**Cat Arm**		Reading Date	**9/24/2024**



Acceptable devation band

Note: One shroud removed on UPS of stator and one on DWS of statoe on top and bottom.

Based these reading on the 4 spots, poles hieght to stator core it seems the poles should move down around 5mm.

Regarding to this observation, it is required to remove all the air shields on top and bottom of rotor and provide proper tooling and take the measurement on all of the poles and readjust in proper elevation.

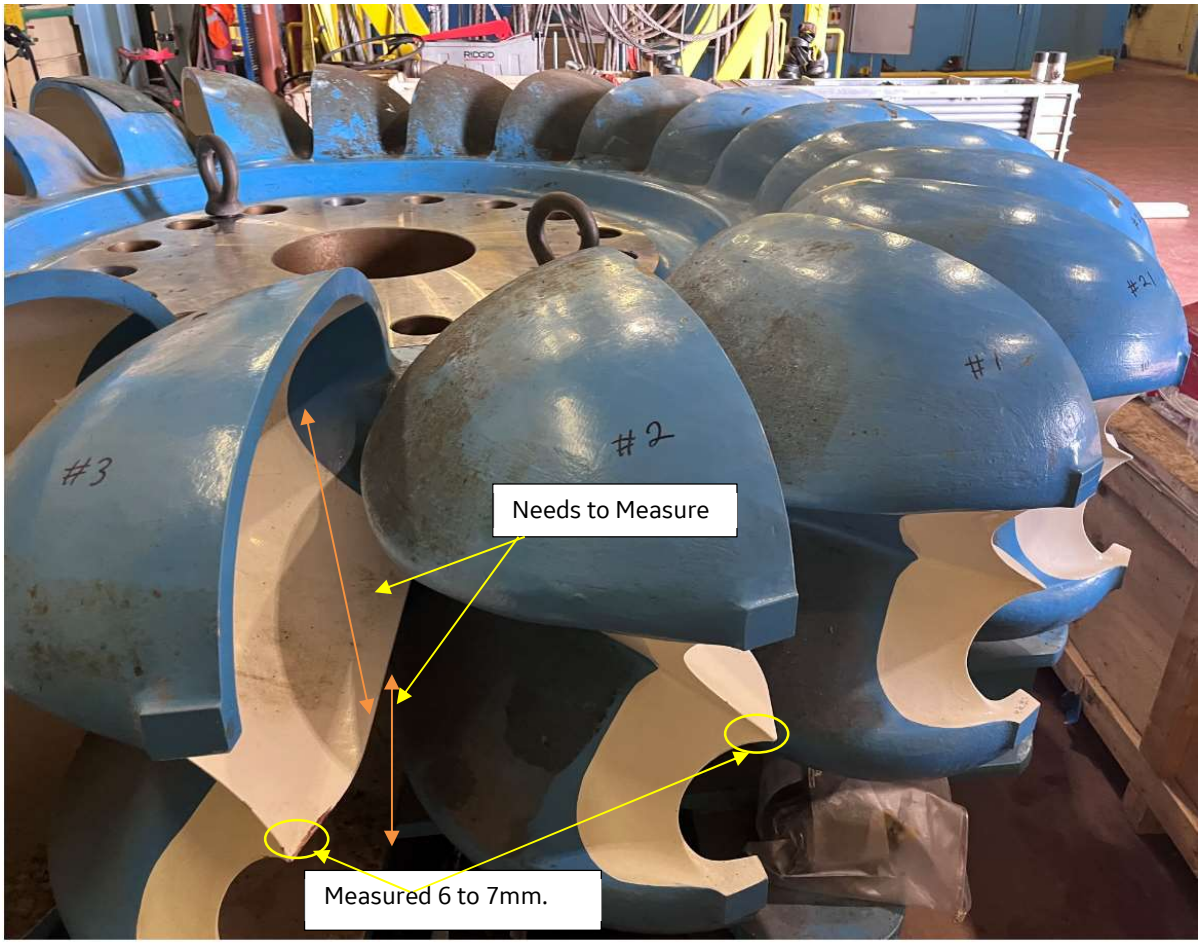
Measuring device(s)

Tool	**Caliper**	…	…	….
Calibration#				
Cal. Due Date				

Taken	Checked	Confirmed	Witnessed(client)
Chad Smith	**Mahdi Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
Date: 9/24/2024	Date 9/24/2024	Date: 9/24/2024	Date 9/24/2024

7 SPARE RUNNER

The spare runner on the generator floor underwent a visual inspection. No VT indications were observed on the painted buckets. The elevation of the bucket tips relative to each other was measured using a self-leveling laser beam and a straight edge. Below are a few images documenting these measurements. Due to tooling constraints and limited resources, the tip measurements were conducted twice. On both occasions, significant deviations in the tip elevations were observed.



Buckets measurement

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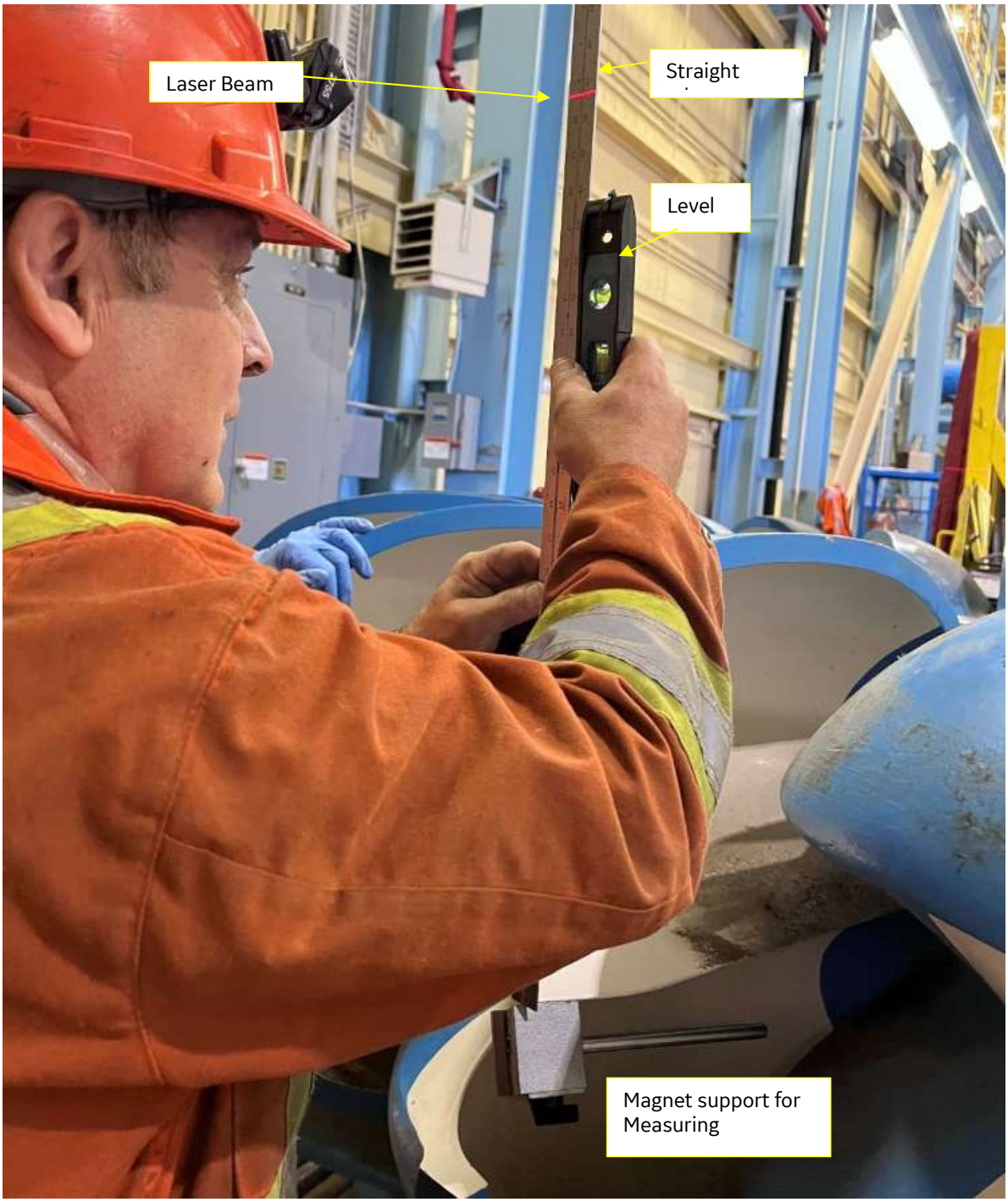

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Runner Flange Measuring

Runner tip thickness measuring.

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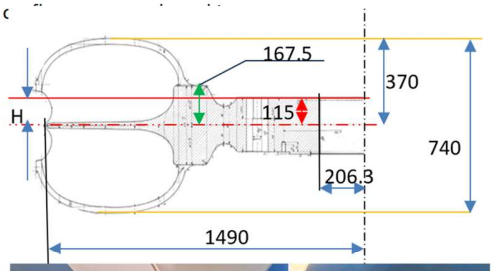
RELEVÉ DE MONTAGE / INSPECTION SHEET

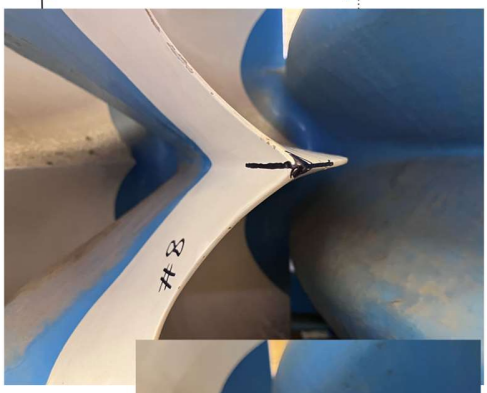
27293400 - MEP00-EQR102

Titre / Title:	**Spare Runner buckets tips hieght to runner Flange**				
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	1 de/of 3	
		0	Produit / Product:		
#Projet / Project:	**272934**		Doc. Reference:		
Projet / Project:	**Cat Arm**		Reading Date	**9/24/2024**	

Description: shoot laser to ruller on tip and read it. After shoot laser to ruler c

Laser Reading				Values in mm		
Bucket#	Tip	Flange	H=F-T	calc	Mea.	Dev.
1	26.875	22.1875	4.688	119.063	115.163	0.1625
2	26.875	22.125	4.750	120.65	116.75	1.75
3	26.813	22.125	4.688	119.063	115.163	0.1625
4	26.813	22.125	4.688	119.063	115.163	0.1625
5	26.625	22.125	4.500	114.3	110.4	-4.6
6	26.500	22.0625	4.438	112.713	108.813	-6.1875
7	26.500	22.0625	4.438	112.713	108.813	-6.1875
8	26.500	22.0625	4.438	112.713	108.813	-6.1875
9	26.500	22.0625	4.438	112.713	108.813	-6.1875
10	26.500	22.0625	4.438	112.713	108.813	-6.1875
11	26.563	22.125	4.438	112.713	108.813	-6.1875
12	26.625	22.125	4.500	114.3	110.4	-4.6
13	26.688	22.125	4.563	115.888	111.988	-3.0125
14	26.750	22.1875	4.563	115.888	111.988	-3.0125
15	26.938	22.1875	4.750	120.65	116.75	1.75
16	26.875	22.1875	4.688	119.063	115.163	0.1625
17	26.938	22.25	4.688	119.063	115.163	0.1625
18	26.938	22.1875	4.750	120.65	116.75	1.75
19	27.000	22.1875	4.813	122.238	118.338	3.3375
20	27.000	22.1875	4.813	122.238	118.338	3.3375
21	26.875	22.1875	4.688	119.063	115.163	0.1625
AVG	26.747	22.1399	4.607	117.021	113.121	-1.8786
Design: **115mm**		Tip tlorances: 0.25%= 1.7mm				
Tip thickness: 8mm		115+1.7=116.7 and 115-1.7=113.3				





Calc: calculated
Meas.: Measured
Dev: Deviation from Design value

Measuring device(s)

Tool	**laser beam**	**stright edge**		
Calibration#	**N/A**	**N/A**		
Cal. Due Date				

Taken	Checked	Confirmed	Witnessed(client)
Sid Lilly	**Mahdi. Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
Owen			
Date: 9/24/2024	Date 9/24/2024	Date: 9/24/2024	Date: 9/24/2024

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RELEVÉ DE MONTAGE / INSPECTION SHEET

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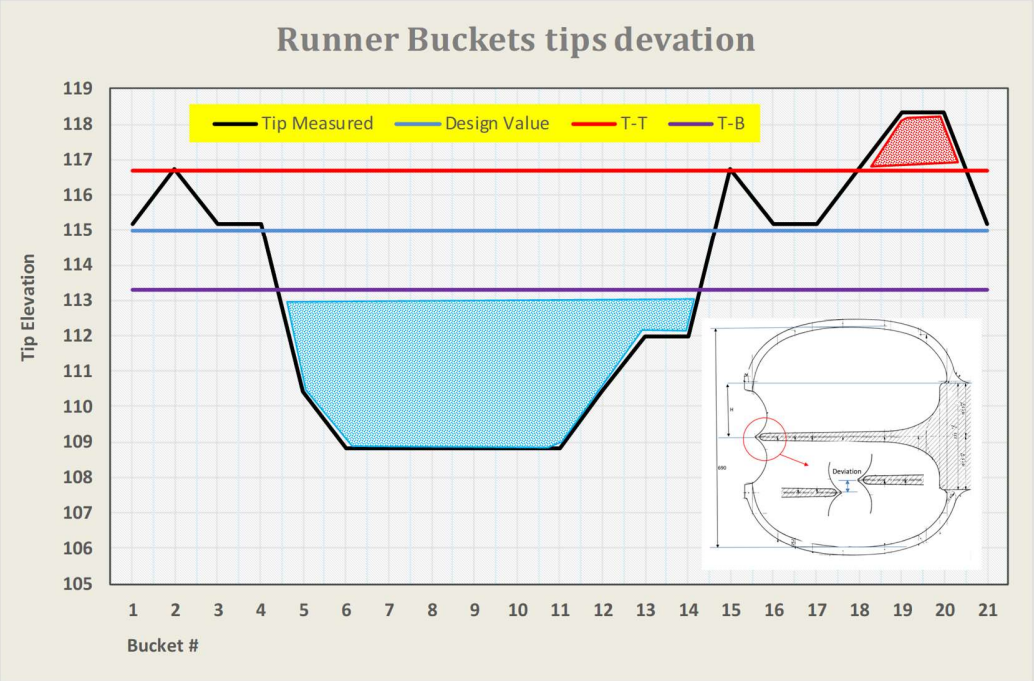
27293400 - MEP00-EQR102	Rev. -

Titre / Title:	**Runner Center Line Elevation measuring**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	2 de/of 3
		0	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	
Projet / Project:	**Cat Arm**		Reading Date	



T-T: Tolerance Top Band T-B: Tolerance Bottom Band

Based on twice measurements by laser beam and straight edge, the buclet tips on #6 to 11 around 6.2mm is upper than design value and in #19 to 20
around 3.5mm lower than refrance amount. Deviation between Max and Min deviation is around 10mm.
Deviation sources:
1) measuring accuracy
2) tip tickness
3) runner manufacturing

Taken	Checked	Confirmed	Witnessed(client)
Sid Lilly Owen	**Mahdi. Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
Date: 9/24/2024	Date 9/24/2024	Date: 9/24/2024	Date 9/24/2024

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RELEVÉ DE MONTAGE / INSPECTION SHEET

27293400 - MEP00-EQR102	Rev. -

Titre / Title:	**Runner Center Line Elevation measuring**			
Client:	**NL Hydro**	Groupe / Unit #	Feuille / Sheet:	3 de/of 3
		0	Produit / Product:	
#Projet / Project:	**272934**		Doc. Reference:	
Projet / Project:	**Cat Arm**		Reading Date	

Tip and Flang reading

Taken	Checked	Confirmed	Witnessed(client)
Sid Lilly	**Mahdi. Ghourchi**	**Mahdi. Ghourchi**	**Jordan Hull**
Owen			
Date: 9/24/2024	Date 9/24/2024	Date: 9/24/2024	Date 9/24/2024

8 RECOMMENDED SCOPE

Based on the current condition of the generator, turbine Runners in Unit 1, Unit 2, and spare runner the recommended actions are listed below:

Note: GE Vernova issues recommendations in good faith based on a single inspection and can not predict component failures, no commercial risk accepted.

8.1 UNIT #1

8.1.1 TURBINE RUNNER

For the life extension of the turbine, refurbishment is essential. Following scope is recommended:

a) **Runner Replacement**: It is recommended to replace the Unit 1 runner with the spare runner during the upcoming outage. To prevent further damage and minimize operational risks, this replacement should occur within the next 12 months. Runner replacement process is described in document 27293400MEP00-PA00 DC-01

b) **Replaced U1 Runner**: After removal from U1, the runner should be sent to a workshop for repair and refurbishment. The dismantled runner from Unit 1 should undergo full testing, including Magnetic Particle Testing (MT) and Ultrasonic Testing (UT), to evaluate the necessary refurbishment. A complete dimensional assessment is required, including flange surface levelness, bucket levelness, upper and lower bucket bowl heights, and bucket thickness measurements in various areas.

c) **Turbine Shaft:** Turbine shaft partial inspection did not reveal rejectable defects. The shaft should be fit for service. After dismantling the runner and before positioning the new runner beneath the turbine shaft, the bottom surface of the turbine shaft flange must be inspected, cleaned, and its elevation/levelness measured. Any discrepancies identified during this process should be addressed and corrected before the assembly of the new runner.

8.1.2 GENERATOR ROTOR

Based on the limited magnetic center measurements obtained from rotor pole readings across four poles, pole adjustment is recommended for machine life extension and stable operation. During the measurement of rotor pole heights relative to the stator core, it was determined that the U1 poles are more than an 0.75'' off from the center of the stator core. Given that the air gap value is 0.85 inches (approximately 22 mm), and according to CEATI standards, the maximum allowable deviation is 0.21 inches (approximately 5.4 mm).

To address this issue, it is necessary to remove all top and bottom shrouds and take precise measurements for all poles before proceeding with the pole adjustment. Due to the rotor pole connection points and their attachment to the rotor core, it may be required to remove the rotor from the pit for this activity. If rotor removal is necessary, all relevant data should be collected and made available prior to the removal to facilitate the pole adjustment process. Check sheets templates must be available for all measurements.

The pole elevation must ensure that the magnetic and hydraulic alignment are within tolerance.

8.2 UNIT #2

8.2.1 TURBINE RUNNER

Based on the Visual testing and nondestructive (ND) test results and elevation readings for this runner, for the life extension of the turbine, following scope is recommended.

The condition of the runner in Unit 2 is generally much better than that in Unit 1; however, for life extension runner should be replaced by 2026.

8.2.2 GENERATOR ROTOR

Measurements taken on four poles at both the Upstream and Downstream sides, on the top and bottom, indicate that the pole height relative to the stator core in Unit 2 is better than in Unit 1, with deviations not exceeding 3/8 inch (~10 mm). However, for an accurate evaluation, it is necessary to remove all top and bottom shrouds and measure the height of each individual pole relative to the stator core. Based on the results, a decision can then be made on whether rotor removal is required for pole adjustment.

8.3 SPARE RUNNER

Before transport the runner to the turbine power pit, it must be confirmed that the runner, in its current condition, is suitable for operation. This involves Geometrical and Physical integrity inspections:

Geometrical:
Measurements taken in September 2024 on the runner tip elevation relative to the runner flange indicated a deviation of approximately 7 mm between the tip elevations. Based on the condition of the runner on the generator floor and the available measurement methods, there is a doubt on September 2024 measurement precision.

To conclude, to proceed with Precise bucket Elevation Measurement. There are 2 options:

Option A: Before installation, utilize accurate tooling to take precise elevation readings of all bucket tips (laser tracker).
Option B: Less precise but functional: After runner installation, use self leveling laser on injector needle tip. Record bucket-to-jet deviation for each bucket. This required deflectors to be removed.

- If within CEATI tolerance: Use as-is.
- If slightly outside CEATI (typically up to double the tolerance): NLH can take responsibility and use-as is.
- If more than twice outside CEATI tolerance: Perform more analysis before installation or monitor unit behavior in-depth.

Geometrical discrepancies can affect: Efficiency, Vibration, Axial thrust. In a second order in can increase cavitation, stress, fatigue, bearing wear. A runner outside CEATI tolerance may have lower efficiency and life duration but can still be worth using with adequate monitoring and inspections.

Since the runner is available at site, the economical solution may be to use even if outside CEATI tolerance with adequate monitoring.

To take responsibility, GEV would have to provide a new runner.

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Physical integrity:

Since the runner is new and of the same manufacture as the two installed, it is expected to be as durable as the other two runners.

The recommended actions would be to ensure its original integrity:

- Visual inspection for linear indication or impact damage. GE does not expect NLH to remove existing paint.
- Visual inspection for protrusion on the coupling surface.
- Maintain OEM recommended periodical inspection as per OMM.
- The runner inspection should include VT 100% + PT or MT on the bucket critical areas. Refer to OMM page 5 of 33.