newfoundland labrador hydro
a nalcor energy company

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June 28, 2016

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

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

Dear Ms. Blundon:

Re: **An Application by Newfoundland and Labrador Hydro (Hydro) pursuant to Subsection 41(3) of the Act for the approval of the Turbine Rehabilitation of Bay d'Espoir Unit 4**

Please find enclosed the original and 12 copies of the above-noted Application, plus supporting affidavit, project proposal, and draft order. The proposed project involves the rehabilitation of Bay d'Espoir Unit 4 turbine, which is necessary for the supply of safe and adequate and reliable power to the Island Interconnected System.

Hydro respectfully requests that this application be addressed in an expedited manner in order to complete the work to meet system load, which begins in September, and to ensure the unit is available and reliable for the 2016/17 winter operating season.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Tracey L. Pennell
Senior Counsel, Regulatory

TLP/cp

cc: Gerard Hayes – Newfoundland Power
Paul Coxworthy – Stewart McKelvey Stirling Scales
Sheryl Nisenbaum – Praxair Canada Inc.
Thomas Johnson, Q.C. – Consumer Advocate
Thomas J. O'Reilly, Q.C. – Cox & Palmer
Larry Bartlett – Teck Resources Limited

IN THE MATTER OF the *Electrical Power Control Act,* RSNL 1994, Chapter E-5.1 (the *EPCA*) and the *Public Utilities Act*, RSNL 1990, Chapter P-47 (the *Act*), and regulations thereunder;

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro (Hydro) pursuant to Subsection 41(3) of the *Act*, for approval of the Rehabilitation of Bay d'Espoir Unit 4 turbine.

TO: The Board of Commissioners of Public Utilities (the Board)

THE APPLICATION OF NEWFOUNDLAND AND LABRADOR HYDRO (Hydro) STATES THAT:

1. Hydro is a corporation continued and existing under the *Hydro Corporation Act, 2007*, is a public utility within the meaning of the Act and is subject to the provisions of the *Electrical Power Control Act, 1994*.

2. Hydro is the primary generator of electricity in Newfoundland and Labrador. The largest of Hydro's hydro-electric generating stations is located at Bay d'Espoir. Unit 4 at Bay d'Espoir is a 76.5 MW unit originally built in 1968. In 1994, a new runner was installed at the unit and at that time new primary seals were installed.

3. Seals are key components of hydro-electric units. The seal clearance is the distance between the stationary and rotating wearing rings of a Francis turbine. These seal clearances are designed and set by the manufacture. The purposes of these design seal clearances are for efficiency, hydraulic balance, prevention of rubbing due to misalignment and imbalance, and for cooling between the runner and stationary wear rings.

4. On June 5, 2016 Bay d'Espoir Unit 4 (76.5MW) was removed from service for annual maintenance and to complete other maintenance works. The upper and lower primary seal clearances were measured as part of the inspection and it was determined that they are now less than acceptable for reliable operation.

5. Hydro consulted two external experts for an opinion on the current operability of the turbine seal clearance measurements. Both advised that this condition exposed the unit to a risk that it would not operate reliably without the potential for mechanical damage and a forced outage.

6. The seal clearances had been reducing over time, which is normal, and the work to address this was identified in the 2019 capital plan as part of Hydro's maintenance approach for the hydraulic turbines. However, in this year's detailed inspection and condition assessment it was learned that the clearances reduced faster than anticipated and reinstating proper seal clearances must now take place in 2016.

7. Returning the unit to service without rectifying the reduced clearances would expose the unit to a high risk of mechanical damage and a forced outage that would be between 6 and 8 weeks. Were a forced outage to occur, 76.5 MW of capacity and the associated energy would be unavailable to the Island Interconnected System while the clearances were rectified. Completion of the turbine refurbishment is required to ensure Hydro can provide safe, reliable electrical service to its customers.

8. The scope of work requires the full dismantling of Unit 4. While the unit is fully dismantled, Hydro is proposing to accelerate the remaining tasks of the 2019 planned refurbishment project work into 2016 which will negate the requirement to take an outage of this unit for this work in 2019.

9. The estimated cost of this project is $1,977,300 and, if commenced by mid-July, is expected to be completed by the end of September.

10. The Applicant submits that the proposed refurbishment of the Unit 4 seals at Bay d'Espoir is necessary to ensure that the Hydro can continue to provide service which is safe and adequate and just and reasonable as required by Section 37 of the *Act.* An Engineering Report supporting this supplemental capital application is attached.

11. Hydro therefore makes Application for an Order pursuant to section 41(3) of the *Act* approving the refurbishment of the seals of Unit 4 at Bay d'Espoir, and the completion of certain overhaul work that was originally scheduled for 2019, at an estimated capital cost of $1,977,300, all as set out in this Application and in the attached project description and justification document.

DATED at St. John's in the Province of Newfoundland and Labrador this 28th day of June 2016.

Tracey Pennell

Tracey L. Pennell
Counsel for the Applicant
Newfoundland and Labrador Hydro
500 Columbus Drive P.O. Box 12400
St. John's, NL A1B 4K7
Telephone: (709) 778-6671
Facsimile: (709) 737-1782

IN THE MATTER OF the *Electrical Power Control Act,* RSNL 1994, Chapter E-5.1 (the *EPCA*) and the *Public Utilities Act*, RSNL 1990, Chapter P-47 (the *Act*), and regulations thereunder;

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro (Hydro) pursuant to Subsection 41(3) of the *Act*, for approval of the Rehabilitation of Bay d'Espoir Unit 4 turbine.

AFFIDAVIT

I, Jennifer Williams, Professional Engineer, of St. John's in the Province of Newfoundland and Labrador, make oath and say as follows:

1. I am General Manager, Hydro Production of Newfoundland and Labrador Hydro, the Applicant named in the attached Application.

2. I have read and understand the foregoing Application.

3. I have personal knowledge of the facts contained therein, except where otherwise indicated, and they are true to the best of my knowledge, information and belief.

SWORN at St. John's in the Province of Newfoundland and Labrador this 29 day of June 2016, before me:)

Tracey Pennell
Barrister – Newfoundland and Labrador

Jennifer M. Williams

(DRAFT ORDER)
NEWFOUNDLAND AND LABRADOR
BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

AN ORDER OF THE BOARD

NO. P.U. __ (2016)

IN THE MATTER OF the *Electrical Power Control Act*, RSNL 1994, Chapter E-5.1 (the *EPCA*) and the *Public Utilities Act*, RSNL 1990, Chapter P-47 (the *Act*), and regulations thereunder;

AND IN THE MATTER OF an Application by Newfoundland and Labrador Hydro (Hydro) pursuant to Subsection 41(3) of the *Act*, for approval of the Rehabilitation of Bay d'Espoir Unit 4 turbine.

WHEREAS the Applicant is a corporation continued and existing under the *Hydro Corporation Act, 2007*, is a public utility within the meaning of the Act and is subject to the provisions of the *Electrical Power Control Act*, 1994; and

WHEREAS Section 41(3) of the Act requires that a public utility not proceed with the construction, purchase or lease of improvements or additions to its property where:

a) the cost of construction or purchase is in excess of $50,000; or
b) the cost of the lease is in excess of $5,000 in a year of the lease,

without prior approval of the Board; and

WHEREAS in Order No. P.U. 33(2015) the Board approved Hydro's 2016 Capital Budget in the amount of $183,082,800; and

WHEREAS on June 5, 2016, Bay d'Espoir Unit 4 turbine was removed from service and the lower primary seal clearances were reviewed and deemed to be now less than acceptable for reliable operation; and

WHEREAS on June 28, 2016 Hydro applied to the Board for approval to rehabilitate Bay d'Espoir Unit 4 turbine; and

WHEREAS the capital cost of the project is anticipated to be $1,977,300; and

WHEREAS the Board is satisfied that the rehabilitation of Bay d'Espoir Unit 4 turbine is necessary and reasonable to allow Hydro to provide service and facilities which are reasonably safe and adequate and just and reasonable.

IT IS THEREFORE ORDERED THAT:

1. The proposed capital expenditure to rehabilitate Bay d'Espoir Unit 4 of $1,977,300 is approved.

2. Hydro shall pay all expenses of the Board arising from this Application.

DATED at St. John's, Newfoundland and Labrador, this day of , 2016.

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A REPORT TO

THE BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

	Electrical
	Mechanical
	Civil
	Protection & Control
	Transmission & Distribution
	Telecontrol
	System Planning

Turbine Rehabilitation

Bay d'Espoir Unit 4

June 28, 2016

newfoundland labrador hydro
a nalcor energy company

SUMMARY

On June 5, 2016 Bay d'Espoir Unit 4 (76.5 MW) was removed from service. There were three projects that necessitated Unit 4 to be removed from service: scheduled annual maintenance; refurbishment on the surge tank that serves Units 3 and 4; and replacement of the main inlet valve bypass valves for Units 3 and 4. As part of the annual maintenance, inspections and assessments are completed. Clearances between the upper and lower primary seals and the runner were measured as part of the inspection. The lower primary seal clearances were reviewed and deemed to be now less than acceptable for reliable operation.

Hydro consulted two external experts for an opinion on the current operability of the turbine seal clearance measurements. Both advised that this condition exposed the unit to a risk that it would not operate reliably without the potential for mechanical damage and a forced outage.

The lower seal clearances had been reducing over time and the work to address this was identified in the 2019 capital plan as part of Hydro's maintenance approach for the hydraulic turbines. This plan contained a major refurbishment project, including addressing the previously identified reduced seal clearances. However, in this year's detailed inspection and condition assessment, the clearances reduced faster than anticipated. The refurbishment project, which includes re-establishing the clearances, must now take place in 2016. Hydro is proposing to accelerate the remaining tasks of the 2019 planned refurbishment project work into 2016. This then negates the requirement to take an outage for this work in 2019.

Reinstatement of the lower seal clearances for Unit 4 is required to provide reliable operation through the 2016/2017 winter operating season, as well as through subsequent years. Returning the unit to service without rectifying the reduced clearances places a high risk of mechanical damage to the unit and a forced outage that would be between 6 and 8

weeks. If a forced outage were to occur in winter, 76.5 MW of capacity and the associated energy would be unavailable to the Island Interconnected System while the clearances were rectified. Completion of the turbine refurbishment is required to ensure Hydro can provide safe, reliable electrical service to its customers.

TABLE OF CONTENTS

1 INTRODUCTION

Bay d'Espoir Unit 4 is a 76.5 MW hydraulic generating unit that was constructed as part of the Bay d'Espoir Stage 1 in 1968. It provides electricity to the Island Interconnected System. Figure 1 is a picture of the Provincial electricity grid showing the location of the Bay d'Espoir Generating Station.

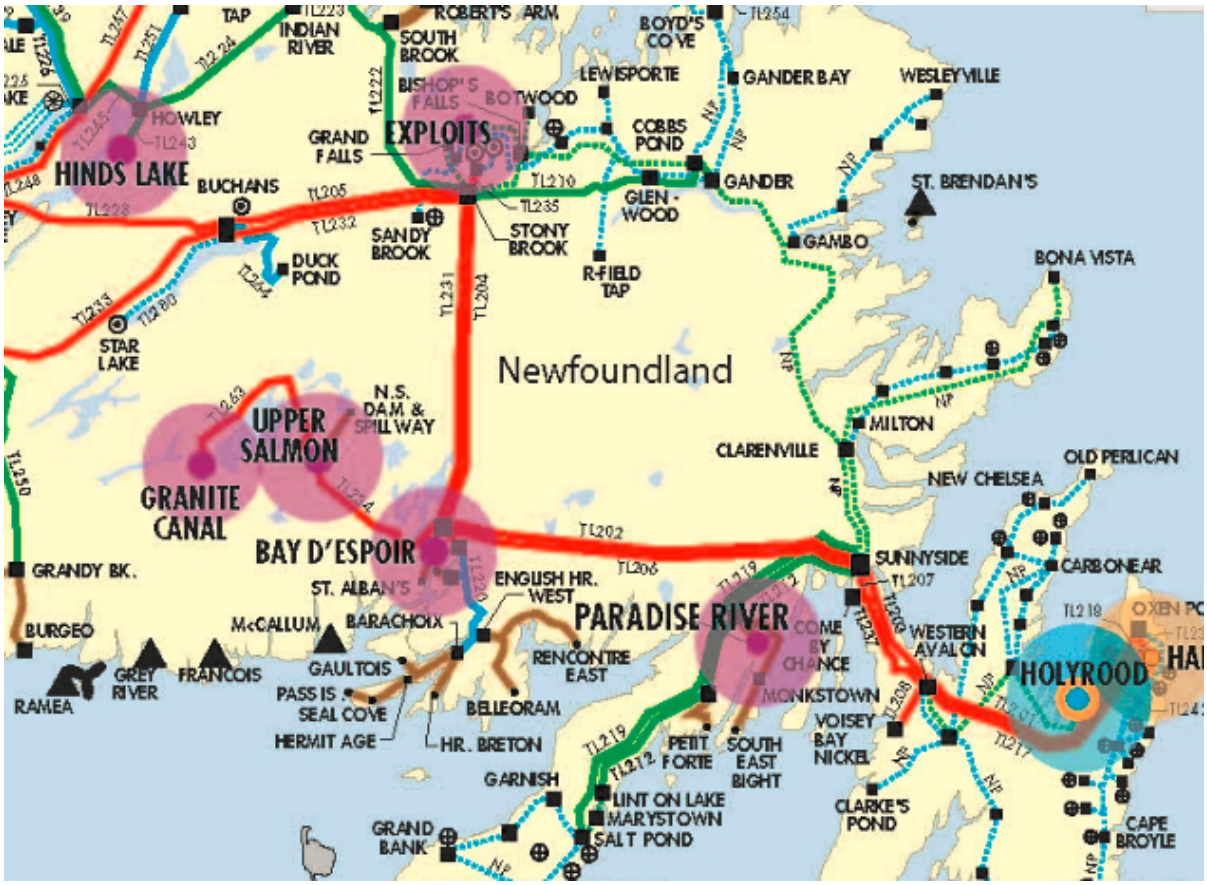


Figure 1: Provincial Grid

In 1994, the original mild steel turbine runner was replaced due to repeated cavitation[1] damage. A stainless steel runner was installed at that time which improved the resistance to cavitation damage and improved runner efficiency. At that time, the primary seals were replaced with an aluminum bronze material and machined in place to create the proper clearance with the new runner. Additional turbine rehabilitation work was carried out

[1] Cavitation is a phenomenon which results in pitting of the runner surfaces.

including head cover and discharge ring modifications, wicket gate bushing replacement, carbon seal replacement, and a unit alignment.

Figure 2 is a photograph of the Bay d'Espoir Generating Station Site.

Figure 2: Bay d'Espoir Hydro Generating Station Site

Figure 3 is a picture of all six 76.5 MW hydraulic generating units inside Power House #1 at Bay d'Espoir.

Figure 3: Bay d'Espoir Hydraulic Generating Units 1 - 6

2 BACKGROUND

The asset management strategy for Hydraulic turbine generators includes three distinct points of intervention:

1. The first is an annual preventative maintenance inspection that primarily consists of non-intrusive visual inspections and tests, as well as the replacement of some regular wear parts, including carbon brushes.

2. On a six year frequency, a unit overhaul is performed that consists of a partial dismantle of the unit (generator rotor is removed) to perform more intrusive condition based inspection and rehabilitation of the unit.
3. Based on equipment condition obtained through the annual inspection and the 6 year overhaul, a major refurbishment of turbine components is planned and placed in the capital budget plan. This refurbishment requires a complete unit dismantlement to refurbish turbine components including the runner (as required), turbine seals, wicket gate components, and other items that require attention based on their condition. The actual timing is based on condition. This intervention is currently in the capital plan, with a program for the refurbishment of the Bay d'Espoir turbines starting in 2019.

One of the tasks in Hydro's asset management program for hydraulic units is the measurement of the upper and lower primary seal clearances. The seal clearance is the distance between the stationary and rotating wearing rings of a Francis turbine. These seal clearances are designed and set by the manufacture. The actual design clearance depends on both the size and speed of the unit. These clearances should not change unless the wearing rings are affected by phenomena such as wear (cavitation, corrosion, erosion) or distortion or the runner incurs axial movement due to bearing wear or misalignment. The purposes of these design seal clearances are for efficiency, hydraulic balance, prevention of rubbing due to misalignment and imbalance, and for cooling between the runner and stationary wear rings.

The measurements taken are compared against previous readings and design clearances. Depending on the results of the measurements, Hydro may consult with internal and external turbine experts to determine if any intervention is required.

The lower primary seal clearance measurements taken in June 2016 for Unit 4 showed an accelerated reduction in the amount of the clearance when compared to recent previous

readings shown in Table 1.[2] In prior years, the clearances had been trending away from design clearance, but at a rate that was not considered urgent for action. A trending away from design is an indicator that future action is required, but is not atypical for hydroelectric units. The work to address the reduced clearances was identified in the 2019 capital plan as part of Hydro's maintenance approach for the hydraulic turbines. This plan contained a major refurbishment project, including addressing the previously identified reduced seal clearances.

To date on the various Bay d'Espoir units, the diametric[3] clearance at the seals has generally been such that a maintenance correction can be completed to re-establish acceptable clearances when measured radially[4]. A maintenance correction would be re-aligning or re-centering the runner. For the June 2016 Unit 4 seal clearance measurements, it was clear that the remaining diametric and radial clearances were not sufficient and that an alignment (or re-centering) could not provide appropriate clearance.

As a result of the measured reduced clearances, Hydro contacted external (Hydro Expertise and Voith Hydro) experts, and performed further testing at their request to gather more information so they could make an informed recommendation. Both external parties consulted subsequently recommended that corrective action must be taken to restore the seal clearances to their original design in order to operate reliably through the winter operating season and for future operation.

In addition to external expertise, additional documented guidance was sought to inform Hydro what level of required action would be required. Section 6.6.2 of Part V of the CEATI[5]

[2] Potential cause of loss of clearance discussed further in this section.
[3] Diametric clearance is the total clearance at the seal. It is the sum of the two radial clearance measurements.
[4] The radial clearance is the measurement from one surface to the other. The clearance can be increased or decreased by tilting the shaft to increase or decrease the clearance. If the shaft was tilted to increase the radial clearance on one side of the runner, the alternate side would decrease, and vice versa.
[5] CEATI: The Centre for Energy Advancement through Technological Innovation (CEATI) is a user-driven organization committed to providing technology solutions to its electrical utility participants, who are brought together to collaborate and act jointly to advance the industry through the sharing and developing of practical and applicable knowledge.

publication: "Hydroelectric Turbine-Generator Units Guide for Erection Tolerances and Shaft System Alignment" was reviewed and compared to the recent measurements. The clearances were found to be not acceptable when compared to the CEATI guide, which concurred with the external expertise consulted. For reference, see Table 1 for the current readings as well as previous readings and CEATI recommended clearances.

The clearance measurements are recorded, using a clockwise rotation looking down from the top of the rotor and using the stator or stationary parts as the reference system. Figure 5 below is a representation of where the readings are taken as if you were looking down onto the rotor (or onto the runner).

To provide perspective, many plastic ID cards are about 30 thousandths of an inch thick. As is the case with any hydroelectric generating unit, appropriate clearances are generally measured in the thousandth of an inch and therefore, repeated measurements are taken by different skilled persons to ensure measurement error is minimized, and that the clearances are confirmed as accurate.

Figure 4 shows a close up detail of the seal area of the turbine. Appendix A shows a large cut away of the turbine generator assembly. In Appendix A, the area depicted below in figure 4 is located by detail 47. Appendix B shows additional detail of the seal area.

Retrieved from http://www.ceati.com/about-us/

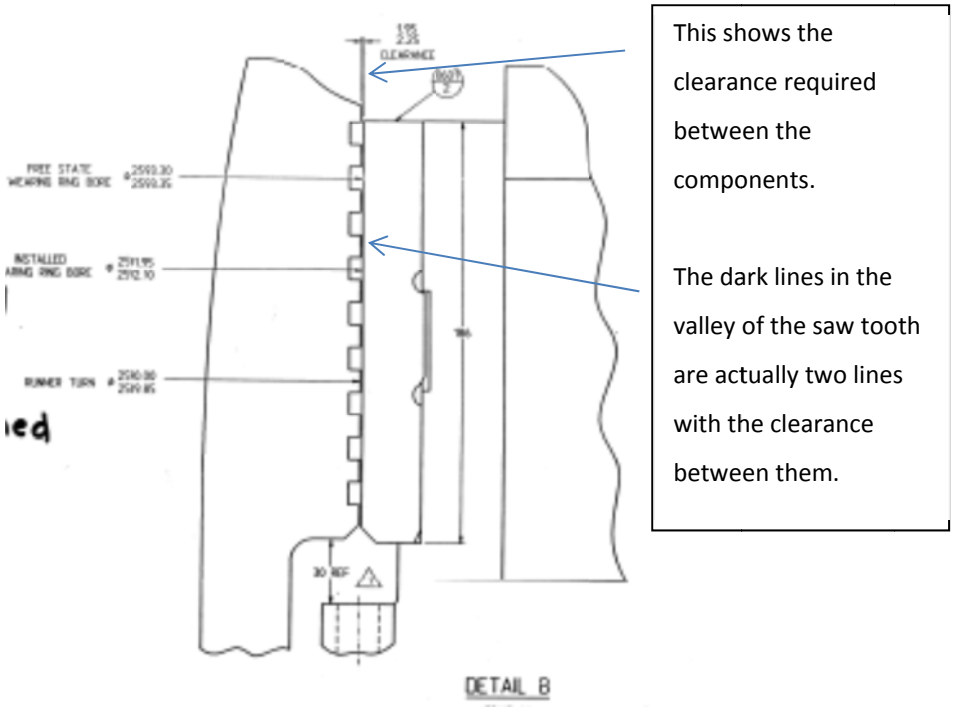


Figure 4: Close up detail of the lower seal area

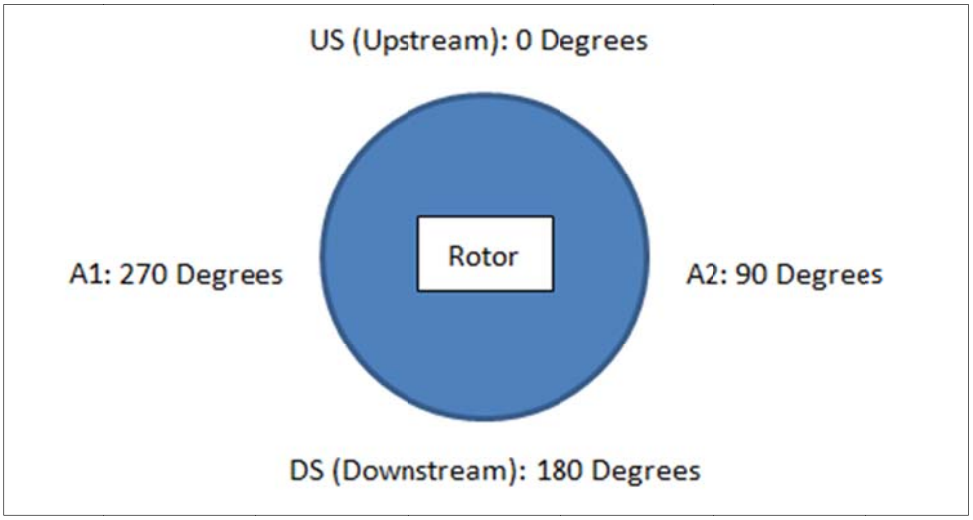


Figure 5: Position of the clearance readings as they relate to the data in Table 1

Table 1: Clearances between Runner and Seal[6]

	US	DS	US+DS	A1	A2	A1+A2
Design Min	0.040	0.040	0.800	0.040	0.040	0.080
Design Max	0.055	0.055	0.110	0.055	0.055	0.110
CEATI Max	0.083	0.083	0.166	0.083	0.083	0.166
CEATI Min	0.020	0.020	0.040	0.020	0.020	0.040
1994	0.035	0.040	0.075	0.040	0.035	0.075
2009	0.050	0.043	0.093	0.014	0.025	0.039
2011	0.068	0.068	0.136	0.012	0.025	0.037
2012	0.065	0.027	0.092	0.015	0.017	0.032
2016	0.067	0.035	0.102	0.005	0.015	0.020

Note for the table below: US = up stream, DS = down stream, and both of these are considered "radial" measurements; US+DS, as well as A1+A2 are added together to get a "diametric" measurement.

The lower seal clearances were taken in 1994, as part of the new runner installation, and while they were not reinstated to the original installation design clearance, they were acceptable for long term operation. The clearance measurement was taken in 2011 as part of the unit overhaul and the readings were also taken in 2009 and 2012 as the opportunity presented itself with the unit down for other reasons.

Hydro took seal clearance measurements of all Bay d'Espoir units in 2016 as part of information gathering for the future refurbishment program that was intended to start in 2019 with Unit 4. Based upon the material increase in the clearance loss measured in 2016, Hydro has now instituted annual lower seal clearance measurements.

Prior to the readings being taken in 2016, as part of the currently scheduled unit overhaul for Unit 4 in 2017, Hydro would have taken the readings in 2017 to continue to monitor the clearances to determine if action was required sooner than the planned turbine refurbishment in 2019. The major intervention to re-establish design clearances was planned to occur in 2019 with the refurbishment project.

[6] The seal clearance readings for the years between 1994 and 2009 are in storage and at the time of this proposal, are being retrieved for completeness of the record.

There are various potential causes for seal clearance loss. A common reason is that the concrete behind the seal is deteriorated and voids have developed, allowing the seal to deform away from circular and ultimately become 'oval' thereby changing the clearance. This appears to be the case when examining the Table 1 data. The US+DS diametric clearances have actually increased, while the A1+A2 diametric clearances have decreased, indicating the seal is 'ovalling'. Hydro has also performed hammer tests[7] and the results further suggest that there are voids that have developed now that the concrete is almost 50 years old. When this occurs, utilities will undertake to grout the voids as part of the work to reestablish the seal clearance.

The 2016 clearance measurements for the other units at Bay d'Espoir currently do not require a major intervention. Units 1, 2, 3, 6, and 7 have seal clearances within acceptable tolerances. Unit 5 has a seal clearance measurement that requires further review, and this review is being undertaken this summer. However, based upon the initial measurements, it is expected that the maximum intervention that may be required on Unit 5 this year is a re-centering of the unit. Essentially, there is enough diametric clearance available on Unit 5 that a re-centering of the unit can likely reestablish clearances to acceptable levels. If a re-centering is required, this work will be scheduled to coincide with other capital work planned that requires that Unit 5 to be out of service and therefore there is not expected to be an additional impact on the unit outage timeline.

3 PROJECT DESCRIPTION

In order to reestablish the required seal clearances for safe, reliable operation, the scope of work consists of the full dismantling of Unit 4. As the unit would be fully dismantled, Hydro is proposing to complete the seal clearance reestablishment as part of the full scope of the refurbishment that was planned for 2019, including a thorough inspection, and replacing or refurbishing worn components found during the inspection. Completion of this work during

[7] A hammer test is performed by tapping the steel liner with a hammer to listen for hollow sounds. This is similar to tapping a wall when looking for a stud to mount a picture.

this major disassembly then negates the need for the refurbishment project that was previously planned in 2019.

The items in the scope of work in the turbine refurbishment project that address the identified reduced seal clearances include:

- Runner lower primary seal grouting and machining to design clearance; and
- An inspection of the upper primary seal, to be machined if required.

The remaining turbine refurbishment tasks will include:

- An inspection of the head cover and bottom ring/bushings. Worn parts will be replaced since they can only be replaced with the unit completely dismantled;
- An inspection of the operating ring bearings and linkage bushings. Worn components will be replaced where practical, and refurbished otherwise;
- All wicket gate stem "V" packing will be replaced;
- Runner cavitation will be refurbished as close to its original condition as practical; and
- An inspection of the concrete behind the scroll case and draft tube. Concrete grouting will be performed where/if required.

Hydro proposes that performing the full turbine refurbishment scope of work is appropriate at this time. The seal clearance re-establishing work requires the full dismantlement of the unit, which is not currently part of any preventative maintenance task and takes place only for major capital refurbishment work. To complete a turbine refurbishment, the unit requires being fully dismantled again. Completing the complete scope of turbine refurbishment would include the seal clearance work and removes the need for a full dismantlement and associated refurbishment in 2019.

Completing the full refurbishment work concurrently with the seal clearance reestablishment adds less than one week to the outage for the seal clearance work alone.

The majority of the remaining tasks can occur while the lower primary seal is being refurbished. Therefore, the overall outage time is not materially impacted by performing the full refurbishment scope of work described above. Further, completing the refurbishment work as part of this project saves the costs associated with the disassembly and reassembly in the future previously planned project. The disassembly and reassembly tasks are approximately 5 weeks duration. Hydro estimates there is an avoidable cost by completing this work now, as opposed to completing the remaining refurbishment work in 2019, of between $400,000 and $500,000.

The execution of the seal clearance work will be overseen by external experts for all aspects of the seal reestablishment.

4 JUSTIFICATION

The clearance readings for the Unit 4 lower primary turbine seal are unacceptable for the return of the unit to service. An independent consultant with expertise in hydraulic generating units and the original equipment manufacturer (OEM) turbine expert both recommended that the unit condition is not acceptable to return it to service.

Re-establishing the seal clearances is required to avoid a potential on-line failure given the risk of the runner contacting the stationary seal due to the lack of sufficient clearance.

4.1 Existing System

Unit 4 is a 76.5 MW vertical Francis hydraulic generating unit constructed in 1968. The runner was replaced in 1994. As part of the runner replacement, other components including the primary stationary seals, and wicket gate bushings were replaced to complete the refurbishment.

Bay d'Espoir Unit 4 is part of the generation capacity for the Island Interconnected System. If this unit is not returned to service, the capacity and energy supplied by this unit would

remain unavailable until the work could be completed during the next planned outage.

4.2 Operating Experience

All units at Bay d'Espoir are measured for seal clearances as part of the preventative maintenance program. It is normal for aged units to experience seal clearance loss (often through 'ovalling') and therefore, utilities typically measure and trend this as part of their asset management program. Bay d'Espoir Units 1-6 lower seal readings demonstrate they all have been 'ovalling' over time, which is not atypical. This requires monitoring and action as the clearances approach a certain level, and urgent action when the rate of loss increases. In addition to consulting outside experts, Hydro compares the amount of seal clearance to technical guides to determine when major intervention is required.

Design clearance is no longer being maintained on the Bay d'Espoir units and this is not atypical for the age of the units, but the unit that currently requires intervention is Unit 4 with clearances as low as 5 thousandths of an inch being recorded between the stationary seal and runner. Unit 5 has clearances being evaluated further this summer to determine if a re-centering is required. A re-centering can typically take place over one to two weeks, and does not require disassembly. All other units are above guide documents minimums and do not require intervention at this time.

4.2.1 Reliability Performance

If the seal reestablishment work is not completed and Unit 4 is returned to service, there is a potential for there to be a contact between the primary seal and the runner. Were this to occur, it would result in an extended unplanned outage that would require a full dismantlement of the unit. If the unit fails on-line due to this issue leading into or during the winter operating season, 76.5 MW would be unavailable for system capacity and energy for the period that the unit was undergoing refurbishment.

Further, currently, there is no known mechanical damage on this unit due to the reduced

clearances. If the unit is returned to service with reduced clearances, a risk exists that mechanical damage would occur if the runner and seal were to make contact and require more extensive work than is currently contemplated in this proposal. It is reasonably expected the mechanical damage would require additional downtime to rectify when compared to the amount of time required to reestablish clearances when no contact has been made. The amount of additional time that would be required would depend upon the nature and extent of the damage that would occur.

4.2.2 Legislative or Regulatory Requirements

There are no legislative or regulatory requirements associated with this project.

4.2.3 Safety Performance

An on-line failure of the unit due to this clearance issue is not expected to create a safety hazard for Hydro employees. However, were an on-line failure to occur at a time when the unit was loaded above 50 MW, it would most likely cause an under frequency load shedding event for the Island Interconnected System.

4.2.4 Environmental Performance

This project does not impact environmental performance.

4.2.5 Industry Experience

A unit at Churchill Falls had to be refurbished due to contact between the rotating and stationary parts during a manual rotation and this resulted in an extended outage. Hydro's consultant at Hydro Expertise shared an example about a runner at a different site within Newfoundland that seized in operation from galling which was caused by the runner and the primary stationary seal making contact.

There are numerous examples of seal clearance loss over time at various utilities. Due to the frequency of this experience, CEATI published the guide "Hydroelectric Turbine-

Generator Units Guide for Erection Tolerances and Shaft System Alignment" to compile its member utilities' experiences, and to develop and share required clearances and recommendations as to when action is required.

4.2.6 Vendor Recommendations

Voith Hydro, the OEM for this runner, recommended that Hydro not return the unit to service until the seal clearance is returned to its design specification.

4.2.7 Maintenance or Support Arrangements

Hydraulic generating units are inspected and maintained by Hydro Operations.

4.2.8 Maintenance History

Table 2 shows the maintenance history for the Bay d'Espoir Unit 4 Turbine.

Table 2: Bay d'Espoir Units 4 Turbine Maintenance History

	BDE Unit 4 Turbine		
Year	**Preventative Maintenance**	**Corrective Maintenance**	**Total Maintenance**
2011	$13,021	$138	$13,159
2012	$6,473	$1,499	$7,972
2013	$5,034	$3,179	$8,213
2014	$12,426	$2,642	$15,068
2015	$1,599	$4,699	$6,298
2016[8]	$1,922	$134	$2,056
Total	$40,475	$12,291	$52,766

4.2.9 Historical Information

Bay d'Espoir Unit 3 was successfully realigned in 2015 to accommodate reduced lower seal clearance. The unit had a radial clearance of 5 thousandths of an inch on the lower primary seal. The unit did not require the same major intervention now required on Unit 4 because there was enough diametric clearance to allow the unit to be aligned such that enough clearance was obtained radially.

[8] 2016 is an incomplete year, and includes costs to May 2016.

Bay d'Espoir Unit 2 (sister unit to Unit 4) was removed in 2002 to grout and machine the lower primary seal to avoid making contact between the runner and the primary seal. The Unit 2 work was performed in a planned fashion based on decreased readings in a relatively short period of time after the new runner was installed in 1993.

4.2.10 Anticipated Useful Life

The proposed work for this unit is part of a normal refurbishment to allow the generating unit to achieve its anticipated maximum normal useful life. The currently planned refurbishment for Unit 4 in 2019 would be removed from the capital plan if this project with the full scope of turbine refurbishment, including the seal clearance re-establishment.

4.3 Forecast Customer Growth

Forecasted customer growth is not applicable to this project.

4.4 Development of Alternatives

Alternatives were considered;

1. Return the unit to service as is, and address the seal clearance in the next major outage in 2017 as part of the capital budget, or wait until the 2019 major turbine refurbishment;
2. Reestablish the seal clearances prior to returning the unit to service through the advancement of the previously planned turbine refurbishment in 2019; and,
3. Reestablish the seal clearances prior to returning the unit to service but not advance the remaining tasks of the turbine refurbishment in 2019.

<u>Alternative 1</u>

Allowing the unit to return to service in its current condition with a plan to perform the turbine refurbishment as part of the 2017 capital submission or as part of the previously planned 2019 major turbine refurbishment requires the tolerance for a risk of failure during operation. This would result in lost generation capacity for the island. Hydro notes that

running at reduced load on this unit does not reduce the risk as the unit still rotates at the same speed no matter the loading and therefore runs the same risk for contact and a forced outage. Hydro does not propose this alternative as an appropriate course of action.

Alternative 2

Due to the degree of clearance loss between the rotating runner and the stationary seal, there is a reasonable likelihood of a forced outage due to the runner contacting the seal. It was recommended by an independent consultant and an OEM turbine expert to re-instate the clearance to acceptable levels prior to returning the unit to service. Both external opinions were arrived at independently. This alternative is more appropriate than Alternative 1 with respect to reliable operation leading into the winter operating season. Completion of the whole turbine refurbishment work addresses the seal clearance and provides a refurbished unit at the conclusion of this work.

Alternative 3:

The difference between Alternative 2 and Alternative 3 is that in Alternative 3 Hydro would not proceed with the full scope of the turbine refurbishment work during the seal clearance reestablishment work. This alternative requires the unit to be dismantled again in 2019, keeping the downtime in the schedule, as well as the extra costs. Completing the refurbishment work now in parallel with the seal clearance reestablishment avoids extra downtime and additional disassembly and reassembly costs in 2019.

4.5 Evaluation of Alternatives

Hydro proposes that Alternative 2 be approved, that the appropriate alternative is to complete the seal clearance re-establishment work as well as the remaining tasks of the turbine refurbishment work that had been planned for 2019.

4.5.1 Energy Efficiency Benefits

There are no energy efficiency benefits that can be attributed to this project.

4.5.2 Economic Analysis

An economic analysis was not performed in this instance as Hydro proposes the unit must have its clearances reestablished prior to returning the unit to service.

5 CONCLUSION

This project is required to ensure that a reliable energy supply is available for the customers of the Island Interconnected System. Since the seal clearance is below an acceptable level to return the unit to service, reestablishing the clearances now is being proposed as the only viable alternative to avoid the risk of near term unplanned failure. Advancing the 2019 work, which includes the seal clearance work, will avoid additional downtime and costs that would be incurred in 2019 so it is also proposed that this work be completed in 2016.

5.1 Budget Estimate

The budget estimate for this project is shown in Table 3.

Table 3: Project Budget Estimate

Project Cost: *($ x1,000)*	**2016**	**2017**	**Beyond**	**Total**
Material Supply	86.0	0.0	0.0	86.0
Labour	301.3	0.0	0.0	301.3
Consultant	0.0	0.0	0.0	0.0
Contract Work	1,230.0	0.0	0.0	1,230.0
Other Direct Costs	16.2	0.0	0.0	16.2
Interest and Escalation	17.1	77.5	0.0	17.1
Contingency	326.7	0.0	0.0	326.7
TOTAL	**1,977.3**	**0.0**	**0.0**	**1,977.3**

The above budget is based on a budgetary estimate for a contractor to perform the majority of the work, and there are tasks that must be completed by contractor forces due to the highly specialized nature of the work. Hydro is exploring possibilities to do some of the work with its own forces which would lower the cost of the project. However, due to other project commitments, Hydro will be able to deploy its own resources to this project only if this project is approved and commenced with minimal delays.

5.2 Project Schedule

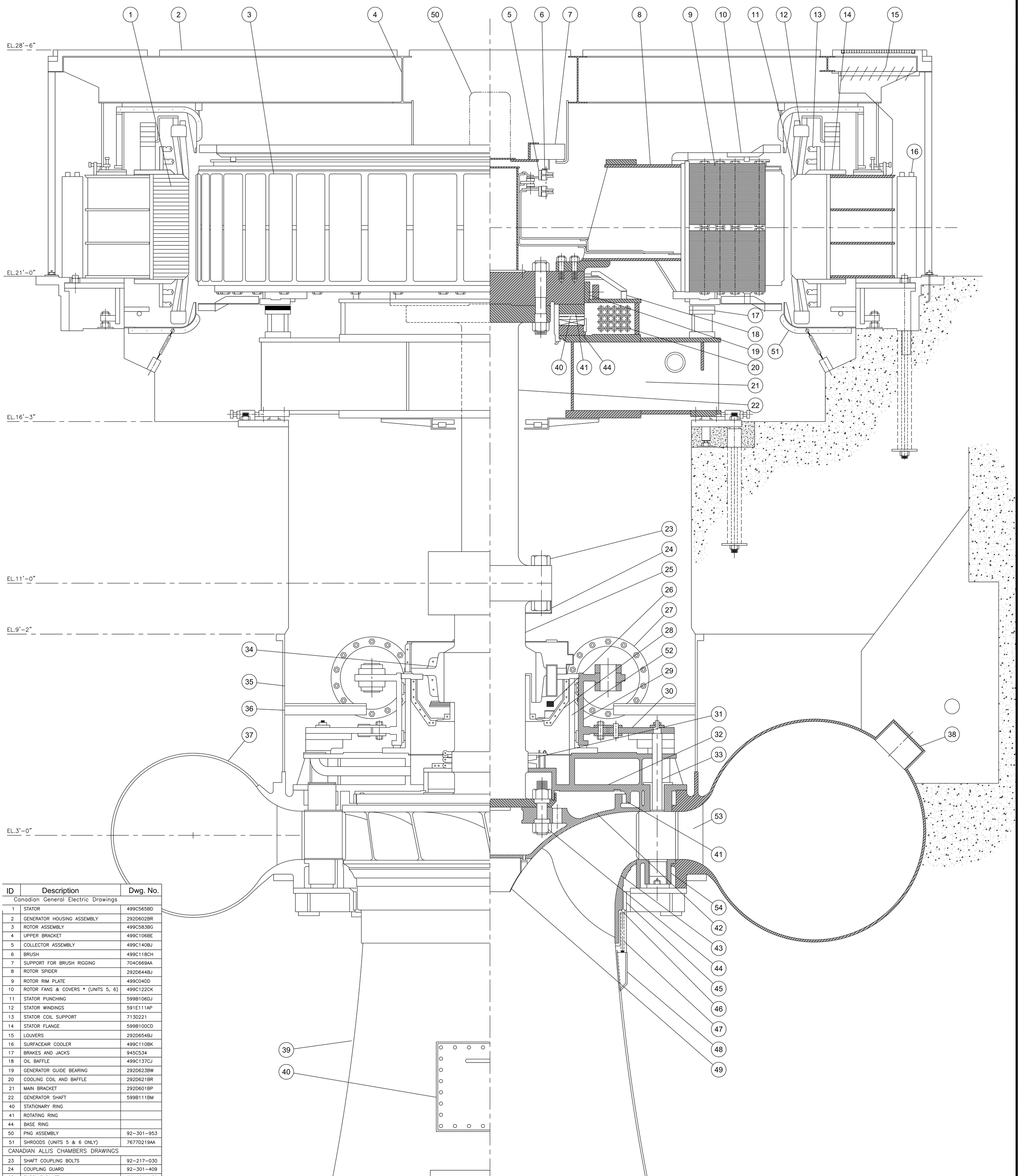
The anticipated project schedule is shown in Table 4. These are tentative dates and reflect an early approval by the Board of Commissioners of Public Utilities (the Board). Hydro also notes that Units 3 and 4 are currently removed from service until the end of July for the Surge Tank 2 refurbishment work.

Table 4: Project Schedule

Activity	Start Date	End Date
Contract Award	July 8, 2016	
Engineering and Material Procurement		July 13, 2016
Contractor Mobilize	July 15, 2016	
Seal refurbishment	July 18, 2016	July 24, 2016
Unit reassembly, and start-up	July 25, 2016	August 12, 2016
Project Closeout	September 30, 2016	N/A

Hydro recognizes that the schedule reflected above is aggressive. Further, the schedule reflects an expedited regulatory process. The system load begins to increase in September and if the project schedule moves into September and Unit 4 is not yet returned to service, the increased load along with Unit 4 at Bay d'Espoir being unavailable increases the likelihood that Hydro would need to put a second unit on at Holyrood, which has the potential for associated additional costs for customers.

This work is being proposed as a supplement to the 2016 Capital Program to ensure that the unit is available and reliable for the 2016/17 winter operating season. Submitting this request as a part of the 2017 Capital Program would result in this unit being unavailable for the 2016/17 winter operating season.



ID	Description	Dwg. No.
	Canadian General Electric Drawings	
1	STATOR	499C565BD
2	GENERATOR HOUSING ASSEMBLY	292D602BR
3	ROTOR ASSEMBLY	499C583BG
4	UPPER BRACKET	499C106BE
5	COLLECTOR ASSEMBLY	499C140BJ
6	BRUSH	499C118CH
7	SUPPORT FOR BRUSH RIGGING	704C669AA
8	ROTOR SPIDER	292D644BJ
9	ROTOR RIM PLATE	499C04DD
10	ROTOR FANS & COVERS * (UNITS 5, 6)	499C122CK
11	STATOR PUNCHING	599B106DJ
12	STATOR WINDINGS	591E111AP
13	STATOR COIL SUPPORT	713D221
14	STATOR FLANGE	599B100CD
15	LOUVERS	292D654BJ
16	SURFACEAIR COOLER	499C110BK
17	BRAKES AND JACKS	945C534
18	OIL BAFFLE	499C137CJ
19	GENERATOR GUIDE BEARING	292D623BW
20	COOLING COIL AND BAFFLE	292D621BR
21	MAIN BRACKET	292D601BP
22	GENERATOR SHAFT	599B111BM
40	STATIONARY RING	
41	ROTATING RING	
44	BASE RING	
50	PNG ASSEMBLY	92–301–953
51	SHROODS (UNITS 5 & 6 ONLY)	7677D219AA
	CANADIAN ALLIS CHAMBERS DRAWINGS	
23	SHAFT COUPLING BOLTS	92–217–030
24	COUPLING GUARD	92–301–409
25	TURBINE SHAFT	92–401–480
26	TURBINE BEARING COOLER	92–301–413
27	SERVO–MOTOR ASSEMBLY	92–401–132
28	LOWER OIL PAN HOUSING	92–401–130
29	OPERATING RING	92–401–120
30	WICKET GATE LEVER	92–301–393
31	CARBON SEAL ASSEMBLY (HUHN)	92–401–631
32	HEAD COVER ASSEMBLY	92–401–117
33	WICKET GATE ASSEMBLY	92–501–584
34	GUIDE BEARING ASSEMBLY	92–401–227
35	TURBINE PIT LINER	92–401–126
36	FLOOR PLATES / SUPPORTS	92–301–439
37	SPIRAL CASE ASSEMBLY	92–301–401
38	SPIRAL CASE MANHOLE	92–301–405
39	DRAFT TUBE LINER	92–401–140
40	DRAFT TUBE MANHOLE	92–301–444
52	TABLE HEAD COVER EXTENSION	92–301–884
53	STAY RING	92–401–485

ID	Description	Dwg. No.
	VOITH HYDRO DRAWINGS (RUNNER REPLACEMENT)	
41	HEAD COVER WEARING RING	2622–1967
42	RUNNER CROWN	2622–1947
43	RUNNER ASSEMBLY	2622–1956
44	RUNNER COUPLING STUD	2622–1951
45	DISCHARGE RING WEARING RING	2622–1966
46	RUNNER BAND	2622–1948
47	DISCHARGE RING INSERT	2622–1985
48	SEAL CLEARANCE MEASUREMENT POCKET	2622–1986
49	RUNNER CONE	2622–1983
54	BOTTOM RING	92–401–124

NEWFOUNDLAND AND LABRADOR HYDRO

DWG.NO.	TITLE

REFERENCE DRAWINGS

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
1	03–01–10	UPDATED STATIONARY RING	K.B.R.			

REVISIONS

ELECT.	
CIVIL	
TRANS.	
MECH.	
P&C	
TELC.	

SCALE: None
DESIGNED:
DRAWN: K.B.Ricketts
DATE: 95–12–08
CHECKED:
APPROVED:

BAY D'ESPOIR GENERATING STATION
TURBINE / GENERATOR ASSEMBLY
UNITS 1 - 6

W.O. NO.

DWG. NO. B1 - 2107 - M - 80

REV. 0

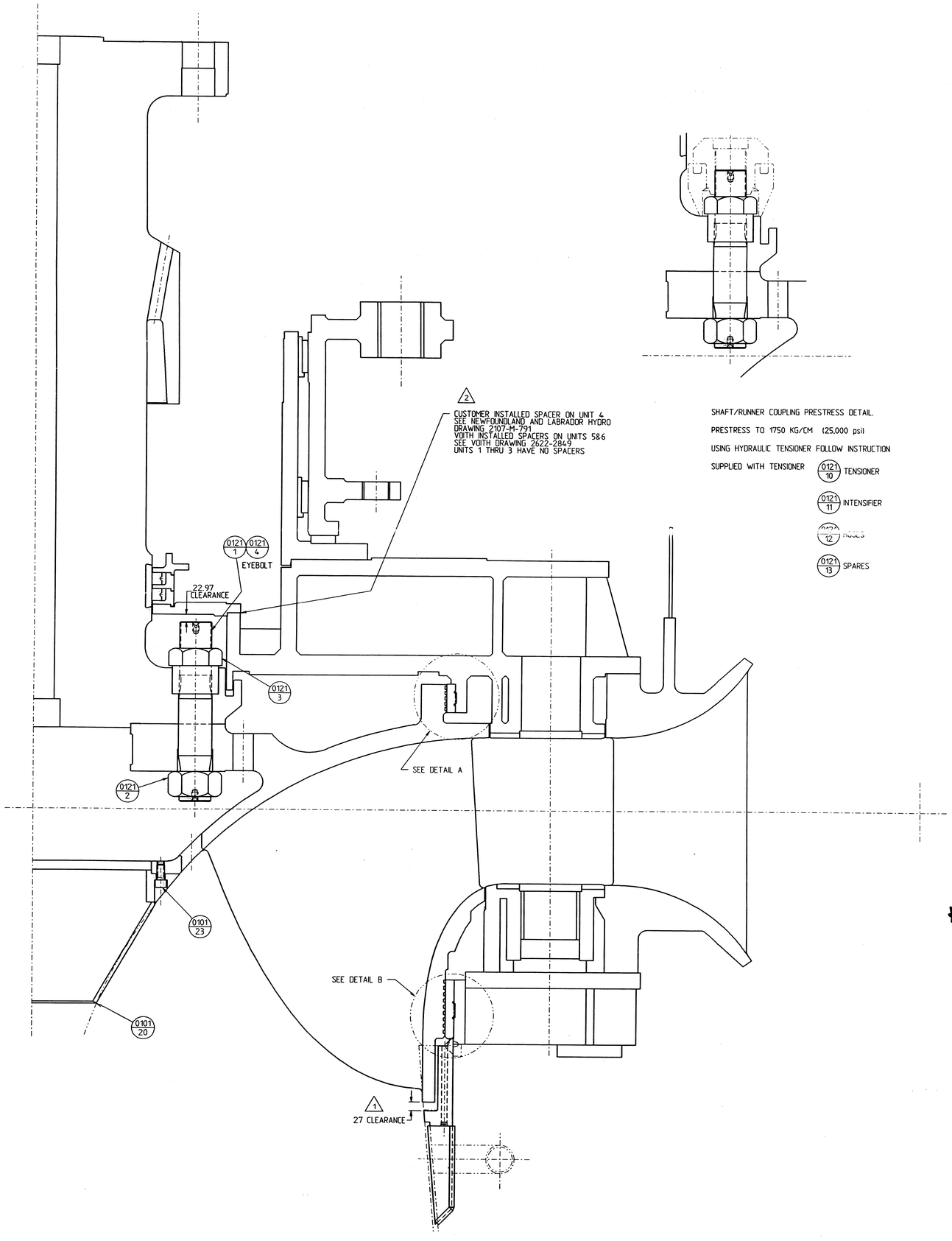
PLOT SCALE = 1 : 1 C.A.D.

Appendix B

NOTE:

△2 THIS DRAWING IS USED ON UNITS 1 THRU 6 EXCEPT FOR SPACERS AT LOCATION (B-6) WHICH ARE USED ON UNITS 4 THRU 6 ONLY.

REVISIONS	
(A-6) 27 WAS 20 (B-3) 30 WAS 25	DED RDS
01 DCS 8-3-93	
REVISED FOR AS BUILT CONDITION PER CUSTOMER PRINT DATED 6-25-96	JRD
02 DED 10-28-96 © 1996	



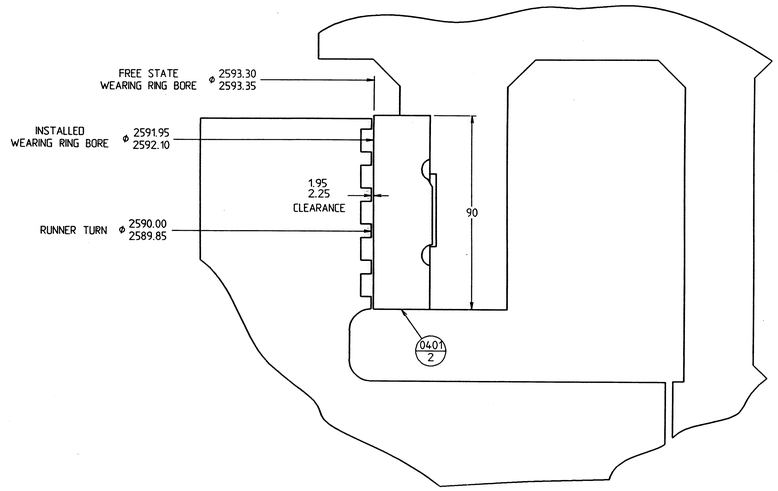
SHAFT/RUNNER COUPLING PRESTRESS DETAIL.

PRESTRESS TO 1750 KG/CM² (25,000 psi)

USING HYDRAULIC TENSIONER FOLLOW INSTRUCTION

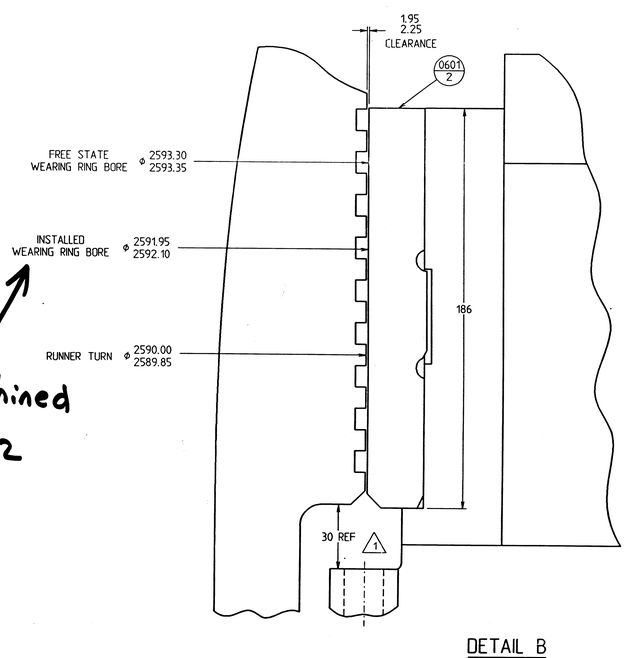
SUPPLIED WITH TENSIONER

- 0121/10 TENSIONER
- 0121/11 INTENSIFIER
- 0121/12 HOSES
- 0121/13 SPARES



DETAIL A

SCALE 1:1



Surface to be machined May 2002

DETAIL B

SCALE 1:1

METRIC FILE NO. 9972

IG CAD DRAWING-NO MANUAL REVISIONS

		Project: BAY D'ESPOIR	Contract No: 35243
		Third angle projection	NEWFOUNDLAND AND LABRADOR HYDRO
		Unless otherwise specified, all dimensions are in millimeters and machining tolerances are: X ± 2, X.X ± 1, X.XX ± 0.25; Chamfer 0.5 min inside R 2.0 max; Reamed holes +0.04 −0.01; Surface finish √ µ m	Material/Spec
			Pattern No. Etc
		Design: DED	Title: FIELD ASSEMBLY
		Dftg: MLS; Mech Eng Appr: RDS	
		Chk: RDS; QA/ME Appr:	
		Date: 10-21-92; Scale: 1:5	
		VOITH — Voith Hydro, Inc. York, Pa.	Drawing No: 2622-1988; Sh 1 of 1; Rev 02
		© All Rights Reserved	Repl. for
		Ref	A0
△2	M&W DWG. NO. 2107-M-791	SPACER (UNIT 4)	
	2622-2849	SPACER (UNITS 5 & 6)	
	DWG.NO.	CROSS REFERENCES	