NEWFOUNDLAND AND LABRADOR HYDRO

Root Cause Investigation of System Disturbances
On January 4 and 5, 2014
Sunnyside Transformer T1 Fire,
Western Avalon Transformer T5 Tap Changer Failure,
Sunnyside Terminal Station Restoration Failure, and
Holyrood Breaker B1L17 Failure

March 2014

newfoundland labrador hydro
a nalcor energy company

Table of Contents

EXECUTIVE SUMMARY 1
1 INTRODUCTION 5
2 REVIEW PROCESS 7
3 BACKGROUND 13
4 SEQUENCE OF EVENTS: RELEVANT TIME FRAME OF EQUIPMENT FAILURE INCIDENTS 13
5 KEY FINDINGS AND RECOMMENDATIONS 17

Appendices:
Appendix 1 - Pictures
Appendix 2 - Drawings
Appendix 3 – PM's & CM's
Appendix 4 – Fault Traces
Appendix 5 – Sequence of Events
Appendix 6 – Relay Cards
Appendix 7 – External Reports - DRAFT
Appendix 8 – Snap Charts
Appendix 9 – Additional Findings and Areas for Continuous Improvement

EXECUTIVE SUMMARY

TapRooT® is a highly structured investigative process designed to focus on the identification of causal factors and specific problems of clearly specified events. By its nature, the purpose of the TapRooT® analysis is to determine the root cause and identify corrective actions directly related to the problem being investigated. In the course of an investigation, TapRoot® often identifies additional areas for consideration that are not directly related to the cause of the problem. TapRoot® is recognized as industry best practices for investigative processes.

Newfoundland and Labrador Hydro (Hydro) has completed a comprehensive review of the events surrounding the supply disruptions on the Island Interconnected System during January 2-8, 2014. The review included investigation of the rotating outages that occurred between January 2-8, 2014[1] and the transmission/terminal station equipment failures that occurred on January 4 and 5, 2014. The focus for this report documents the root cause investigation into four incidents that contributed to the outages, which occurred on January 4 and 5, 2014. These incidents are the Sunnyside Transformer T1 Fire, Western Avalon Transformer T5 Tap Changer Failure, Sunnyside Terminal Station Restoration Failure, and Holyrood Breaker B1L17 Failure. The purpose of this investigation is to identify recommendations and corrective actions that will reduce the likelihood of a reoccurrence of these incidents, based on root causes or most probable root causes where a clear specific root cause was not attainable.

This portion of the review is prepared by an internal team of Nalcor Energy employees. This report utilizes data collected from field inspections of the four incidents by the investigation team, analysis performed by Nalcor staff, equipment inspections by original equipment manufacturers (OEM) such as ABB, Reinhausen and CG Global; external analysis of protection systems performance by Henville Consulting Inc.; and external validation of the TapRooT® process by consultant Brian Tink.

[1] Rotating outages occurred on January 2, 3, 5 and 8, 2014.

On January 4, 2014 an internal fault occurred on Sunnyside T1 transformer, which due to a breaker failing to open, resulted in a fire on the transformer and wide-spread customer outages. The fault on Sunnyside T1 in combination with other factors such as cold weather conditions, power system loading, equipment failures, and protection modifications contributed to the Sunnyside Bus Restoration Failures and Holyrood Breaker B1L17 Breaker Failure. While the cause has not yet been determined on Western Avalon T5 Transformer, there appears to be a connection between this transformer's tap changer failure, and the system disturbance caused by Sunnyside T1 failure.

The key findings of the TapRooT® investigation with recommendations and corrective actions are presented in this report.

- TA1: Conduct a formal risk/reward review on expanding the current program for the installation of on line continuous gas monitor on generator step up (GSU) transformers to include other transformers installed on the Hydro System.
- TA2: When system conditions allow, conduct an in-depth analysis of the DC system for Breaker B1L03 to determine if any high-impedance paths exist which may affect its operation.
- TA3: Consider conducting a formal risk/reward review of system design to determine whether 230kV transformers require their own 230kV breaker in all terminal stations, as this would reduce complexity and increase reliability.
- TA4: Consider conducting a formal risk/reward review of the 230kV breaker failure protection philosophy for transformers at stations that currently do not have breaker fail protection.
- TA5: Consider implementing transformer protection initiation of breaker fail protection at all stations that have breaker fail protection.
- TA6: Conduct an analysis of the Island Interconnected System to determine if a transient overvoltage, due to system harmonics, was a cause of the Western Avalon T5 Failure.

TA7: Review application of lockout protection on all transformers to ensure that the proper isolation of the transformer automatically blocks the initiation of 138kV breaker failure protection on the associated breakers.

TA8: Consider having additional resources (P&C technologists and engineers) available on site to support the restoration of power in emergency situations.

TA9: Review breaker failure protection applications of all transformer protection designs at stations using the same breaker failure relay (Schweitzer Engineering Laboratories type SEL-501). This review would determine whether the breaker failure protection re-trip function (if applied in the SEL-501) is being used in a similar non-conventional application to that at Sunnyside. If it is, modify the scheme to prevent undesirable or unexpected response from the non-conventional application.

TA10: Revise work method SWM-000318 to include:

- Correct procedure to seal the breaker air receiver tanks to prevent moisture ingress while the interrupters are removed; and
- Visual inspection of the breaker air receiver tanks prior to the reinstallation of the interrupters.

TA11: Conduct a risk/reward review of the current practice for the application of the Room Temperature Vulcanizing (RTV) coating with consideration given to the following alternatives which would reduce the amount of time the interrupters are removed from the main receiver tank:

- Materials that can be applied without having to disassemble the breaker;
- Installing spare interrupters that have the RTV coating applied; and
- Applying RTV in a nearer controlled environment (Holyrood has some facilities).

TA12: Conduct a review of the Transmission and Rural Operations (TRO) Central Annual Work Plan to identify opportunities for improvement as it relates to the prioritization and timely execution of work. The review should include, but not be limited to, factors affecting the priority and execution of work, such as the

availability of resources (staff, tools and equipment) to effectively execute the annual work plan.

1 INTRODUCTION

This focus area report is part of an internal report on the Hydro power disruptions on January 4 and 5, 2014. The main report references this focus area with respect to root causes and corrective actions around four incidents. These incidents are the Sunnyside Transformer T1 Fire, Western Avalon Transformer T5 Tap Changer Failure, Sunnyside Terminal Station Restoration Failure and Holyrood Breaker B1L17 Failure.

Hydro employs several processes for the systematic investigation of the fixable root causes of quality, safety, production, or maintenance problems. For complex events, the TapRooT® System combines both inductive and deductive techniques for investigations, which can be used both reactively – to create corrective actions that prevent a recurrence – or proactively – to improve performance.

TapRooT® is a highly structured investigative process designed to focus on the identification of causal factors and specific problems of clearly specified events. By its nature, the purpose of the TapRooT® analysis is to determine the root cause and identify corrective actions directly related to the problem being investigated. In the course of an investigation, TapRoot® often identifies additional areas for consideration that are not directly related to the cause of the problem. TapRoot® is recognized as industry best practices for investigative processes.

From an investigation and TapRooT® analysis, the system disturbances of January 4 and 5, 2014, can be attributed to a combination of cold weather, power system loading, equipment failures, and protection modifications.

At 09:05 on January 4, 2014 a fault occurred on Sunnyside T1 transformer, which was the initiating event. Subsequent events were the failure of Western Avalon T5 Transformer Tap Changer, Sunnyside Bus Restoration Failure and Holyrood Breaker B1L17 failing, all of which are interrelated incidents which contributed to causing power outages primarily to the Avalon

Peninsula. Figure 1 below is a pictorial representation of the four incidents and their interdependencies.

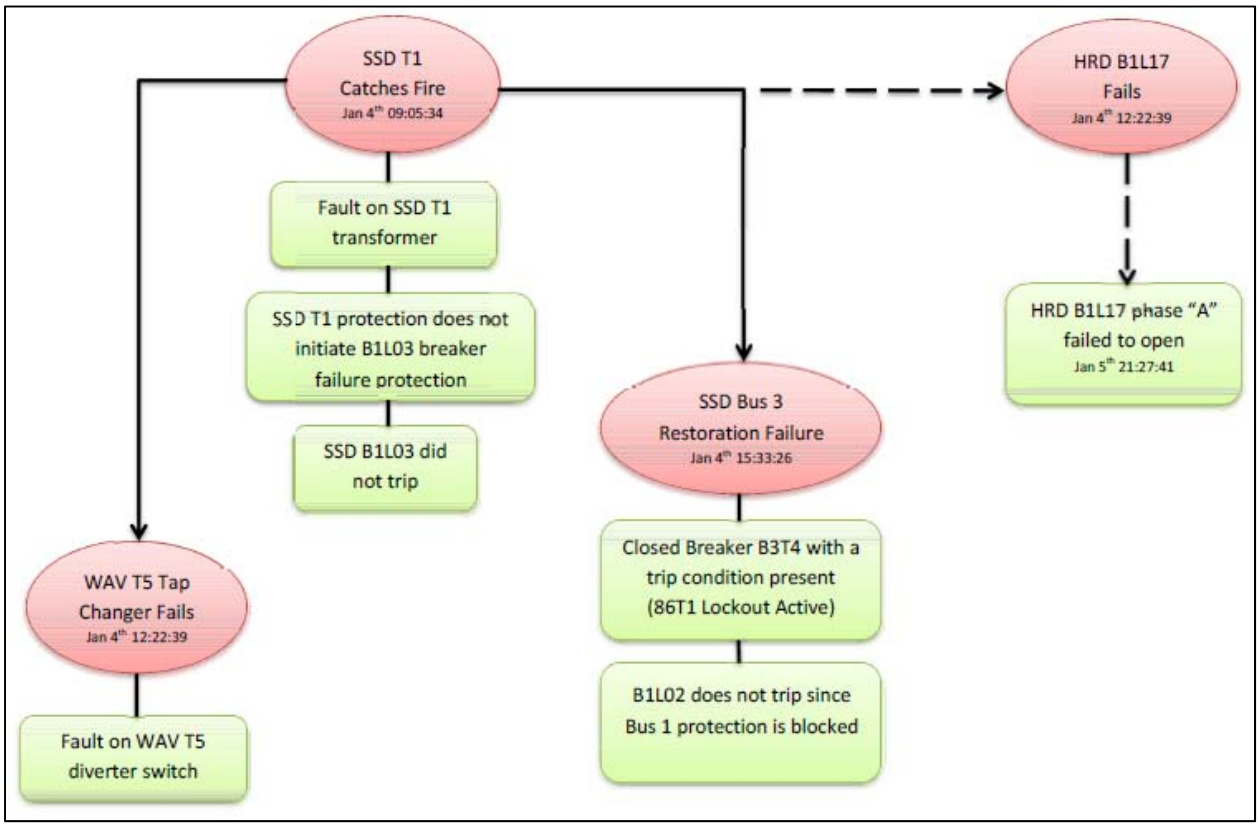


Figure 1 – Incident Interdependences

An internal fault occurred on Sunnyside T1 transformer and if everything operated as the design intended, it would have been taken offline and isolated from the grid for further investigation with a short localized disruption of power. However, breaker B1L03 failed to operate correctly, which caused the fault to remain longer and led to the T1 transformer fire, as well as triggering further system disturbances.

While the investigation has not been completed on Western Avalon T5 Transformer, there appears to be a connection between this transformer's tap changer failure and the system disturbance caused by Sunnyside T1 failure.

In response to the disturbance caused by Sunnyside T1 and breaker B1L03 failure, all three Holyrood generating units tripped offline. An analysis of the fault traces have shown that breaker B1L17, which is one of two breakers connecting generating Unit G1 at Holyrood to the grid, failed at this time.

During the restoration effort of Sunnyside Station, there were difficulties in isolating T1 Transformer, which led to further delays in getting power restored to customers.

Subsequent sections of this report provide a more detailed analysis of the full sequence of events; determining the causal factors, root causes, and provides corrective actions.

2 REVIEW PROCESS

Events within the Hydro system which result in widespread customer outages and/or significant equipment damage are subject to a comprehensive review and investigation. Hydro utilizes its *Standard for Root Cause and Repeat Failure Analysis* (a TapRooT® Investigation) for these comprehensive investigations. As such, the management team selected the four events of January 4 and 5, 2014 to be investigated utilizing the TapRooT® process due to the impact on customers and substantial damage to equipment.

To carry out the investigation it was deemed essential to assemble a qualified team to assist with performing a thorough analysis of the events. The team follows a standard process for conducting root cause investigations. The team utilized both internal and external resources in determining the root causes of the incidents. The team membership had a previous working knowledge of the TapRooT® process itself, as well the support of a TapRooT® Process Matter Expert to help guide the investigation from an external perspective. Independent utility industry experts, with an in-depth knowledge of the operations of power systems, including experience with power system disturbances, were involved in the overall investigation. Subject matter experts were utilized to help with system and data analysis, as well as review protection

system operation and design. OEMs and their field-service technicians assisted with equipment design reviews, as well as disassembly, and forensic field investigations. All external members of the team provided independent reports, which supplement this investigation.

2.1 Team Composition

The team composition consisted of Hydro resources, process experts, subject matter experts and OEM technical experts.

2.2 Hydro Resources

Dave Hicks, Manager of Electrical Engineering for Project Execution and Technical Services (PETS), with 24 years experience with Hydro, mostly with high voltage terminal station equipment specification and design. Dave has past experience with Terminals Station Review Committee and is current chair of Transformers and Switchyard Technical Council.

Perry Taylor, Senior Electrical Engineer, with more than 13 years experience covering system analysis, high voltage equipment specification and design review, as well as experience with operation and maintenance of high voltage switchyard of Churchill Falls and the underground power house. Perry is a member of the Transformers and Switchyard Technical Council; a former member of the TapRooT® Technical Council; has been trained in TapRooT® process and has conducted multiple TapRooT® investigations of equipment failures throughout Nalcor Energy.

Blaine Piercey, Senior Electrical/Mechanical Supervisor of Terminal Stations Maintenance crews for TRO Central with more than 29 years experience with Hydro working primarily with terminal station equipment operations and maintenance, including high voltage transformers, circuit breaker overhauls, and air support systems.

Brad Eddy, Electrical Equipment Engineer, with more than five years experience dealing primarily with Hydro's power transformers refurbishment and replacement programs. Brad has

been trained in TapRooT® process and has conducted multiple TapRooT® investigations of equipment failures throughout Nalcor Energy.

2.3 Process Experts

Brian Tink, TapRooT® Process Matter Expert and former member of Ontario Power Generation, with 30 years working with both generation and transmission assets.

2.4 Subject Matter Experts

Brian Scott of AMEC, subject matter expert with more than 30 years experience with operation and maintenance with New Brunswick Power's system including power system analysis and power system disturbances events. He was director of reliability and operations for New Brunswick Power.

Blair Seckington of AMEC, subject matter expert with more than 30 years experience with operation and maintenance of power systems including power system disturbances, with Ontario Power Generation. He was a condition assessment and reliability expert with Ontario Power Generation.

Charlie Henville, of Henville Consulting Inc., a Senior Protection and Control Design Review Engineer and former BC Hydro protection and control engineer with more than 44 years of professional engineering experience.

2.5 OEM Technical Experts

ABB: Mustaf Lahloub, transformer field service engineer and forensics expert.
ABB: Scott Morris, field service technician for air blast circuit.
CG Power: Chris Sarrasin, field service technician for power transformers.
Reinhaussen: Markus Zwicknagel, field service technician for tap changers.

2.6 Process Followed

The processes followed by the team are shown in Figure 2 – Process Flow Diagram.

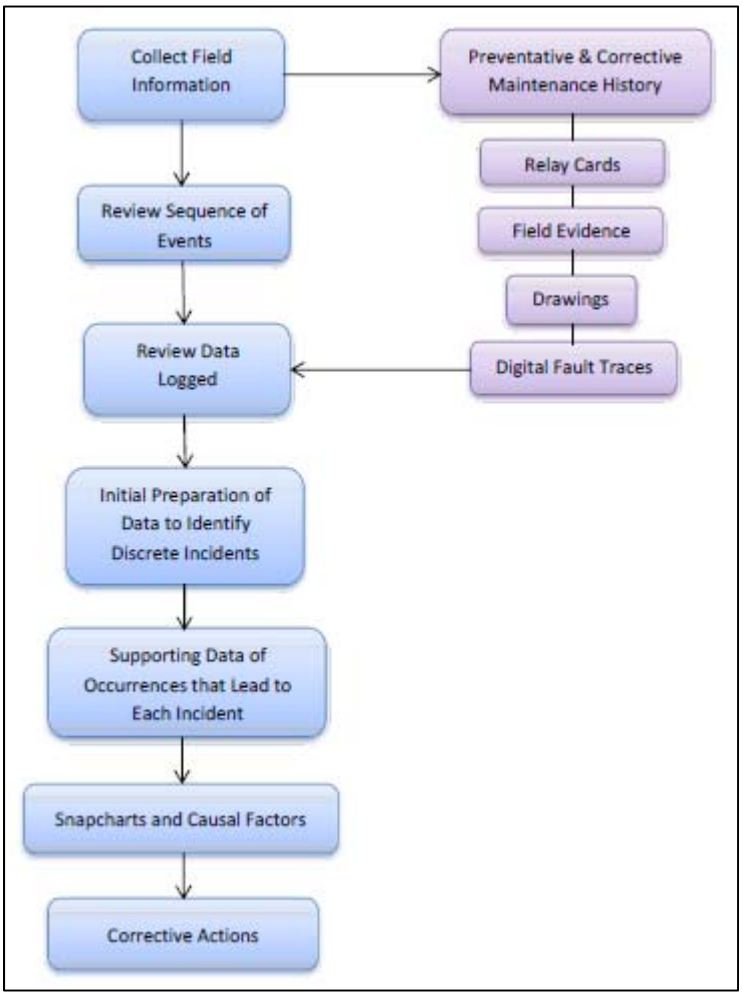


Figure 2 - Process Flow Diagram

In addition to the work performed by external consultants and OEMs, the internal team made an extensive effort, with the help of numerous colleagues throughout the system, to collect all the vital information relevant to the events of January 4 and 5, 2014. Such information included sequence of events records, fault traces, drawings, preventative maintenance and corrective maintenance records, as well as discussions with participants in the incidents. All relevant information was shared with external consultants and OEMs to aid their detailed analysis of failed equipment. Using the collected information, as part of the TapRooT® process, a timeline

of events leading up to the incident was created on a SnapCharT®. Conditions to support these events were added to the SnapCharT® and causal factors were identified. These causal factors were then analyzed to identify root causes for the incident. Recommended corrective actions were then developed based on the root causes.

2.7 Schedule

While the root cause investigation officially started on January 7, 2014, with the establishment of the scope of the investigation and assembling the team, internal members of the team were at the various sites on January 5, 2014 to help ensure the preservation of evidence. Site visits to the Sunnyside, Western Avalon and Holyrood Terminal Stations were completed by various members of the investigation team throughout the subsequent investigation.

Brian Tink was consulted and visited the site for the first time on January 13, 2014 to help facilitate the TapRooT® process.

Consultation began immediately with ABB (OEM for Sunnyside T1) on performing an internal inspection to help determine the cause for the failure of Sunnyside T1, as well to begin the design review. A design review was done of Sunnyside T1 and sister units Sunnyside T4, Stony Brook T1 and T2. Mustafa Lahloub began his investigation into the failure and was onsite in Sunnyside immediately following the incident. He performed an internal inspection on January 21, 2014 as soon as the oil test results were complete and the transformer had been drained of its oil. A preliminary report of their findings has been submitted for review, which provides a detailed synopsis of the cause of failure. Their report supplements this report and is attached in Appendix 7 – External Reports.

ABB (OEM for Holyrood breaker B1L17) was consulted, and on January 16, 2014 Scott Morris, a field service representative, came to site to inspect Holyrood breaker B1L17. Mr. Morris also came back to Holyrood on January 27 to oversee the rebuild of breaker B1L17. On February 3, 2014 he travelled to Bishop's Falls to oversee the teardown inspection of the components

removed from breaker B1L03 at Sunnyside. Mr. Morris provided two separate reports of his findings, one for each investigation. Both reports supplement this report.

Knowing the incidents of January 4 and 5, 2014 would have a significant impact on the overall power system, and for which the fault recorders would have captured essential data, Charlie Henville was immediately engaged to help with the analysis of this data and to conduct a review of the performance and design of the protection systems. This would help with early identification of any issues that may have contributed to the incidents. Mr. Henville's report supplements this report.

On January 11, 2014, a field service representative from Reinhausen (tap changer OEM for Western Avalon T5 tap changer) came to Western Avalon to inspect the diverter switch, associated with the tap changer. While this investigation is not complete, Reinhausen has provided a preliminary report of their findings. On February 21, 2014, Markus Zwicknagel from Reinhausen and Chris Sarrasin from CG Global (OEM for Western Avalon T5 transformer) were on site to conduct an internal inspection of the Western Avalon transformer T5 tap changer and transformer, to access damage and provide a report as to the cause of the failure.

The team has since met with representatives of the Liberty Consulting Group (Liberty) as part of the Public Utilities Board (PUB) review, during which they reviewed our process and the investigation. While the root cause has been clearly determined for some incidents, there are still some unknowns, due in part to insufficient information to complete a thorough analysis. Further comments from Liberty will be explored and will contribute to the final analysis.

In total, the team has been engaged in the process almost full-time, apart from a few exceptions and competing priorities, for a total of eight weeks.

3 BACKGROUND

The TapRooT® root cause analysis method was utilized by the team for the root cause analysis of the above incidents. Hydro has a Root Cause and Repeat Failure Analysis (RCRFA) Technical Council whose mandate is to ensure that major system disturbances and/or equipment failures are thoroughly investigated by an appropriate team to identify root causes and corrective actions. The RCRFA Technical Council has a Standard for Root Cause and Repeat Failure Analysis, and this standard was followed for this investigation.

The TapRooT® method involves the following general steps:

1. Identification of the incident(s);
2. Information collection (documented on a SnapCharT®);
3. Identification of immediate causes (causal factors in TapRooT® terminology);
4. Identification of all root causes associated with each causal factor; and
5. Creation of corrective actions for each root cause.

Provided that the investigation obtains sufficient information, each causal factor results in one or more root causes, and each root cause results in one or more corrective actions. The purpose of the corrective actions is to prevent the incident from reoccurring.

4 SEQUENCE OF EVENTS: RELEVANT TIME FRAME OF EQUIPMENT FAILURE INCIDENTS

4.1 Incident 1: Sunnyside Transformer T1 Catches Fire

At 09:05:34 on January 4, 2014, a fault occurred on the Sunnyside T1 transformer. The T1 protection operated correctly and initiated a trip to five breakers to clear the fault. Only four of the five circuit breakers tripped within 186 milliseconds to clear the fault. The breaker B1L03 failed to open and the fault remained on Sunnyside T1 transformer. Since the fault was not

cleared quickly, it resulted in additional damage and the subsequent fire of the Sunnyside T1 transformer. The fault lasted for two seconds until line protection on TL203 operated and cleared the fault. This resulted in a widespread (187,500 customers) power interruption across the system. Figure 3 below, is a portion of the single line diagram of the Sunnyside Terminal Station showing the equipment involved in the incident. The complete single line for Sunnyside Terminal Station is attached in Appendix 2 – Drawings.

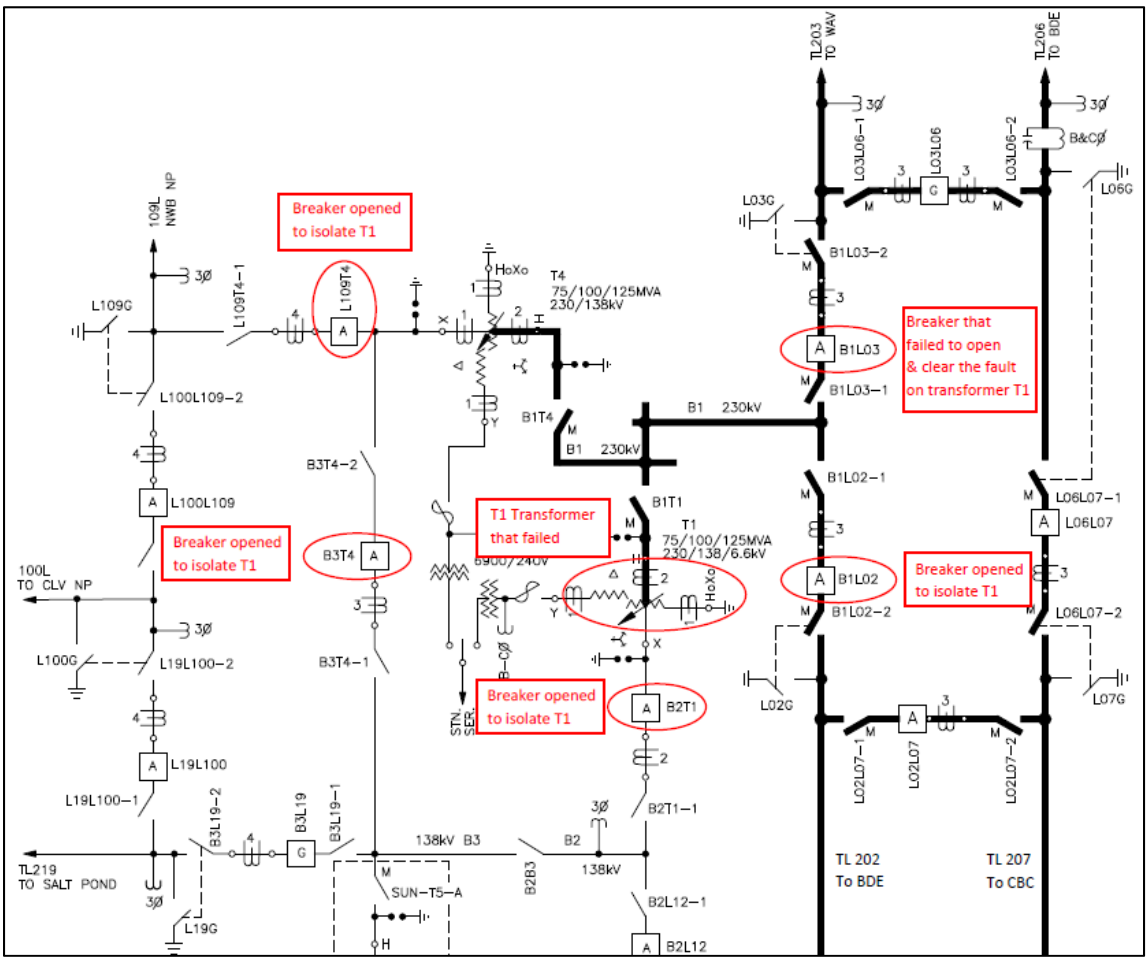


Figure 3 – Sunnyside Terminal Station at 09:05:34

4.2 Incident 2: Western Avalon Transformer T5 Tap Changer Failure

At 12:22:39 on January 4, 2014, Western Avalon T5 tap changer failure resulted in a fault on the transformer. The T5 transformer protection operated correctly and initiated a trip of one breaker and one load break switch, both of which operated correctly and cleared the fault. This

incident resulted in an extended outage for some customers, as the T5 Transformer trip had to be investigated before restoration of the station. Figure 4 below is a portion of the single line for the Western Avalon Terminal Station showing the equipment involved in the incident. The complete single line for Western Avalon Terminal Station is attached in Appendix 2 – Drawings.

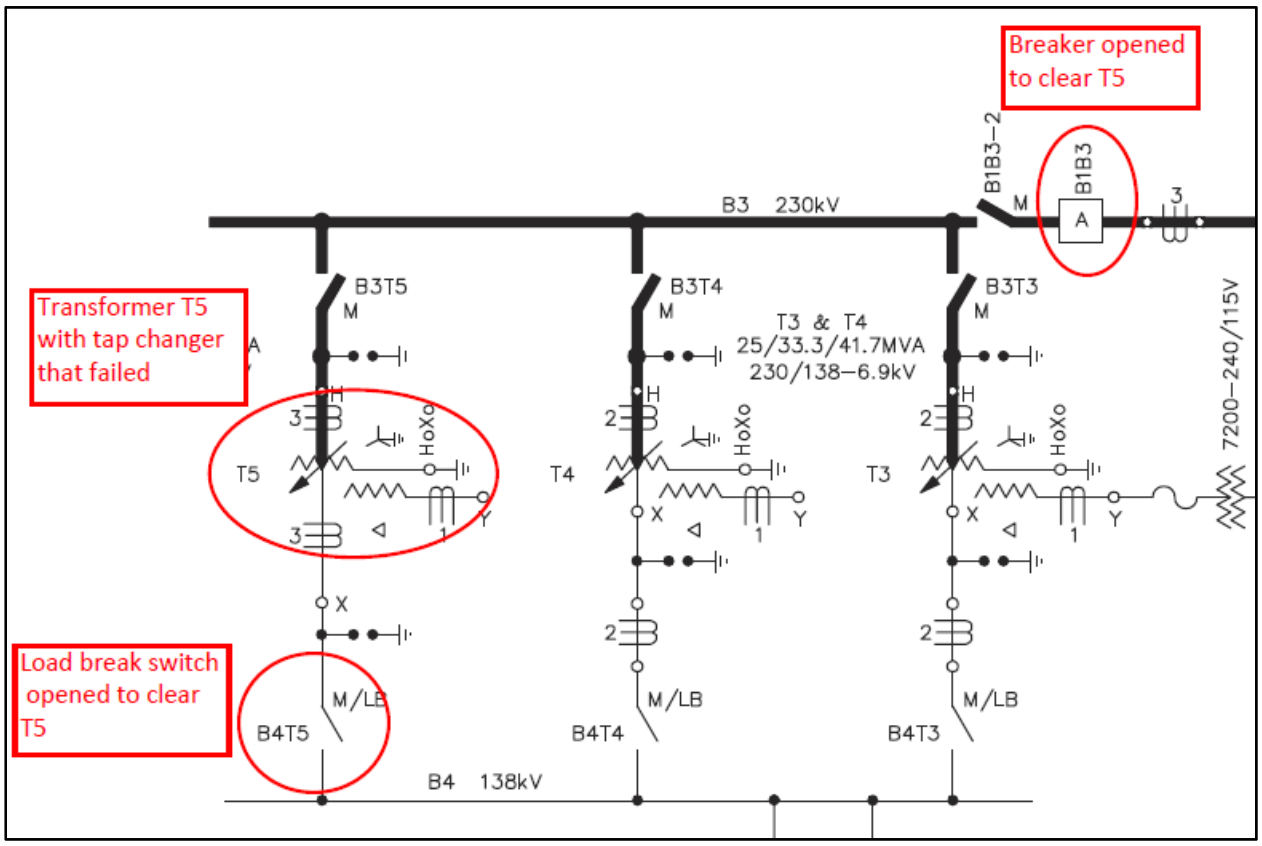


Figure 4 – Western Avalon Terminal Station at 12:22:39

4.3 Incident 3: Sunnyside Terminal Station Restoration Failure

At 12:58:30 on January 4, 2014, an unsuccessful attempt was made to restore power to customers. Temporary protection modifications were made following that unsuccessful attempt to isolate the suspected area of damage due to the fire. At 15:33:26, a second attempt was made to restore power to customers supplied from the Sunnyside Terminal Station. These temporary modifications had an adverse effect on the protection and resulted in a power interruption (165,000 customers) across the system. The details of this event are complex and

involve inherent design issues that are further explained in the "Protection Systems Impacts on 4 January 2014 Supply Disruptions - External Protection Review" by Mr. Henville. Figure 5 below is a portion of the single line of the Sunnyside Terminal Station showing the equipment involved in the incident. The complete single line drawing for Sunnyside Terminal Station is attached in Appendix 2 – Drawings.

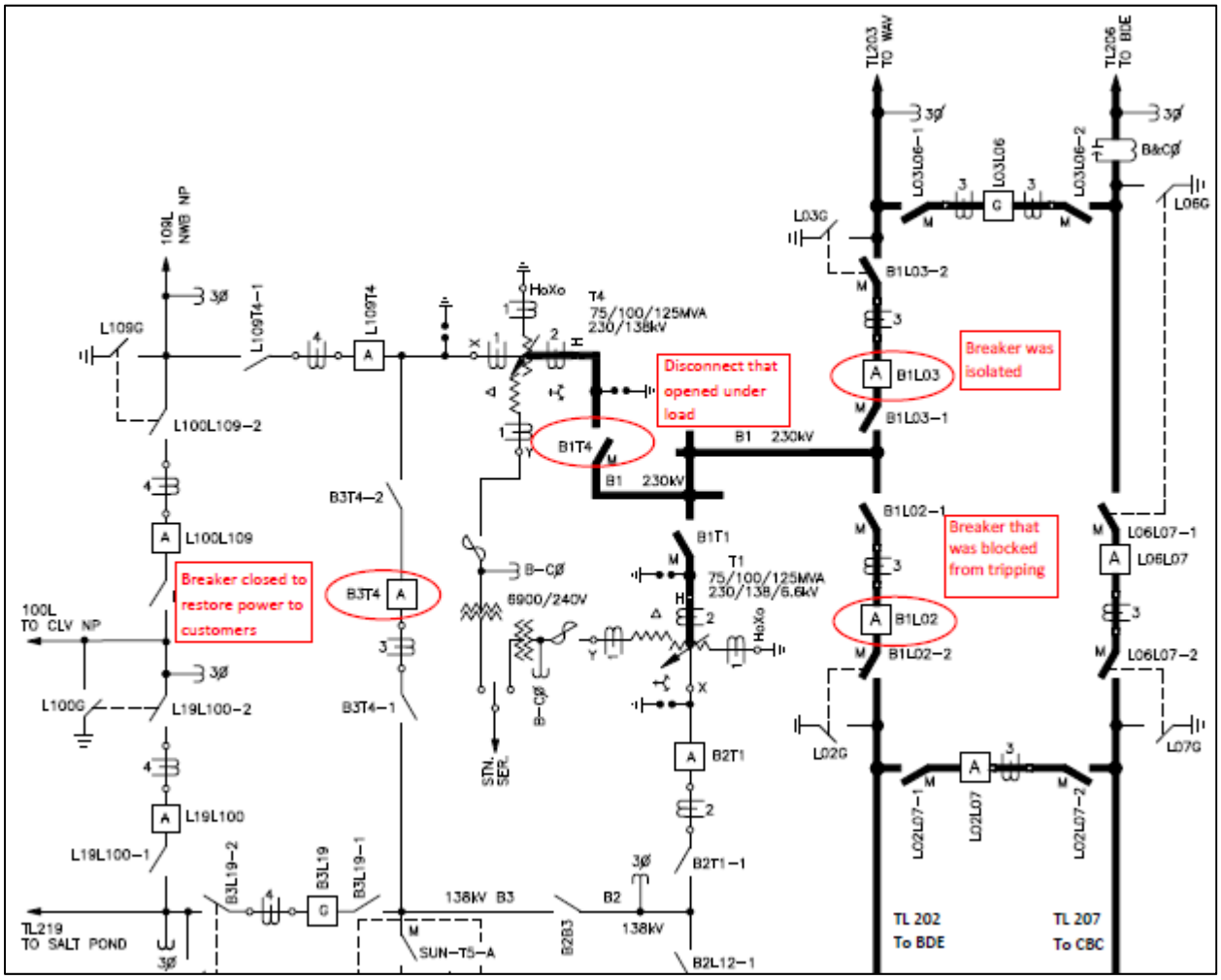


Figure 5 – Sunnyside Terminal Station

4.4 Incident 4: Holyrood Breaker B1L17 failure

At 21:27:34 on January 5, 2014, the Holyrood Terminal Station 230kV disconnect B1T1 was closed in preparation to bring Holyrood Generating Unit G1 online. Closing B1T1 disconnect

caused a significant system imbalance, as one phase of breaker B1L17 had failed to open despite breaker indications showing it as being open on all three phases. The protection for TL217 and Bus B1 operated correctly to clear the imbalance. However, as a result of the neutral overcurrent on the system that resulted from one phase of B1L17 failing to open and the heavy loading on the transmission system at the time, a widespread (110,000) customer interruption was initiated by this event. Figure 6 below is a portion of the single line for Holyrood Terminal Station showing the equipment involved in the incident. The complete single line for Sunnyside Terminal Station is attached in Appendix 2 – Drawings.

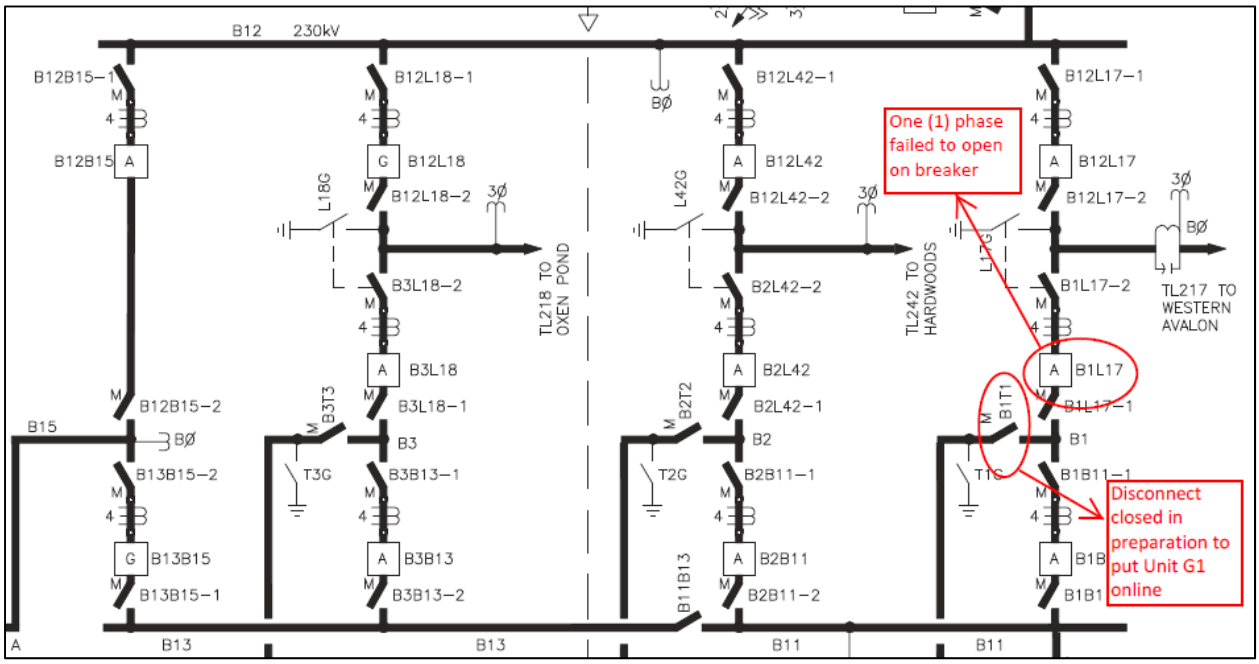


Figure 6 – Holyrood Terminal Station at 21:27:39

5 KEY FINDINGS AND RECOMMENDATIONS

As stated earlier in this report, the TapRooT® method was utilized by the investigation team for the root cause analysis of the four incidents that occurred on January 4 and 5, 2014.

The analysis of the four incidents resulted in a total of eight immediate causes (causal factors in TapRooT® terminology), eight root causes, and 12 recommendations. Below is the breakdown

by incident:

- Sunnyside T1 Fire: three causal factors, two root causes and five recommendations;
- Western Avalon T5 Tap Changer Failure: one causal factor, zero root causes and one recommendation (Investigation not complete);
- Sunnyside Terminal Station Restoration Failure: two causal factors, three root causes and three recommendations; and
- Holyrood Breaker B1L17 Failure: one causal factor, three root causes and three recommendations.

5.1 Incident 1: Sunnyside Transformer T1 Catches Fire

Sunnyside T1 transformer failed due to a bushing failure that initiated inside the transformer. As a result of breaker B1L03 failing to open and no 230kV breaker failure protection associated with T1 transformer fault, the fault was present for an extended period of time and consequently, a fire developed. Figure 7 below is the SnapCharT® of the incident which shows the sequence of events and associated information.

Causal Factor #1: Fault on Transformer T1

The presence of combustible gases in transformer oil is an indication of activity inside the transformer and sudden changes can indicate a problem with the transformer. Early detection of changes in these gases can prevent a catastrophic transformer failure.

Hydro currently performs annual independent laboratory analysis of transformer oil, and plans on installing continuous online gas monitors on existing GSU transformers. In addition, all new transformers being purchased have continuous online gas monitors. Sunnyside T1 had a gas relay, which detects both gas accumulation and gas pressure, but does not have a continuous online gas monitor. Continuous online gas monitors were not available at the time Sunnyside T1 was installed in 1978.

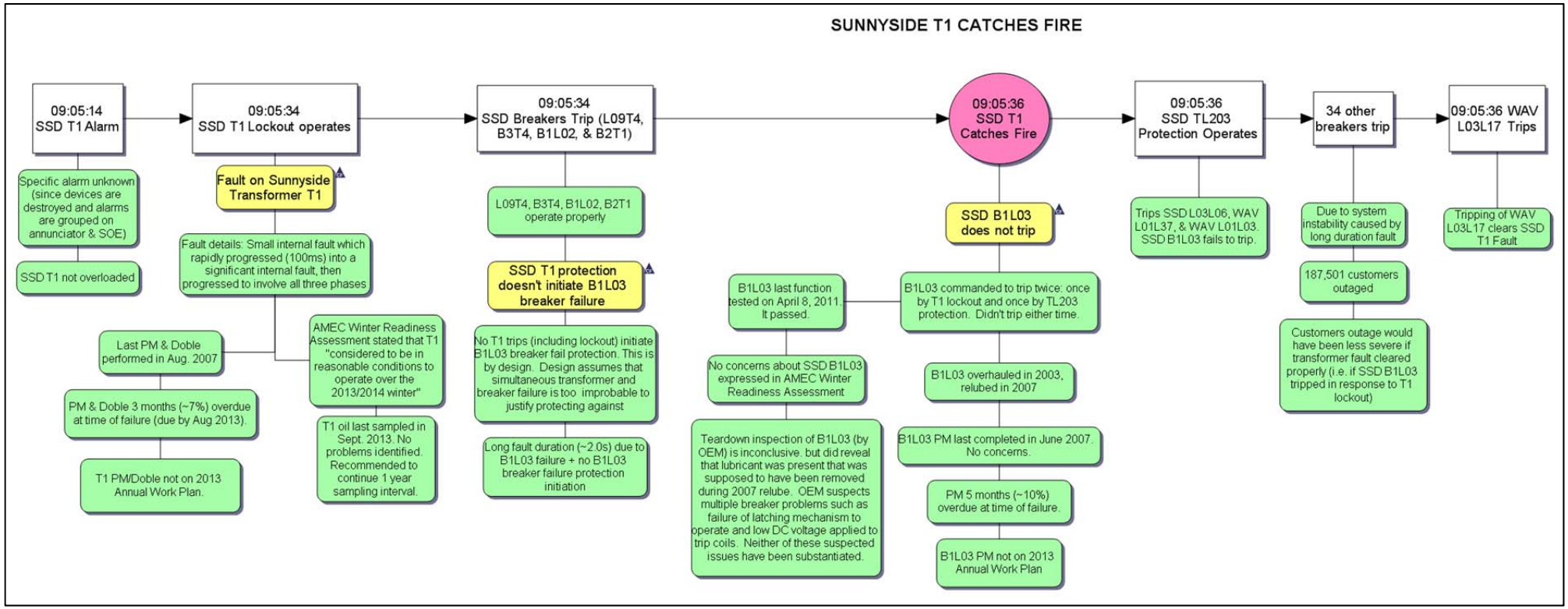


Figure 7 – Sunnyside Transformer T1 Fire SnapCharT®

Root Cause #1: Errors Not Detectable

Errors Not Detectable is a TapRooT® term, which means a problem goes undetected. In this case, it refers to the fact that the generation of combustible gases in the transformer was occurring without being detected by the transformer's gas relay, or any other transformer protection.

Corrective Action #1

Recommendation #	Recommendation
TA1	Conduct a formal risk/reward review on expanding the current program for the installation of online continuous gas monitor on GSU transformers to include other transformers installed on the Hydro system.

Causal Factor #2: SSD B1L03 Does Not Trip

Based on the report by ABB of the inspection of B1L03 the findings are not conclusive and points to issues such as possible high-impedance connections in control circuits, low voltage on DC system, some corrosion of components, low temperatures and/or dirty linkages. In consultation with Hydro's experienced staff and the findings of the ABB report, further testing is required to determine the immediate cause for the B1L03 failure. Breaker B1L03 was overhauled and function tested before it was returned to service. No issues were noted during the standard tests conducted.

Recommendation #	Recommendation
TA2	When system conditions allow, conduct an in-depth analysis of the DC system for breaker B1L03 to determine if any high-impedance paths exist which may affect its operation.

Causal Factor #3: Sunnyside T1 Protection Does Not Initiate B1L03 Breaker Failure Protection

By design, the protection for Sunnyside T1 transformer does not initiate breaker failure protection of the 230kV breakers that protect the transformer. This is also true for Sunnyside T4 transformer. The fault that occurred on T1 on the morning of January 4, 2014 would have cleared faster if the T1 protection initiated breaker B1L03's failure protection and may have cleared it fast enough to prevent the system collapse and transformer from catching fire. The decision not to have this protection initiated was made decades ago during the design of the station. The probability of simultaneous failure of both a transformer and a breaker was considered too low justify this protection.

Root Cause #2: Problem Not Anticipated

During the design of the Sunnyside Terminal Station, the simultaneous failure of a transformer and a 230kV breaker was considered to be too low of a risk to protect against.

Recommendation #	Recommendation
TA3	Consider conducting a formal risk/reward review of system design to determine whether 230kV transformers require their own 230kV breaker in all terminal stations, as this would reduce complexity and increase reliability.
TA4	Consider conducting a formal risk/reward review of the 230kV breaker failure protection philosophy for transformers at stations that currently do not have breaker fail protection.
TA5	Consider implementing transformer protection initiation of breaker fail protection at all stations that have breaker fail protection.

5.2 Incident 2: Western Avalon Transformer T5 Tap Changer Failure

A preliminary analysis of a phase-to-phase fault across the diverter switch of Western Avalon T5 tap changer, suggests a breakdown of insulating materials and/or abnormally high system voltage. Further analysis is required to determine the cause of the fault. Internal inspection of the transformer suggests that it has sustained no damage other than to the tap changer, but further testing is required. Figure 8 below is the SnapCharT® of the incident which shows the sequence of events and associated information.

Causal Factor #4: Fault on Western Avalon T5 Diverter Switch

To date, the root cause for the diverter switch failure has not been determined. From the equipment inspection and subsequent report provided by Reinhausen's field representative, it is their assessment that the failure of the diverter switch was due to a system overvoltage or break down of the insulating oil for the diverter switch. Due to the failure of the hard drive at the Western Avalon Terminal Station, just prior to the incident on January 4, 2014 digital fault traces are not available to determine if a system over-voltage was present. To determine if a system over-voltage or disturbance was the cause of the tap changer failure, further investigation is required.

Recommendation #	Recommendation
TA6	Conduct an analysis of the Island Interconnected System to determine if a transient overvoltage due to system harmonics is a cause of the Western Avalon T5 Failure.

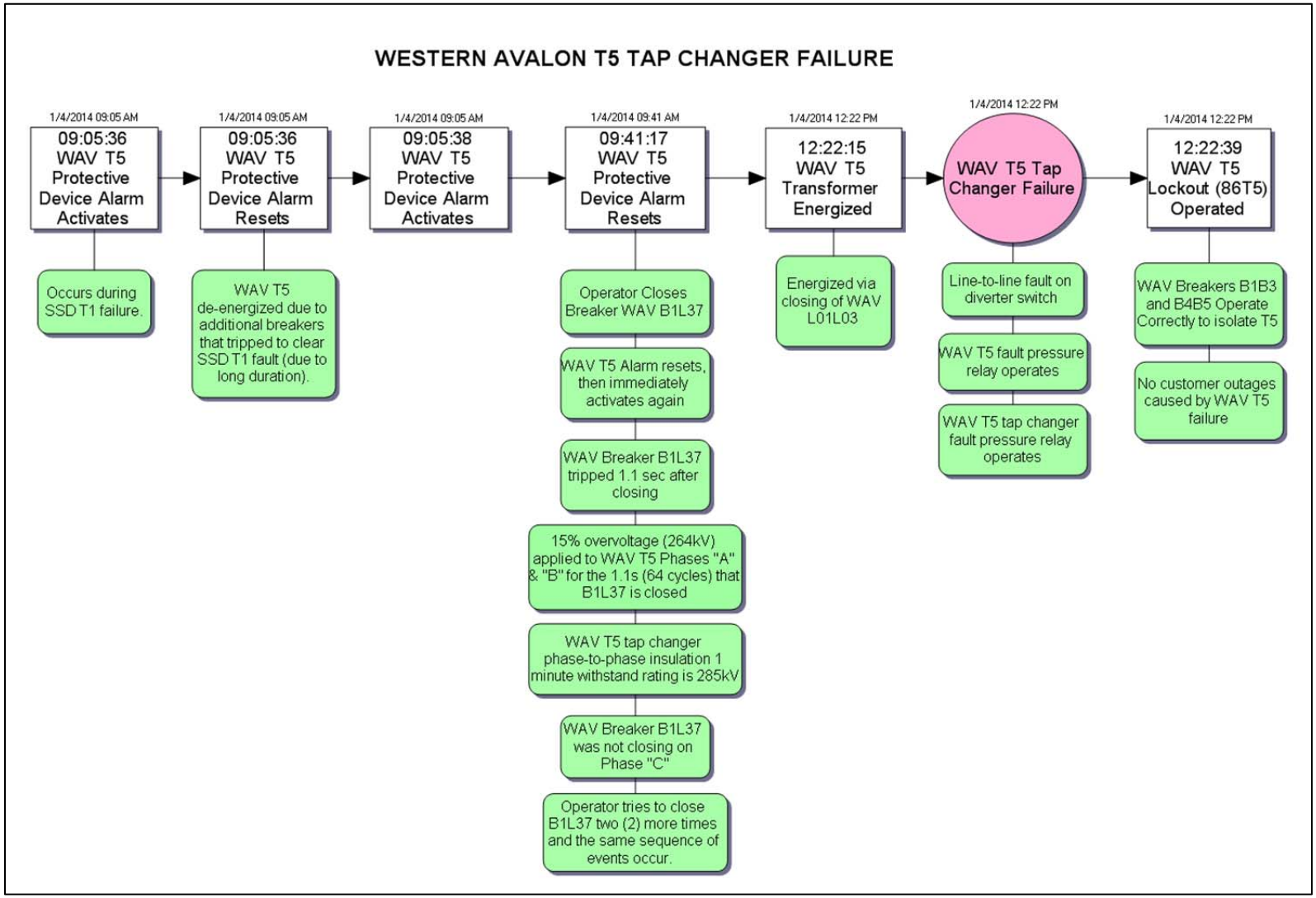


Figure 8 – Western Avalon T5 Tap Changer Failure SnapCharT®

5.3 Incident 3: Sunnyside Terminal Station Restoration Failure

The Sunnyside Terminal Station restoration failure occurred as a result of unnecessary initiation of the breaker failure protection after the fault on T1 had been isolated. The restoration was further impeded by non-conventional application of the B3T4 breaker failure protection and modifications that occurred during the transformer fire event, which protection modification had an adverse effect on the Sunnyside Bus 1 protection. Figure 9 below is the SnapCharT® of the incident which shows the sequence of events and associated information.

Causal Factor #5: Breaker B3T4 Closed with Trip Condition Present

By design, the initiation of B3T4 breaker failure protection was not removed after the isolation of the Sunnyside T1 transformer. When the crews isolated the T1 transformer via the 230kV B1T1 disconnect and 138kV B2T1-1 disconnect, the control circuitry should have automatically blocked the trip commands to any equipment associated with the tripping zone of transformer T1, such as breaker B3T4. However, this is not how the protection scheme is designed and as a result, when B3T4 was closed, its breaker failure protection was initiated and resulted in an extended outage to customers.

Root Cause #3: Problem Not Anticipated

The design of the Sunnyside Terminal Station protection scheme is such that isolation of the T1 transformer would not block the initiation of B3T4 breaker failure.

Recommendation #	Recommendation
TA7	Review application of lockout protection on all transformers to ensure that the proper isolation of the transformer automatically blocks the initiation of 138kV breaker failure protection on the associated breakers.

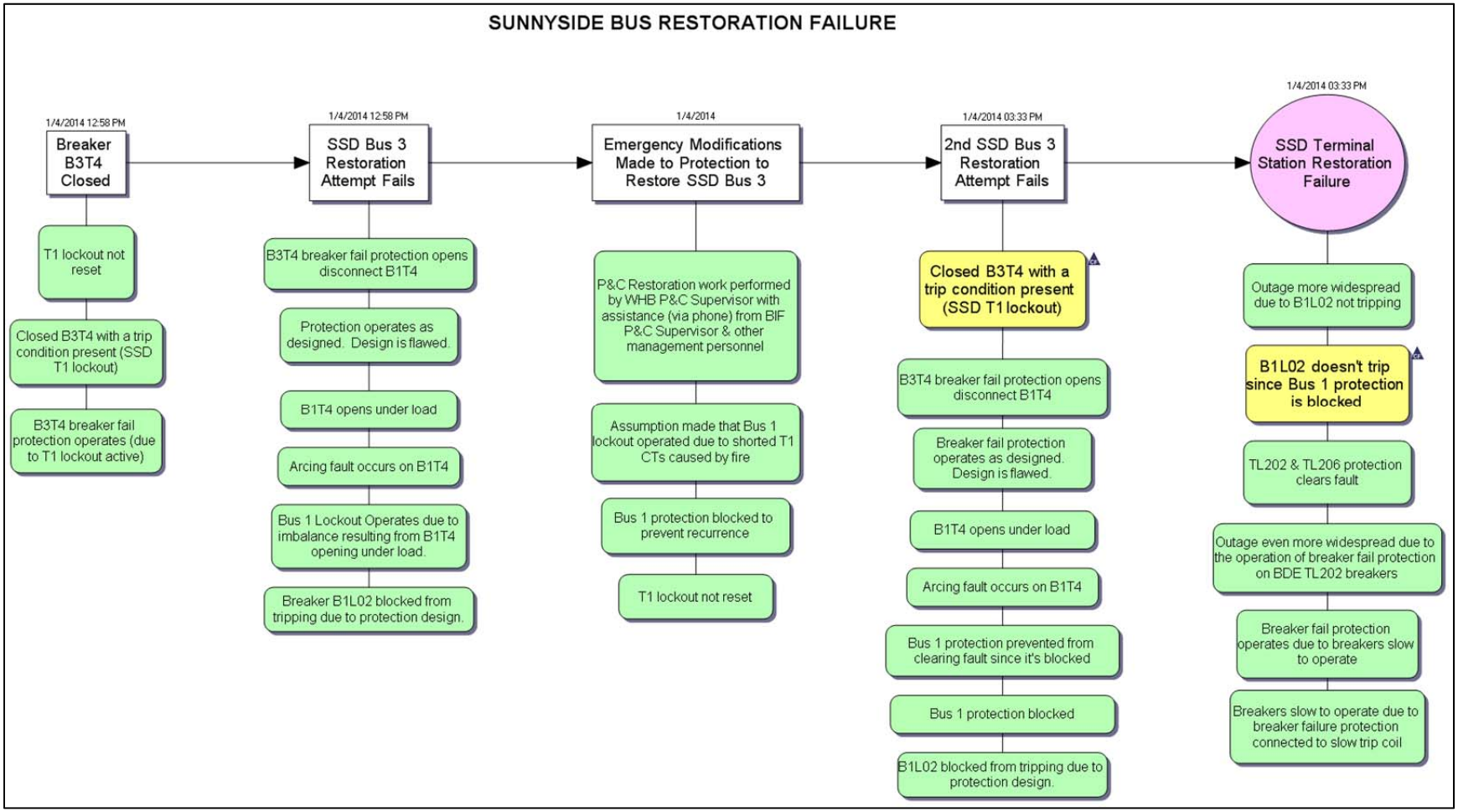


Figure 9 – Sunnyside Terminal Station Restoration Failure SnapCharT®

Causal Factor #6: Sunnyside Breaker B1L02 Does Not Trip Since Bus 1 Protection is Blocked

After the first attempt at 12:58 to restore power to customers supplied from the Sunnyside Terminal Station was unsuccessful, staff reviewed the targets from the protection. They determined that the differential protection operated and initiated the Bus 1 lockout 86B1. In consultation with the Energy Control Center (ECC), it was assumed that the Bus differential protection operated from the Current Transformer (CT) wires on transformer T1, which were likely shorted as a result of the fire. The P&C technician at the site was the supervisor and in consultation with others, emergency modifications were made to the protection to isolate the CT wiring. These emergency modifications had an unforeseeable and undesirable effect on the protection and contributed to a widespread outage at 15:33, when the breaker B3T4 was closed in a second attempt to restore power to customers.

Root Cause #4: Knowledge Based Decision Required

Knowledge Based Decision Required is a TapRooT® term which means that personnel with sufficient knowledge of the work are required to make the decision (or assist with it). In the case of the Sunnyside Terminal Station restoration, the P&C supervisor on site at the time of the fire was relatively unfamiliar with the protection wiring configuration.

Recommendation #	Recommendation
TA8	Consider having additional resources (P&C technologists and engineers) available on site to support the restoration of power in emergency situations.

By design, the non-conventional application of the re-trip function on B3T4 breaker failure protection prevented 230kV breaker B1L02 from opening, when an arcing fault occurred on 230kV disconnect B1T4. When breaker B3T4 was closed, the breaker failure protection was initiated and resulted in the 230kV disconnect B1T4 being opened. Since the re-trip function for breaker B3T4 prevents the tripping of 230kV breaker B1L02, the 230kV disconnect was opening under load and eventually flashed over and resulted in an arcing fault on the B1T4 disconnect.

Additionally, modifications made to Bus 1 protection prevent the breaker B1L02 from opening and clearing the arcing fault. The combination of these two conditions lead to line protection for TL202 and TL206 having to operate to clear the fault and resulted in widespread outages to customers.

Root Cause #5: Problem Not Anticipated

The Sunnyside Terminal Station protection scheme was not designed at the time utilizing conventional applications of the re-trip function with respect to breaker failure applications.

Recommendation #	Recommendation
TA9	Review breaker failure protection applications of all transformer protection designs at stations using the same breaker failure relay (Schweitzer Engineering Laboratories type SEL-501). This review would determine whether the breaker failure protection re-trip function (if applied in the SEL-501) is being used in a similar non-conventional application to that at Sunnyside. If it is, modify the scheme to prevent undesirable or unexpected response from the non-conventional application.

5.4 Incident 4: Holyrood Breaker B1L17 failure

At 21:27 on January 5, 2014 while attempting to connect Holyrood Generating Unit G1 to the grid, the Holyrood 230kV disconnect B1T1 was closed and a fault occurred on the system. It was subsequently determined that breaker B1L17 had previously failed during a trip operation and the failure allowed one of its phases to remain closed while the other two were open. There were no issues with Holyrood Generating Unit G1 that caused this incident. Figure 10 below is the SnapCharT® of the incident which shows the sequence of events and associated information.

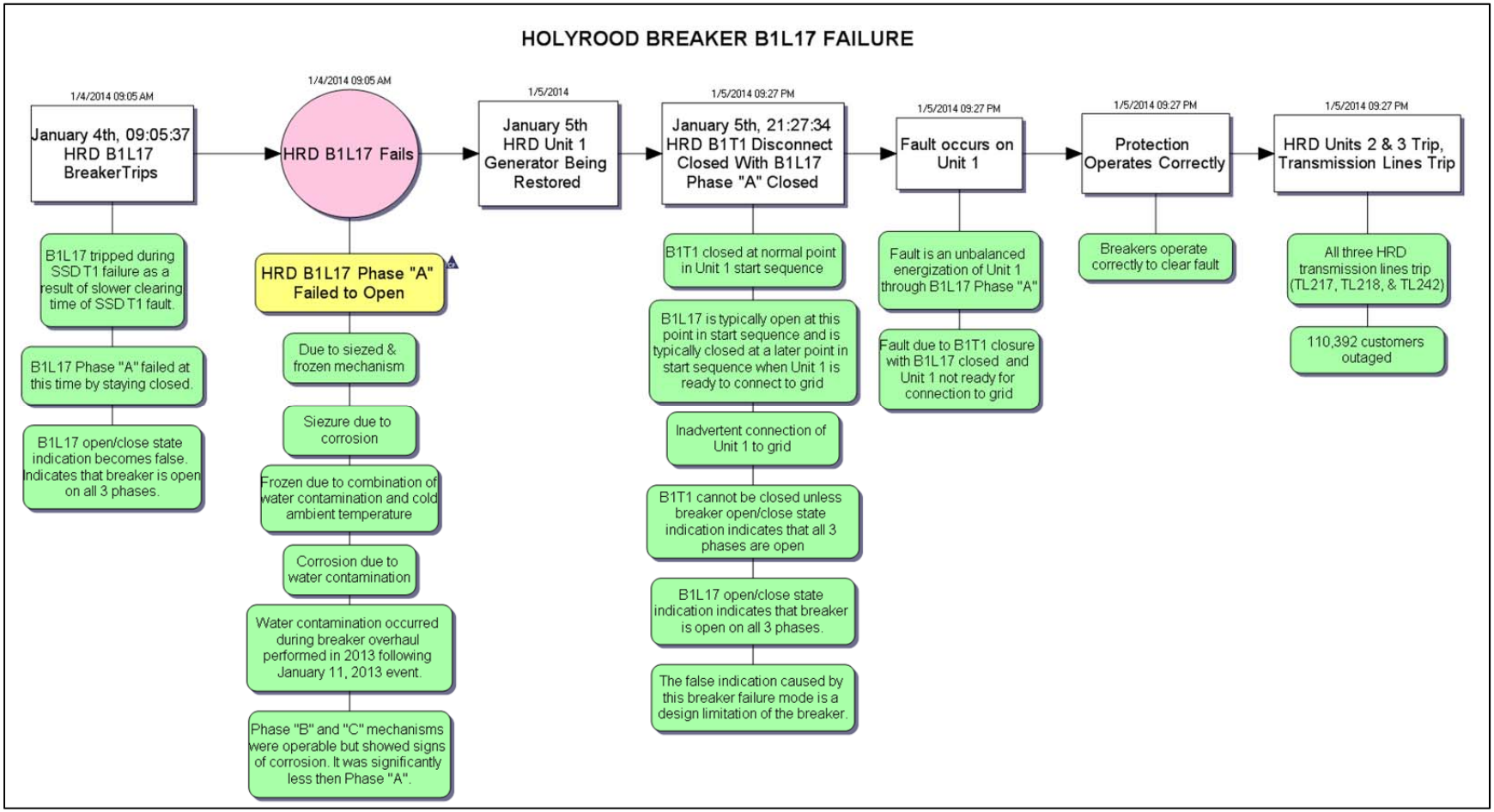


Figure 10 – Holyrood Breaker B1L17 Failure SnapCharT®

Causal Factor #7: Holyrood Breaker B1L17 Phase "A" Failed to Open

Based on an inspection conducted by Hydro maintenance personnel, supported by an expert from the OEM ABB, it was determined that moisture in the main receiver tank for the phase "A" on breaker B1L17 at Holyrood was the immediate cause of its failure to operate correctly on January 5, 2014. Moisture in the main receiver tank lead to corrosion of the main control rod drive on phase "A". This combination of moisture and cold temperatures on January 4, 2014 resulted in the control rod on phase "A" seizing/freezing and failing to open.

In early 2013 breaker B1L17 had work performed on it. This work consisted of the application of RTV coating to its porcelain insulators to reduce the probability of flashover. This work was in response to the flashover that occurred on this breaker on January 11, 2013. The work involved removing the breaker interrupters to apply the RTV coating and protecting the breaker air receiver tanks from environmental contamination while the interrupters are off. For this job, the interrupters were planned to be removed for two weeks, but were actually removed for six weeks due to a reprioritization of work at that time. This increased the exposure time of the breaker without adequate coverage which is the most probable cause of how water got into the receiver tanks of all three phases.

Root Cause #6: Situation Not Covered

The work method SWM-000318 entitled Interrupter Head (Air Blast Circuit Breaker) – Replace, does not contain instructions on how to prevent moisture contamination of the breaker air receiver tanks while the interrupters are removed.

Recommendation #	Recommendation
TA10	Revise work method SWM-000318 to include: i) Correct procedure to seal the breaker air receiver tanks to prevent moisture ingress while the interrupters are removed; and ii) Visual inspection of the breaker air receiver tanks prior to the reinstallation of the interrupters.

Root Cause #7: Work Package Needs Improvement

The current approach to applying the RTV coating is to apply it to the existing interrupters at the Whitbourne maintenance shop. This requires the interrupters and supporting insulator columns being removed from the main receiver tank for the duration of the RTV application, which takes two weeks.

Recommendation #	Recommendation
TA11	Conduct a risk/reward review of the current practice for the application of the RTV coating with consideration given to the following alternatives which would reduce the amount of time the interrupters are removed from the main receiver tank: i) Materials that can be applied without having to disassemble the breaker; ii) Installing spare interrupters that have the RTV coating applied; and iii) Applying RTV in a nearer controlled environment (Holyrood has some facilities).

Root Cause #8: Scheduling Needs Improvement

As a result of maintenance personnel being rescheduled to perform other high-priority work, the reinstallation of the breaker B1L17 interrupters was deferred for four weeks.

Recommendation #	Recommendation
TA12	Conduct a review of the TRO Central Annual Work Plan to identify opportunities for improvement as it relates to the prioritization and timely execution of work. The review should include, but not be limited to, factors affecting the priority and execution of work, such as the availability of resources (staff, tools and equipment), to effectively execute the annual work plan.

Appendices

Figure 1 – Sunnyside T1 Transformer

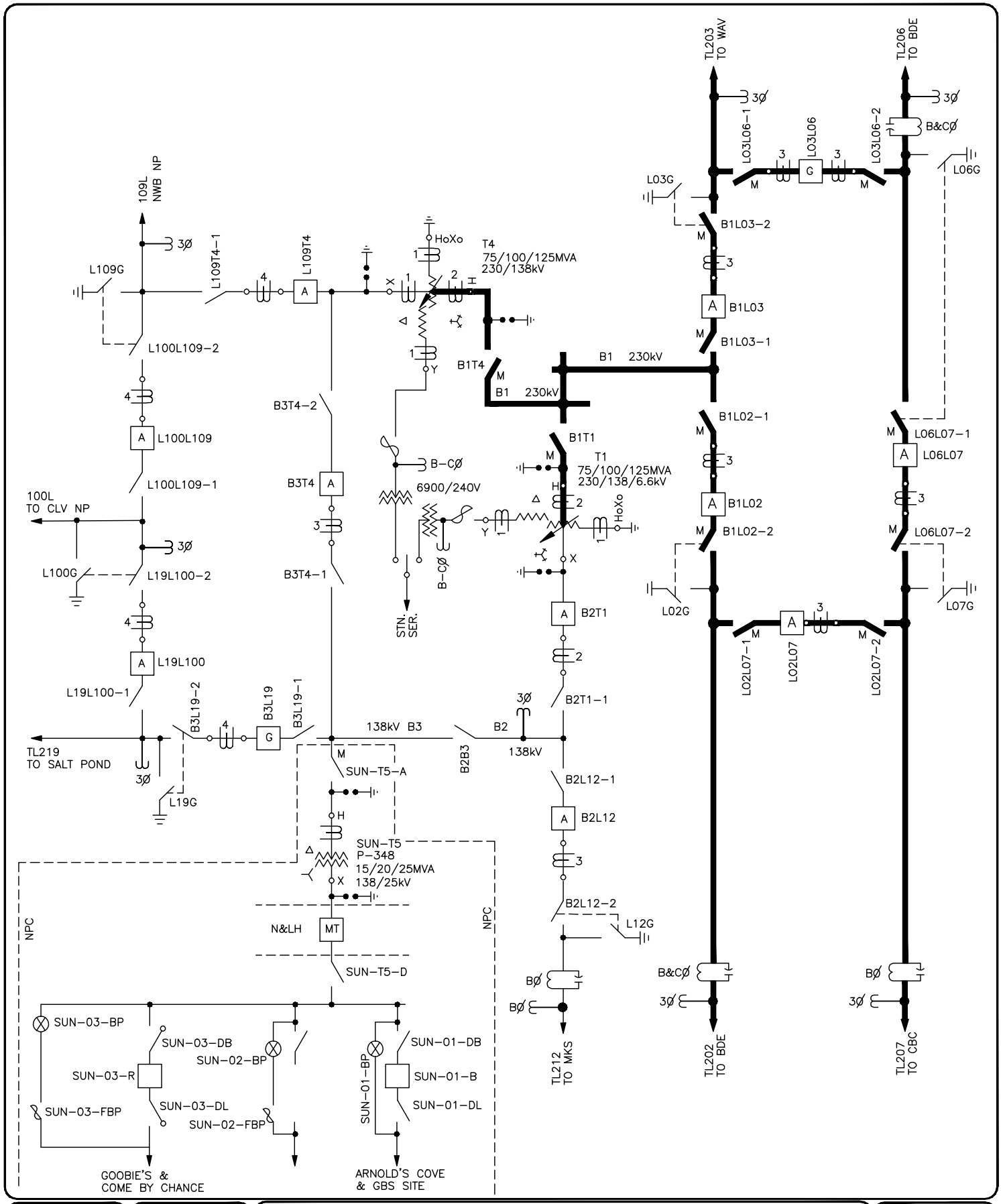
Figure 2 – Sunnyside T1 Transformer Tank Rupture

Figure 3 – Western Avalon T5 Transformer

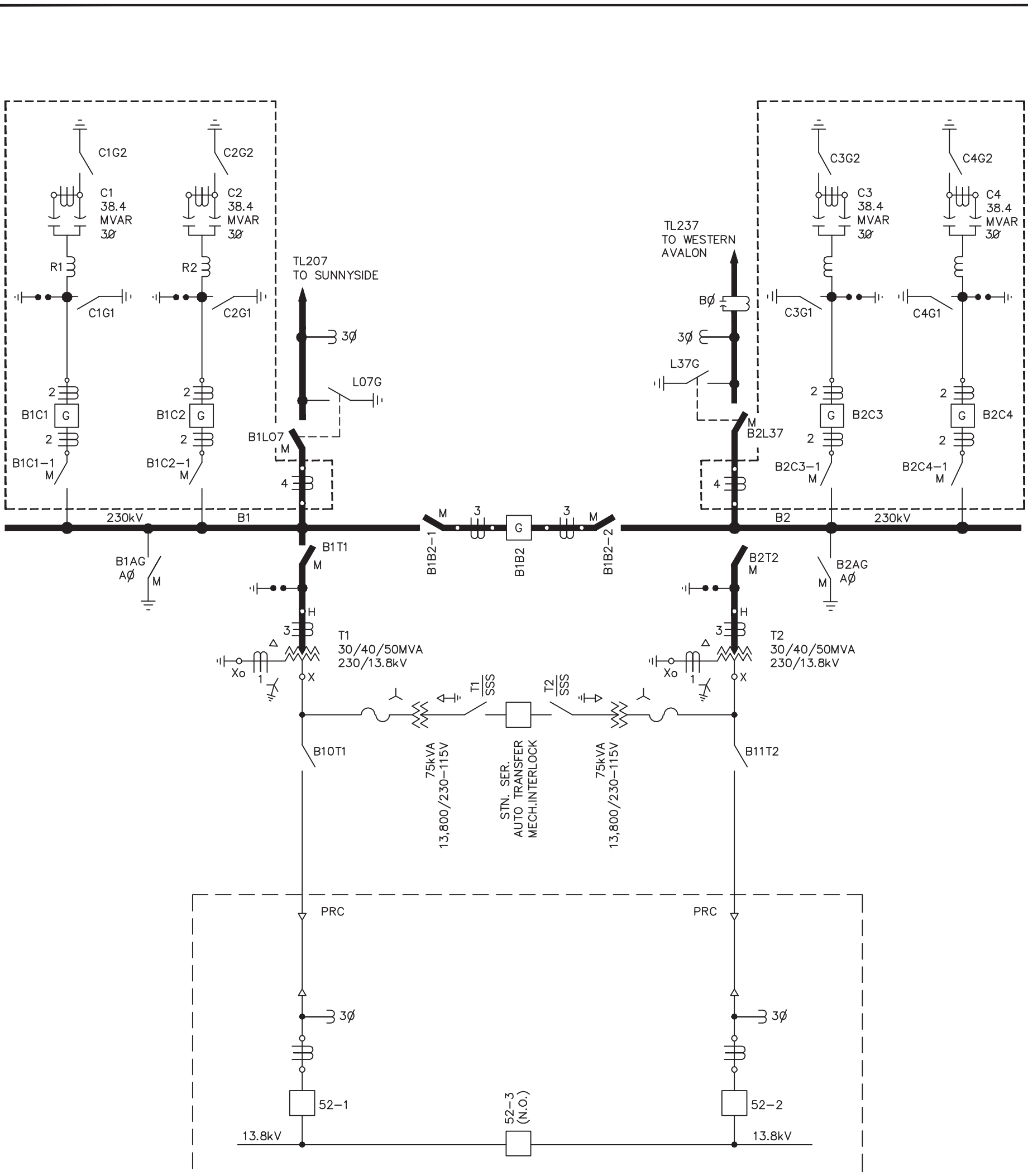
Figure 4 – Western Avalon T5 Transformer Tap Changer Diverter Switch

Figure 5 - Holyrood 230kV DLF Breaker

Figure 6 – Holyrood B1L17 Seized Control Rod Drive

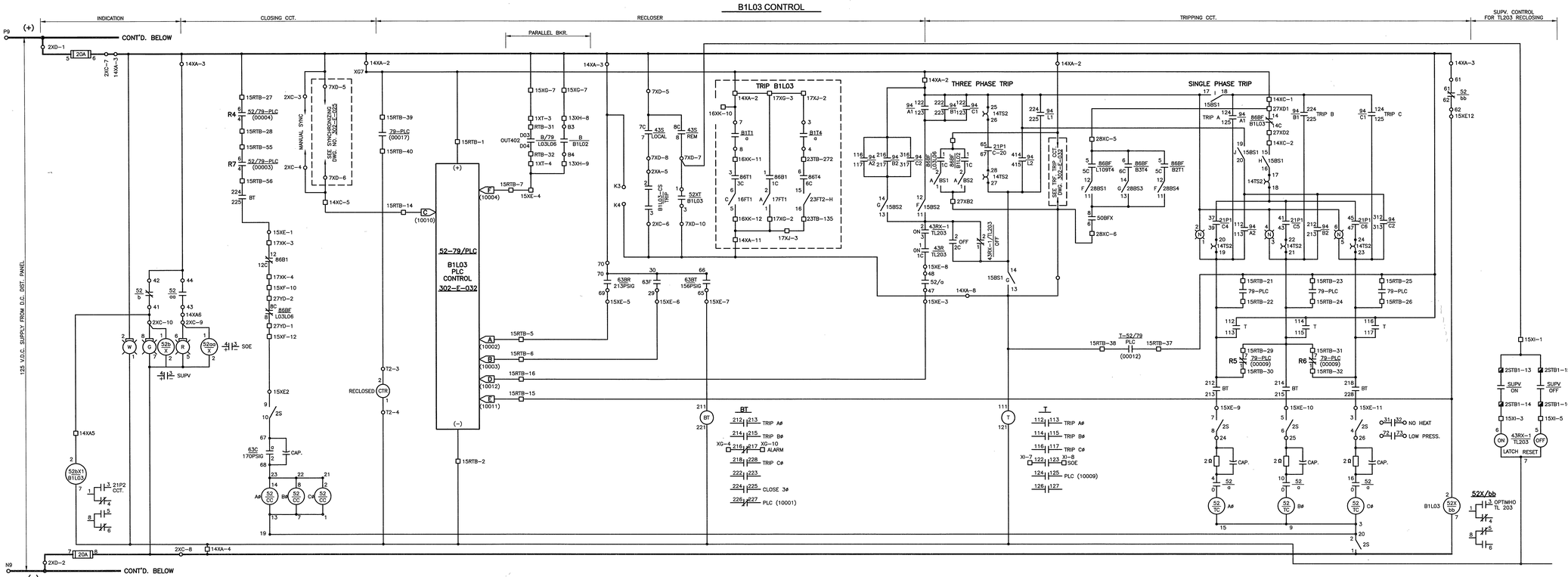


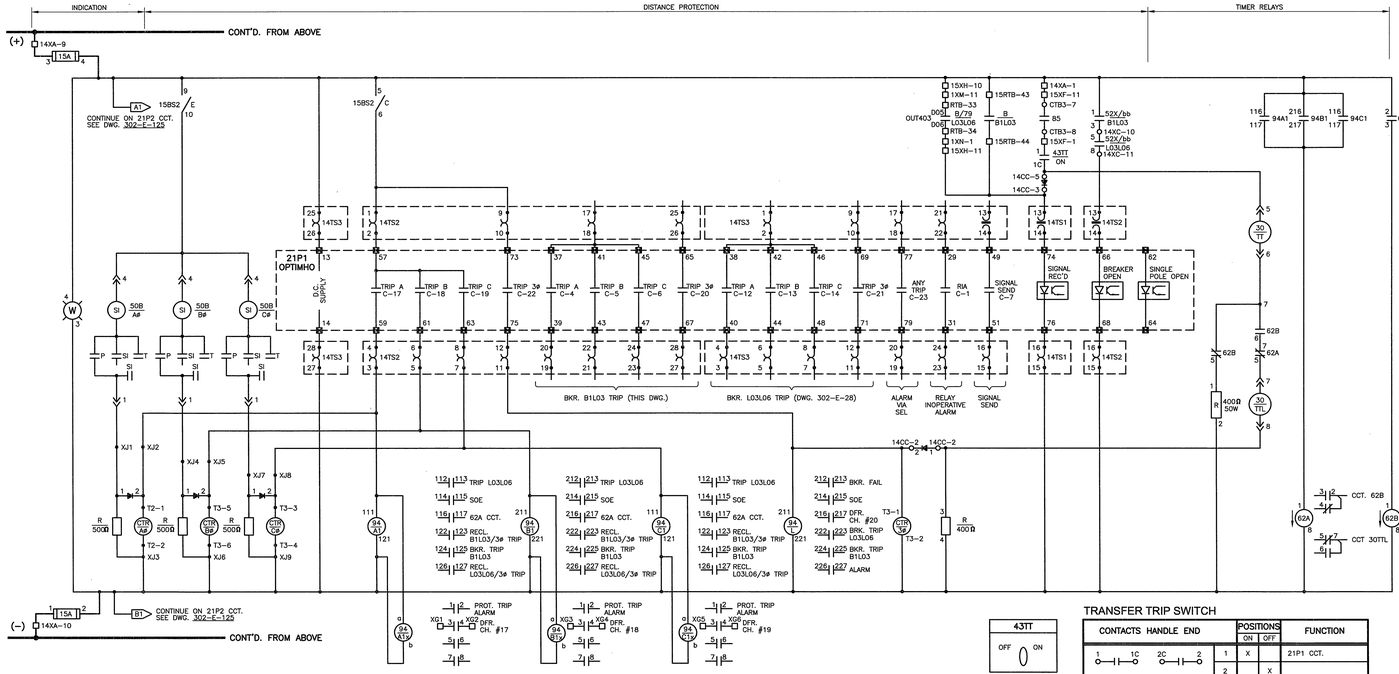
DRAWN BY: J.T.	REVISED BY: D.R.	NEWFOUNDLAND AND LABRADOR HYDRO	DWG NO SSD-1
APPROVED BY: D. KING		SYSTEM OPERATING DIAGRAM SUNNYSIDE TERMINAL STATION	REV NO 12
DATE: 2012/12/18			



DRAWN BY J.T.	REVISED BY D.R.	NEWFOUNDLAND AND LABRADOR HYDRO	DWG NO
APPROVED BY G. BRODERICK		SYSTEM OPERATING DIAGRAM COME BY CHANCE TERMINAL STATION	REV NO 5
DATE 2012–02–21			

B1L03 CONTROL





DEVICE	DESCRIPTION	REF DWG.	LOCATION	TYPE
T	3–PHASE TRIP AUX. RELAY		PANEL 15	ABB RXMS1
BT	BLOCK TRIP RELAY		PANEL 15	ABB RXMB1
21P1	LINE PROT. DISTANCE RELAY – GEC OPTIMHO		PANEL 14	LFZP111
29M	MANUAL OPERATED DISC. IND. LIGHT CONTACT		230kV DISC.	
30TT	TRANSFER TRIP RECEIVER TARGET RELAY		PANEL 15	HSA–16A
30TTL	TRANSFER TRIP LOCKOUT TARGET RELAY		PANEL 15	HSA–16A
25W	SYNCHRONIZING RELAY	302–E–24	PANEL 7	
25X3	SYNCHRONIZING AUX. RELAY		PANEL 7	
43TT	TRANSFER TRIP SWITCH		PANEL 15	SBM
43R	RECLOSER OFF & ON SWITCH		PANEL 15	SBM
43S	SUPERVISORY TRANSFER SWITCH		PANEL 7	
50B	LINE BACK–UP PROT. RELAY	302–E–24	PANEL 15	
52X/bb	AUX. RELAY FOR BREAKER OPEN		PANEL 14	KRPA–11DG
52CS	BREAKER CONTROL SWITCH		PANEL 14	SBM
52y/o	AUX. RELAY FOR SUPV. IND.		PANEL 2	P & B KRP11DG
62 A,B	TRANSFER TRIP TIMER AUX. RELAYS		PANEL 15	AGAST.–2122–D–9
63BR	PRESSURE SWITCH RECLOSING INTERLOCK		230kV BKR.	
63BT	PRESSURE SWITCH TRIPPING INTERLOCK		230kV BKR.	
63C	PRESSURE SWITCH CLOSING INTERLOCK		230kV BKR.	
63F	PNEUMATIC BACK–UP TRIP CONTACT		230kV BKR.	
85	CARRIER TRANSFER TRIP RELAY		CARR. CAB.	
94 A,B,C(1,2)	PHASE TRIP RELAY		PANEL 14	ABB RXMS1
94L(1,2)	LOCKOUT TRIP RELAY		PANEL 14	ABB RXMS1
	PHASE TRIP AUX. RELAY		PANEL 14	
CTR	COUNTER FOR SINGLE PHASE		PANEL 15	4Y9434–PS
CTR/L	COUNTER FOR 3 PHASES		PANEL 15	4Y9434–PS
43RX–1	LATCH RELAY FOR RECLOSER SUPV. CONTROL		PANEL 15	S & D 255XCXP
43RX–2	AUX. RELAY FOR SUPV. INDICATION		PANEL 15	P & B KRP11DG
52bX1	AUX. RELAY FOR BREAKER OPEN		PANEL 14	P & B KRP11DG
21P2	LINE PROTECTION DISTANCE RELAY – PRIMARY No.2		PANEL 14	SEL 321–1
86BF	BKR FAIL LOCKOUT RELAY		PNL 27, 28	HEA–61
52–79 PLC	PROGRAMMABLE LOGIC CONTROLLER (BREAKER CONTROL/RECLOSING)		PANEL 15	COMPACT 984
79–L03L06	L03L06 RECLOSING CONTROL (SEL AUTOMATION CONTROLLER)		PANEL 1	SEL–2411

B1L03–CS

TRIP / CLOSE

BREAKER CONTROL SWITCH

CONTACTS HANDLE END				POSITIONS		
				CLOSE	NORM.	TRIP
1 1C	2C 2	1				
		2				X
3 3C	4C 4	3	X			
		4	X			

TARGET TYPE WITH PISTOL GRIP HANDLE SPRING RETURN TO NORMAL POSITION

43R

OFF / ON

RECLOSER SWITCH

CONTACTS HANDLE END				POSITIONS	
				ON	OFF
1 1C	2C 2	1	X		
		2			X
3 3C	4C 4	3	X		
		4			X
5 5C	6C 6	5	X		
		6			X
7 7C	8C 8	7	X		
		8			X

OVAL HANDLE MAINTAINED CONTACTS

43TT

OFF / ON

TRANSFER TRIP SWITCH

CONTACTS HANDLE END				POSITIONS		FUNCTION
				ON	OFF	
1 1C	2C 2	1	X			21P1 CCT.
		2			X	
3 3C	4C 4	3	X			TRANSFER TRIP SEND
		4			X	
5 5C	6C 6	5	X			21P2 CCT.
		6			X	
7 7C	8C 8	7	X			
		8			X	

OVAL HANDLE MAINTAINED CONTACTS

NOTES:

1. 52aa – AUX. SW. OPEN WHEN BREAKER IS OPEN. – CLOSE WHEN BREAKER IS CLOSED. IN CASE OFDISAGREEMENT , CONTACT REMAIN CLOSED UNTIL THE FAULTY POLE OR POLES ARE TRIPPED BY THE PNEUMATIC BACK–UP TRIP DEVICE. 52bb – AUX. SW. CLOSE WHEN BREAKER IS OPEN. – OPEN WHEN BREAKER IS CLOSED. IN CASE OFDISAGREEMENT , CONTACT REMAIN OPEN UNTIL THE FAULTY POLE OR POLES ARE TRIPPED BY THE PNEUMATIC BACK–UP TRIP DEVICE.
2. T – TERMINALS ARE LOCATED ON TRIP RELAY ASSEMBLY SUB–PANEL.
3. —□— DENOTES TERMINALS ON "CANSFIELD" RECLOSER CASE.
4. 2STB REFERS TO SUPERVISORY JUNCTION BOX NO. 2, 1STB IS BOX NO. 1

		37.	10–09–28	MINOR REVISIONS	C.R.H.	FLD REV		
		36	09–05–28	L03L06 RECLOSING CONTROL UPGRADE	W.B.			
		35.	08–06–20	B1L03, L06L07 BREAKER CONTROL PLC INSTALL	C.R.H.	FLD. REV		
		34	05–08–18	REVISED AS BUILT	C.M.	FLD. REV		
302–E–032	B1L03 PLC CONTROL SCHEMATIC	33	01–09–11	138kV BKR. FAIL ADDITION	G.W.			
302–E–049	125V D.C. DISTRIBUTION PANEL	32	00–11–23	AS BUILT (FOR TL207 BACK–UP PROT. UPGRADE)	W.B.			
302–E–062	ANNUNCIATOR SCHEMATIC DIAGRAM	31	99	TRANSCAN DFR ADDED				
DWG.NO.	TITLE	NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
REFERENCE DRAWINGS		REVISIONS						

NOTICE: This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO

ORIGINAL DRAWING NOT SEALED

NEWFOUNDLAND AND LABRADOR HYDRO

SUNNYSIDE TERMINAL STATION
230kV .B.C.B. B1L03 CONTROL
& TL203 PRIMARY No. 1 PROTECTION
D.C. SCHEMATIC DIAGRAM

ELECT.	SCALE:	N.T.S.	
CIVIL	DESIGNED:	C. WARREN	
TRANS.	DRAWN:	D. MONTAGUE	
MECH.	DATE:	1991–10–09	
P&C	CHECKED:		
TELC.	APPROVED:		

W.O. NO.

DWG. NO. A0 - 302 - E - 093

REV. 37.

PLOT SCALE 1:1 C.A.D.

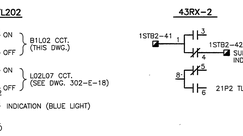
9/28/2010 10:43:33 AM

DEVICE	DESCRIPTION	REF DWG.	LOCATION	TYPE
A	RECLOSER START–TIMING RELAY		PANEL 13	ESNA–2122–D–5
B	LOCKOUT ANTIPUMP RELAY		PANEL 13	B.B. – P16
C	INTERVAL TIMER BETWEEN SUCCESSIVE CLOSE/RECLOSE OPERATIONS		PANEL 13	ESNA–2122–D–5
D	CLOSE CONTROL RELAY		PANEL 13	B.B.–P8
E	RELAY TO OPERATE LOCKOUT TRIP DURING RECL. & SEAL–IN FOR "BR"		PANEL 13	CLARE "E"
F	AUX. RELAY FOR TRANSIENT PRESS. DROP & DISAGREEMENT TRIP		PANEL 13	ESNA–2122–D–5
T	3–PHASE TRIP AUX. RELAY		PANEL 13	B.B. – P8
BR	LOW AIR PRESSURE BLOCK RECLOSE RELAY		PANEL 13	C.P. CLARE "E"
BT	BLOCK TRIP RELAY		PANEL 13	B.B. – P8
BX	3–POLE TRIP RELAY AFTER UNSUCC. CLOSE/RECLOSE		PANEL 13	B.B. – P8
21P1	LINE PROT. DISTANCE RELAY – ZONE 1,2,3 PRIMARY No.1	302–E–024	PANEL 12	GEC OPTIMHO
29M	MANUAL OPERATED DISC. IND. LIGHT CONTACT		230kV DISC.	
30TT	CARRIER RECEIVER TARGET RELAY		PANEL 13	HSA–16A
30TTL	CARRIER LOCKOUT TARGET RELAY		PANEL 13	HSA–16A
25W	SYNCHRONIZING RELAY		PANEL 7	
25X3	SYNCHRONIZING AUX. RELAY	302–E–024	PANEL 7	
43TT	TRANSFER TRIP SWITCH		PANEL 13	SBM
43R	RECLOSER OFF & ON SWITCH		PANEL 13	SBM
43S	SUPERVISORY TRANSFER SWITCH		PANEL 7	
50B	LINE BACK–UP PROT. RELAY	302–E–024	PANEL 13	
52Y/a	AUX. RELAY FOR SUPV. IND.		PANEL 2	P&B KRP11DG
52CS	BREAKER CONTROL SWITCH		PANEL 12	SBM
62 A,B	TRANSFER TRIP TIMER AUX. RELAYS		PANEL 13	AGAST.–2122–D–9
63BR	PRESSURE SWITCH RECLOSING INTERLOCK		230kV BKR.	
63BT	PRESSURE SWITCH TRIPPING INTERLOCK		230kV BKR.	
63C	PRESSURE SWITCH CLOSING INTERLOCK		230kV BKR.	
63F	PNEUMATIC BACK–UP TRIP CONTACT		230kV BKR.	
85	CARRIER TRANSFER TRIP RELAY		CARR. CAB.	
85X	CARRIER AUX. RELAY		PANEL 13	
94 A,B,(1,2)	PHASE TRIP RELAY		PANEL 13	ABB RXMS1
94L(1,2)	LOCKOUT TRIP RELAY		PANEL 13	ABB RXMS1
94 A1x,B1x,C1x	PHASE TRIP AUX. RELAY		PANEL 13	
TS1,2,3	OPTIMHO TEST BLOCK		PANEL 12	GEC
52X/bb	OPEN BREAKER INDICATION RELAY		PANEL 13	P&B KRP11DG
CTR	COUNTER FOR SINGLE PHASE		PANEL 13	4X9434–PS
CTR/L	COUNTER FOR 3 PHASES		PANEL 13	4X9434–PS
43RX–1	LATCH RELAY FOR RECLOSER SUPV. CONTROL		PANEL 13	S&D 255XCXP
43RX–2	AUX. RELAY FOR SUPV. INDICATION		PANEL 13	P&B KRP11DG
27A,B,C	VOLTAGE RELAYS		PANEL 12	ASEA–RXMB
27X	AUX. TIMER FOR 27 RELAYS		PANEL 12	ASEA–RXKM2H
94AR	TRIP RELAY FOR AUTO RESTORATION		PANEL 12	ASEA–RXMS1
52bx1	AUX. RELAY FOR BREAKER OPEN		PANEL 12	P&B–KRPA–11DG
21P2	LINE PROTECTION DISTANCE RELAY – PRIMARY No.2		PANEL 12	SEL 321–1
86BF	BKR. FAIL. LOCKOUT RELAY – G.E.		PNL. 27,28	HEA–61
21P1/TTX	AUXILIARY TRANSFER TRIP RELAY		PANEL 12	ABB RXMS1

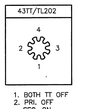
NOTES:

1. 52aa – AUX. SW. OPEN WHEN BREAKER IS OPEN. – CLOSE WHEN BREAKER IS CLOSED.
   IN CASE OF DISAGREEMENT , CONTACT REMAIN CLOSED UNTIL THE FAULTY POLE OR POLES ARE TRIPPED BY THE PNEUMATIC BACK–UP TRIP DEVICE.
   52bb – AUX. SW. CLOSE WHEN BREAKER IS OPEN. – OPEN WHEN BREAKER IS CLOSED.
   IN CASE OF DISAGREEMENT , CONTACT REMAIN OPEN UNTIL THE FAULTY POLE OR POLES ARE TRIPPED BY THE PNEUMATIC BACK–UP TRIP DEVICE.
2. T – TERMINALS ARE LOCATED ON TRIP RELAY ASSEMBLY SUB–PANEL.
3. –□– DENOTES TERMINALS ON "CANSFIELD" RECLOSER CASE.
4. 2STB REFERS TO SUPERVISORY JUNCTION BOX NO. 2, 1STB IS BOX NO. 1

TL202 RECLOSER (SUPV. CONTROL)



TRANSFER TRIP CONTROL SWITCH - 43TT PRIMARY/SECONDARY T.T.



CONTACTS HANDLE END		IND. POS. 1	2	3	4	FUNCTION
1C 3C 2	1			×		
	2		×		×	21P1 RECV. (SEC.)
3C 4C 4	3			×	×	21P1 RECV. (PRI.)
	4	×	×	×		
5C 6C 6	5		×		×	21P2 RECV. (SEC.)
	6			×	×	21P2 RECV. (PRI.)
7C 8C 8	7		×		×	SEC. T.T. SEND
	8			×	×	PRIM. T.T. SEND
9C 10C 10	9				×	
	10		×		×	ALARM
11C 12C 12	11			×	×	ALARM
	12	×	×	×		
13C 14C 14	13		×		×	SUPV. – SEC. ON
	14			×	×	SUPV. – PRI. ON
15C 16C 16	15		×		×	
	16			×	×	

SBM (C.E.) – KNURLED HANDLE MAINTAINED CONTACT

BREAKER CONTROL SWITCH

B1L02–CS: TRIP / CLOSE

CONTACTS HANDLE END		POSITIONS CLOSE	NORM.	TRIP
1 1C 2C 2	1	X		
	2			X
3 3C 4C 4	3	X		X
	4	X		

TARGET TYPE WITH PISTOL GRIP HANDLE SPRING RETURN TO NORMAL POSITION

43R: OFF / ON

CARRIER RECLOSER SWITCH

CONTACTS HANDLE END		POSITIONS ON	OFF
1 1C 2C 2	1	X	
	2		X
3 3C 4C 4	3	X	
	4		X
5 5C 6C 6	5	X	
	6		X
7 7C 8C 8	7	X	
	8		X

OVAL HANDLE MAINTAINED CONTACTS

SEE DWG. 302–E–024 (230kV A.C. SCHEMATIC)

27A/TL202	27B/TL202	27C/TL202
114/115	214/215	314/315
124/125	224/225	324/325
116/117 SUPV. IND. CCT.	216/217 SUPV. IND. CCT.	316/317 SUPV. IND. CCT.
126/127 94AR/TL202&7 CCT.	226/227 94AR/TL202&7 CCT.	326/327 94AR/TL202&7 CCT.

SUPERSEDE DWG.: F–302–E–28
F–302–E–29

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D.
32.	08–04–28	B1L03, L06L07 BKR. CONTROL PLC INSTALLED	C.R.H.	FLD.REV.		
31	05–06–10	TELEPROTECTION UPGRADE (TL202, TL206)	C.M.			
30	01–09–08	138kV BKR. DFAIL ADDITION & REVISED AS BUILT	W.B.			
29	00–11–23	AS BUILT (FOR TL207 BACK–UP PROT. UPGRADE)	W.B.			
28	99	TRANSCAN DFR ADDED	–			
27	97	TL202 21P2 ADDED	–			
26	97–09–04	TL202/206 AUTO RESTORATION ADDITIONS	W.B.			

302–E–125 230kV TL202,203,206,207 PRIMARY #2 & B.U. PROTECTION D.C.
DWG.NO. TITLE
REFERENCE DRAWINGS

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO

ORIGINAL DRAWING NOT SEALED

HYDRO — NEWFOUNDLAND AND LABRADOR HYDRO

SUNNYSIDE TERMINAL STATION
230kV A.B.C.B. B1L02 CONTROL & TL202
PROTECTION D.C. SCHEMATIC DIAGRAM

ELECT.	SCALE: NONE
CIVIL	DESIGNED: J. FOLEY
TRANS.	DRAWN: D. MONTAGUE
MECH.	DATE: 1994–07–21
P&C	CHECKED:
TELC.	APPROVED:

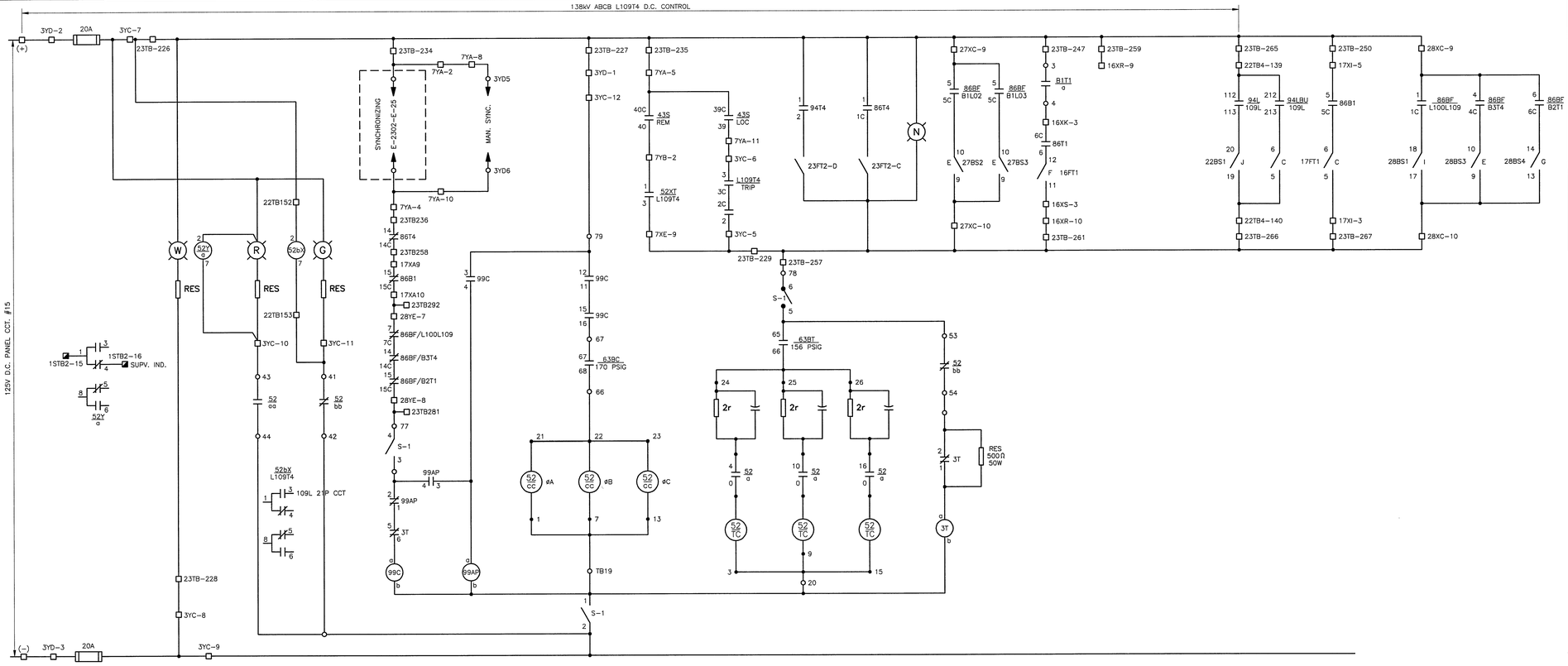
W.O. NO.

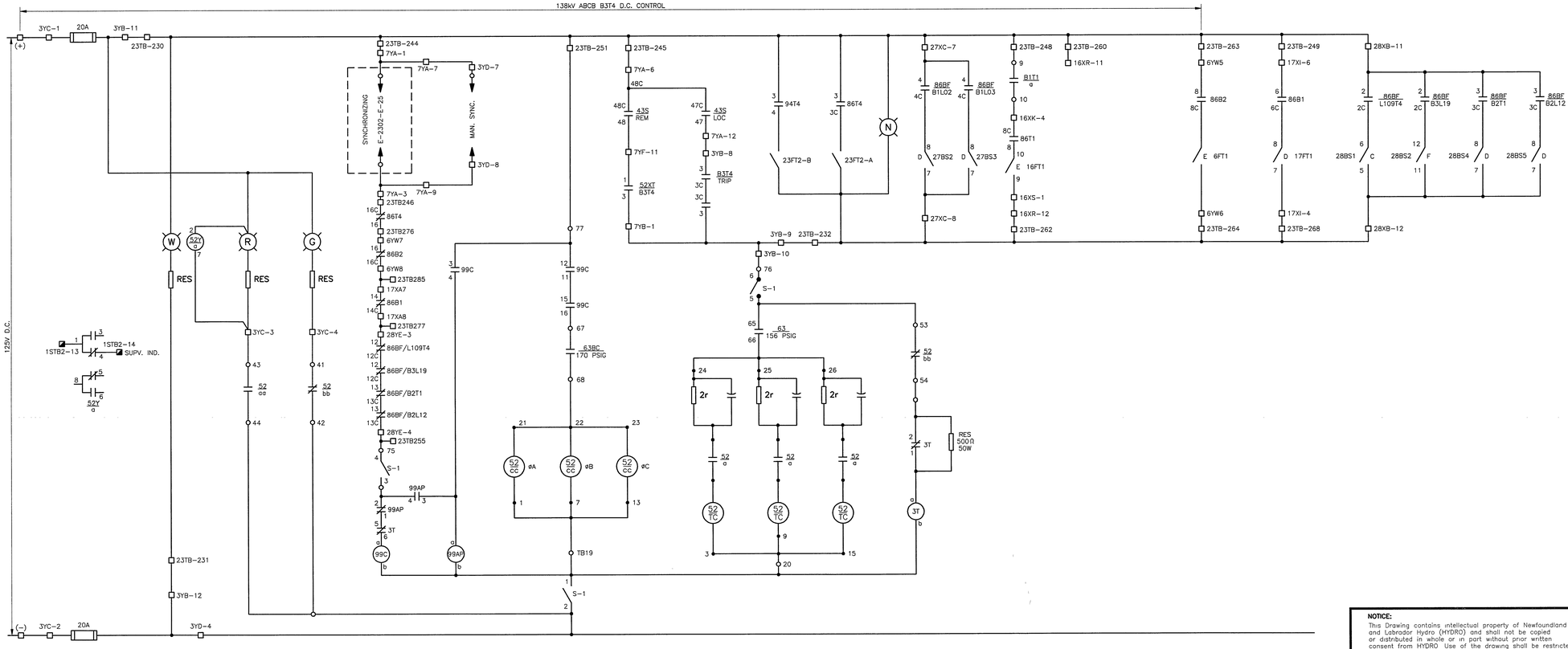
DWG. NO. A0 - 302 - E - 092

REV. 32.

Apr 28, 2008 – 2:44pm

PLOT SCALE 1:1 C.A.D.





DEVICE	DESCRIPTION	DEV. DEVEL.	LOCATION	TYPE
99C	ABCB CLOSING AUX. RELAY		ABCB	B. BOV. P8AXM
99AP	ABCB ANTI-PUMP RELAY		ABCB	B. BOV. P8AXM
3T	TRIP CHECK RELAY		ABCB	B. BOV. P8AXM
52 CC	ABCB CLOSING COIL		ABCB	B. BOV. DCF
52 TC	ABCB TRIPPING COIL		ABCB	B. BOV. DCF
43S	SUPERVISORY SELECT SWITCH		LINE CONTROL PNL.	CCE. SBM
63BC	PRESS. SWITCH INTERLOCK FOR CLOSING		ABCB	B. BOV. DCF
63BT	PRESS. SWITCH INTERLOCK FOR TRIPPING		ABCB	B. BOV. DCF
52 a	ABCB AUX. CONTACT		ABCB	B. BOV. DCF
52 aa,bb	ABCB AUX. SWITCHES		ABCB	B. BOV. DCF
94L 109L	TRIP RELAY 109L		PANEL NO. 22	ABB RXMS1
94L 100L	TRIP RELAY 100L		PANEL NO. 21	ABB RXMS1
86B	138kV BUS DIFF.			
86T1	TRF. NO. 1 LOCKOUT RELAY			
86T2	TRF. NO. 2 LOCKOUT RELAY			
52Y/a	AUX. RELAY FOR SUPV. IND.	A0-302-E-35	PNL 4 (SHOWN ON PNL 3 DRAWING)	P&B KRP11DG
86BF	BREAKER FAIL LOCKOUT RELAY – GE			HEA-G1
52bX	AUX. RELAY FOR BREAKER OPEN		PANEL NO. 22	P&B KRP11DG

LEGEND:

- OUTDOOR EQUIPMENT TERMINAL WITH CONNECTION TO OTHER EQUIPMENT
- INDOOR PANEL TERMINAL WITH CONNECTION TO OTHER EQUIPMENT
- OUTDOOR EQUIPMENT TERMINAL INTERNAL CONNECTION

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
14	05-06-08	100L & 109L PROTECTION UPGRADE	C.M.	AYL	EFB	
13	03-02-04	REVISED AS BUILT	H.P.	FLD.REV.		
12	00-09-09	138kV BKR. FAIL. PROT. ADDITION, REVISED AS BUILT & REDRAWN ON CAD	C.M.	LS	AYL	
11	94-10-24	REVISED AS BUILT	W.B.			
10	94-08-14	AS BUILT	D.M.			
9	90-09-28	T.L. 219 ADDED	C.H.			

DWG.NO. | TITLE

REFERENCE DRAWINGS

REVISIONS

ORIGINAL DRAWING NOT SEALED

NEWFOUNDLAND AND LABRADOR HYDRO

ELECT.	SCALE: N.T.S.
CIVIL	DESIGNED: E. FERRER
TRANS.	DRAWN: W.R.L.
MECH.	DATE: 1976-05-28
P&C	CHECKED:
TELC.	APPROVED:

SUNNYSIDE TERMINAL STATION
138 kV ABCB L109T4 & ABCB B3T4
D.C. CONTROL SCHEMATIC

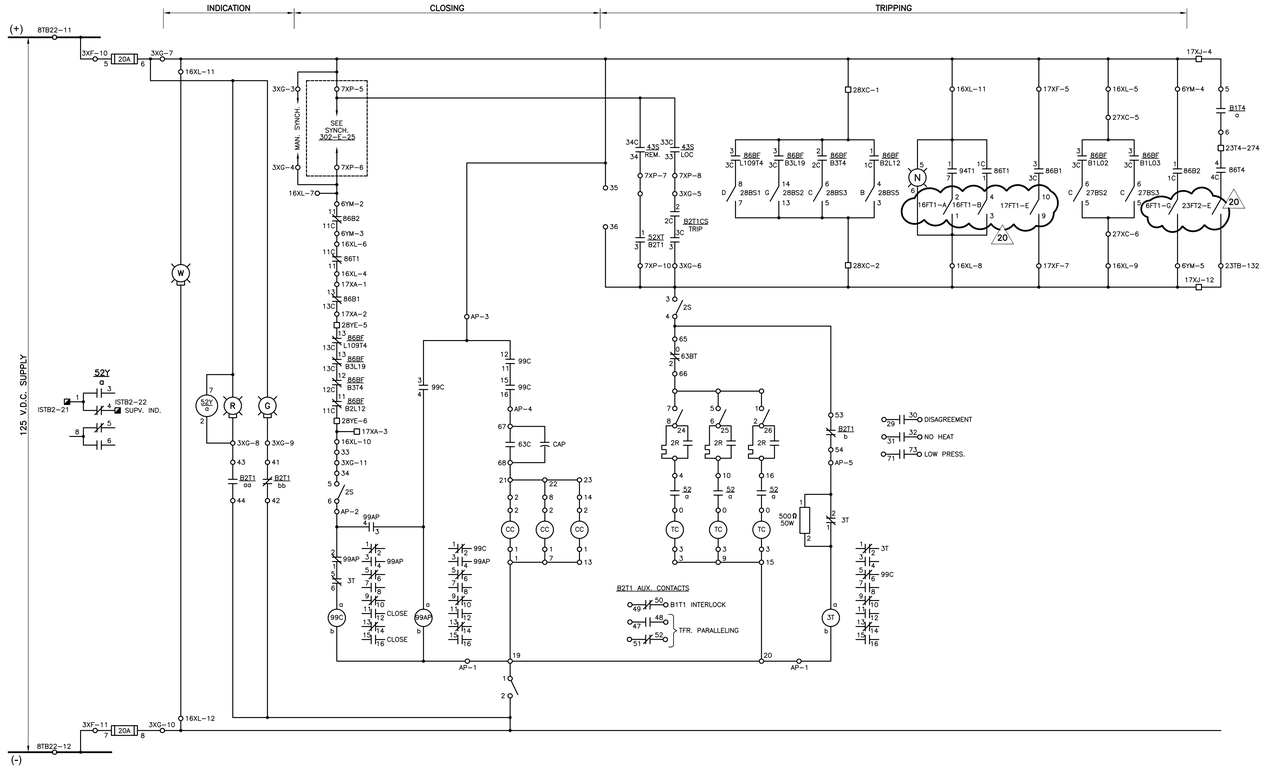
W.O. NO.

DWG. NO. B1- 302 - E - 70

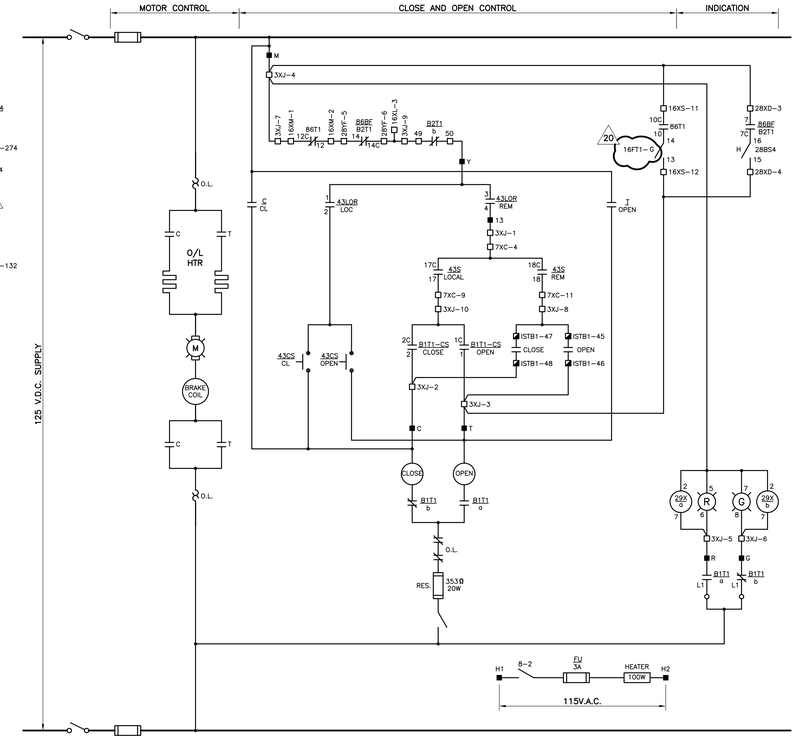
REV. 14

PLOT SCALE 1:1 C.A.D.

BREAKER B2T1

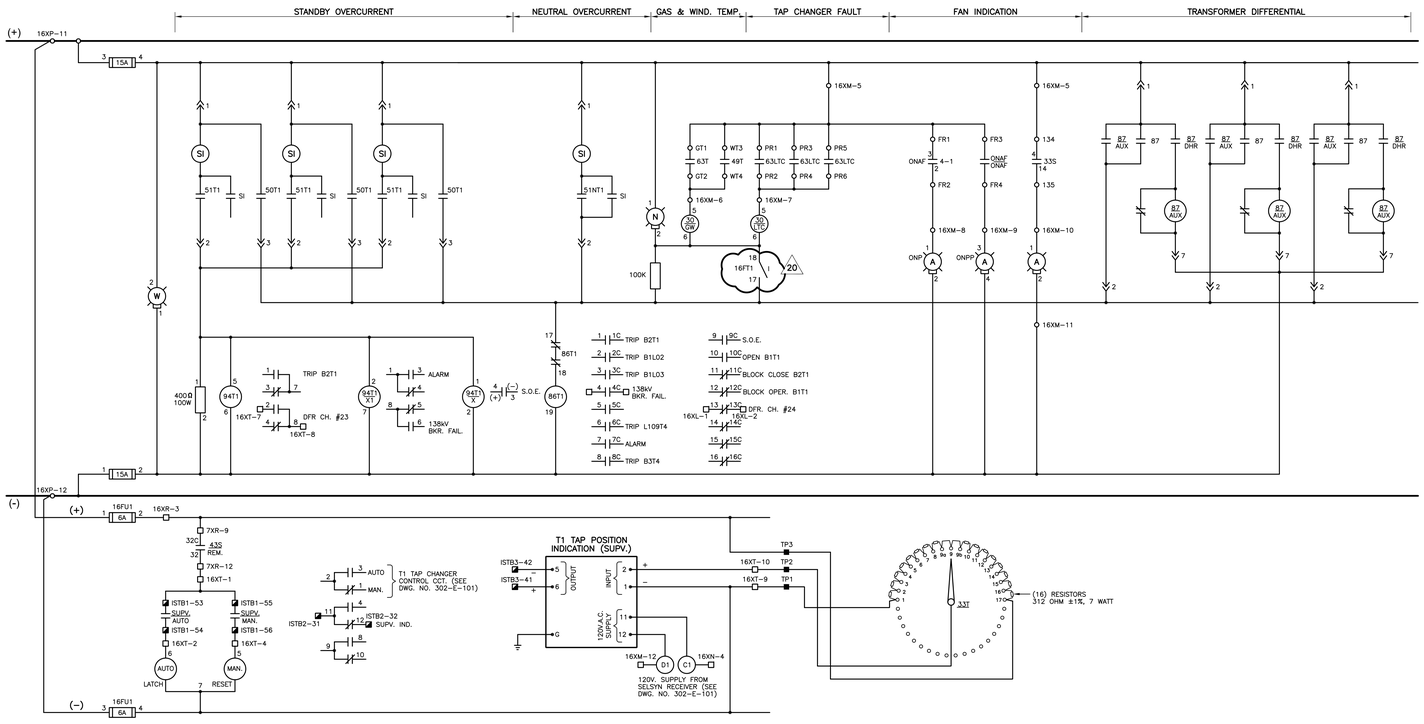


M.O.D. B1T1



DEVICE	DESCRIPTION	DEVICE DEV. REF. DWG.	LOCATION	TYPE
4-1	TFR. FAN CONT. STARTER		TFR.	
63 RAM	TFR. TAP CHANGE TRANSFER SW.		PNL. 16	SBM
50/51T1	TFR. STANDBY OVERCURRENT REL.		PNL. 16	IAC53B
51NT1	TFR. GROUND OVERCURRENT REL.		PNL. 16	IAC
3OLTC	TFR. TAP CHANGE FAULT TARGET REL.		PNL. 16	HSA
3OGW	TFR. GAS AND WINDING TEMP. TARGET REL.		PNL. 16	HSA
49T	TFR. WINDING TEMP. DEVICE		TFR.	
63T	TFR. GAS PRESS. REL.		TFR.	
63LTC	TFR. TAP CHANGER FAULT DEV.		TFR.	
84CS	TFR. TAP CHANGE REMOTE C. SW.		PNL. 16	SBM
86T1	TFR. PROT. LOCKOUT REL.		PNL. 16	HEA
94T1	TFR. PROT. TRIPPING REL.		PNL. 16	HGA
CC	BKR. CLOSING COIL		BKR.	
TC	BKR. TRIPPING COIL		BKR.	
KI	BKR. KEY INTERLOCK		BKR.	
3T	BKR. TRIP CHECK REL. + RES. 500Ω, 50W		BKR.	B.BOV. P8 24V.D.C.
52/a-b	BKR. AUX. CONTACT		BKR.	
63C	BKR. BLOCK CLOSE PRESS. SWITCH		BKR.	
63BT	BKR. BLOCK TRIP PRESS. SWITCH		BKR.	
99C	BKR. CLOSING REL.		BKR.	B.BOV. P8 125V.D.C.
99AP	BKR. ANTI-PUMP REL.		BKR.	B.BOV. P8 125V.D.C.
43S	BKR. SUPERV. SELECTOR SW.		PNL. 7	SBM
B2T1-CS	BKR. CONTROL SW.		PNL. 3	SBM
86B	138kV BUS. DIFF. LOCKOUT REL.		PNL. 6	HEA
94T	TFR. DIFF. TRIPPING REL.		PNL. 16	B.BOV. P8
29X/a,b	AUX. RELAYS FOR SUPV. INDICATION		PNL. 3	P & B KRPIIDG
43X	LATCH RELAY FOR T1 AUTO/MAN. (SUPV.		PNL. 16	S & D 255XCXP
5	M. O. DISC. FOR DETAIL ITE DWGS.			
8-1,2				
9				
33				
33LS		M.O.DISC.		
43				
43CS				
43LOR				
29T/a-b	DISC. AUX. CONTACT	M.O.DISC.		
B1T1-CS	DISC. CONTROL SW.		PNL. 3	SBM
94T1/X	AUX. RELAY FOR S.O.E. STATUS		PNL. 16	GE ETS201A
86BF	138kV BKR. FAIL. LOCKOUT RELAYS - GF		PNL. 28	HEA-61

TRANSFORMER T1



BREAKER B2T1 C.S.

B2T1 CS: TRIP / CLOSE

CONTACTS HANDLE END		POSITION		
		CLOSE	NORM	TRIP
1-2	1	X		
	2			X
3-4	3	X		X
	4	X		

PISTOL GRIP HANDLE
SPRING RETURN TO NORM.

M.O. DISC. B1T1 C.S.

B1T1 CS: OPEN / CLOSE

CONTACTS HANDLE END		POSITION		
		CLOSE	NORM	OPEN
1-2	1			X
	2	X		
3-4	3			X
	4	X		

PISTOL GRIP HANDLE
SPRING RETURN TO NORM.

29X a: ISTB2-23, ISTB2-24, SUPV. IND. CONTACT 1

29X b: ISTB2-25, ISTB2-26, SUPV. IND. CONTACT 2

ALARMS: 136, 138, OT1, 27 OUT OF STEP, TOP OIL, 137, 139, OT2 — ANNUNCIATOR PANEL

ALARMS: GA1, OL3, OL1, WT1, 63T LOW OIL, LTC LOW OIL, 49T, GA2, OL4, OL2, WT2 — ANNUNCIATOR PANEL

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO.

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
20	13-04-10	FIELD REVISIONS	W.B.	F. REV.		
19	05-08-17	REVISED AS BUILT	C.M.	FLD.REV.		
18	03-02-03	REVISED AS BUILT	H.P.	FLD.REV.		
17.	01-09-08	REV. "AS BUILT" (138kV BKR. FAIL. ADD.) & REDRAWN	C.R.H.			
16.	00-10-16	AS BUILT	D.O.			
15.	99-	TRANSCAN DFR ADDED	D.O.			
14.	95-04-18	S.O.E. ADDITIONS	C.M.			

DWG.NO. | TITLE
REFERENCE DRAWINGS
REVISIONS

ORIGINAL DRAWING NOT SEALED

HYDRO — NEWFOUNDLAND AND LABRADOR HYDRO

ELECT.	SCALE:	N.T.S.
CIVIL	DESIGNED:	
TRANS.	DRAWN:	C.R.H.
MECH.	DATE:	2001-09-08
P&C	CHECKED:	
TELC.	APPROVED:	

SUNNYSIDE TERMINAL STATION
M.O. DISC. B1T1, T1 AND A.B.C.B. B2T1
D.C. SCHEMATIC DIAGRAM

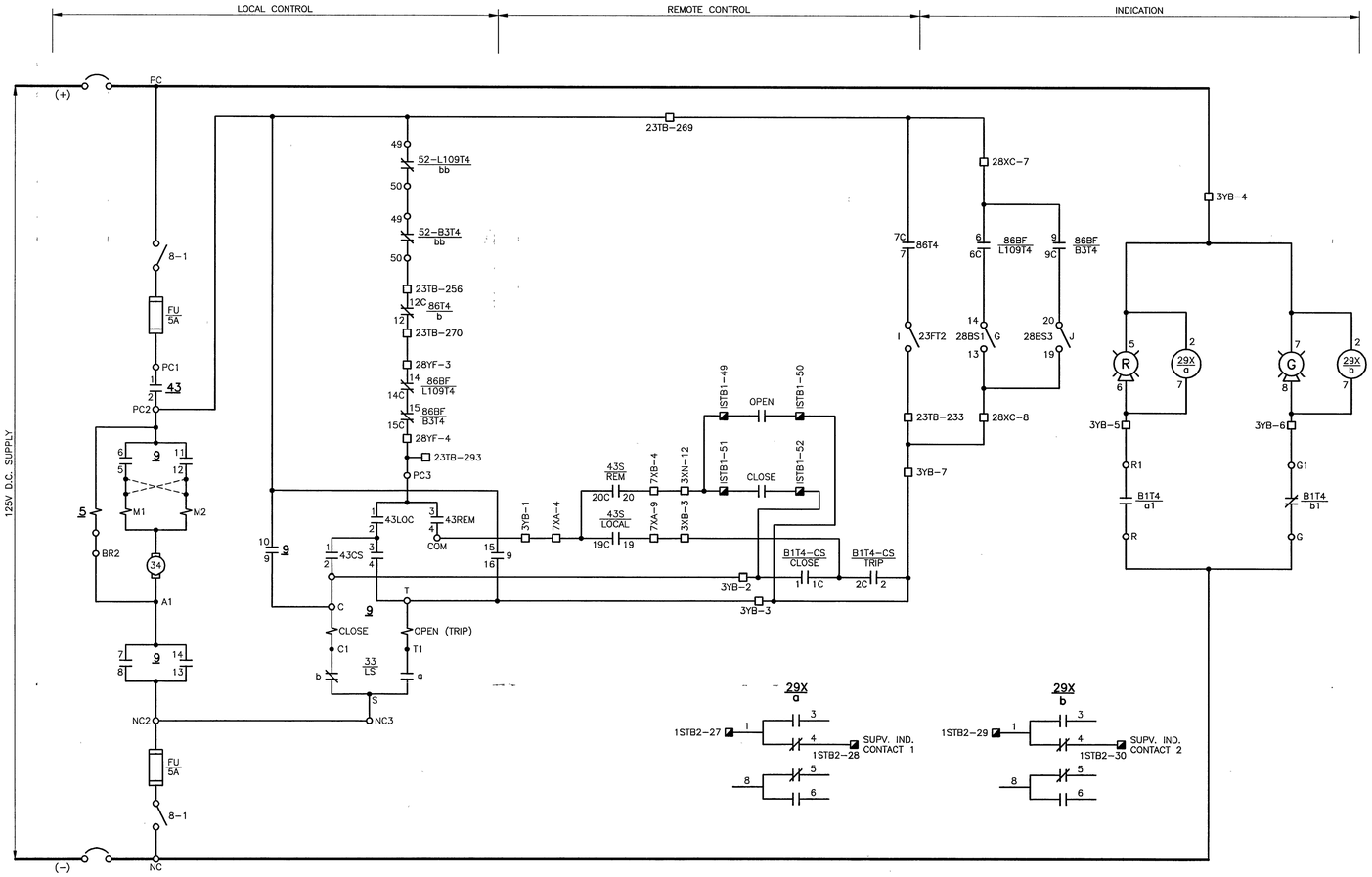
W.O. NO.

DWG. NO. A0 - 302 - E - 030

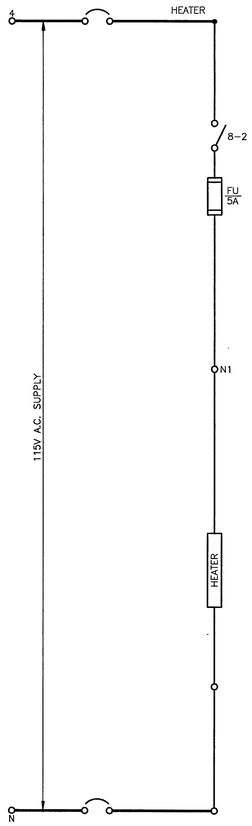
REV. 20

PLOT SCALE 1:1 C.A.D.

DEVICE	DESCRIPTION	LOCATION	TYPE
5	ELECTROMAGNETIC BRAKE	B1T4 DISCONNECT	
9	MOTOR REVERSING CONTACTORS	B1T4 DISCONNECT	
8–1	DPST CONTROL POWER SWITCH	B1T4 DISCONNECT	
8–2	SPST HEATER SWITCH	B1T4 DISCONNECT	
33	POSITION AUX. CONTACTS	B1T4 DISCONNECT	
33/LS	LIMIT CONTACT ON DEVICE 33	B1T4 DISCONNECT	
43	MANUAL SELECTOR SWITCH	B1T4 DISCONNECT	
52–L109T4/bb	BREAKER AUX. CONTACT	L109T4 BREAKER	
84	1/2 H.P. MOTOR	B1T4 DISCONNECT	
86T4/b	TRANSFORMER LOCKOUT RELAY CONTACT	TRANS. T4 PANEL	C.G.E. HAE
B1T4–CS	B1T4 REMOTE CONTROL SWITCH	CONTROL PNL.	C.G.E. SBM
43CS	LOCAL PUSH BUTTON	B1T4 DISCONNECT	
43 LOR	LOCAL OFF REMOTE SELECTOR SWITCH	B1T4 DISCONNECT	
52–B2T4/bb	BREAKER AUX. CONTACT	B2T4 BREAKER	
29X/a,b	AUX. RELAY FOR SUPV. INDICATION	PANEL No. 3	P&B KRP11DG
86BF	BREAKER FAIL LOCKOUT RELAY–GE	PANEL No. 28	HEA–61



B1T4 D.C. SCHEMATIC



A.C. SCHEMATIC

DISCONNECT B1T4 CONTROL SWITCH

CONTACTS		POSITIONS		
		CLOSE	NORM.	TRIP
1 1C 2C 2	1	X		
	2			X
3 3C 4C 4	3	X		X
	4	X		

TARGET TYPE WITH PISTOL GRIP HANDLE
SPRING RETURN TO NORMAL POSITION

CONTACT DIAG. 9		
CONTACT NO.	POSITIONS	
	CLOSE	OPEN
1–2		
3–4		
5–6	X	
7–8	X	
9–10	X	
11–12		X
13–14		X
15–16		X

CONTACT DIAG. 33		
CONTACT NO.	POSITIONS	
	CLOSE	OPEN
a	X	
b		X
a1	X	
b1		X

CONTACT DIAG. 43		
CONTACT NO.	POSITIONS	
	MAN.	MOTOR
1–2		X

X – CONTACT CLOSED

NOTES:
1. TO CHANGE ROTATION OF MOTOR REVERSE M1 & M2 LEADS.
2. REVERSING CONTACTOR IS MECHANICALLY INTERLOCKED.
3. □ INDICATES TERMINALS IN CONTROL/RELAY PANELS.
4. ○ INDICATES TERMINALS IN EXTERNAL EQUIPMENT.
5. ● INDICATES INTERNAL CONNECTIONS.

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO.

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
6	05–08–17	REVISED AS BUILT	C.M.	FLD. REV.		
5	03–02–04	REVISED AS BUILT	H.P.	FLD.REV.		
4	08–09–01	138kV BKR. FAIL ADDITION & AS BUILT. (REDRAWN)	D.O.		AYL	
3	10–90	SUPV. CONTROL & IND. ADDED	D.C.M.			
2	26–02–77	AS BUILT	D.B.F.			
1	05–76	GEN. REVISIONS	D.B.F.			

DWG.NO. | TITLE — REFERENCE DRAWINGS

REVISIONS

ORIGINAL DRAWING NOT SEALED

ELECT.	SCALE: N.T.S.
CIVIL	DESIGNED:
TRANS.	DRAWN: J.G.
MECH.	DATE: SEPT. 9, 1975
P&C	CHECKED:
TELC.	APPROVED:

NEWFOUNDLAND AND LABRADOR HYDRO

SUNNYSIDE TERMINAL STATION
MOTOR OPERATED DISCONNECT B1T4
A.C. & D.C. SCHEMATIC DIAGRAM

W.O. NO.

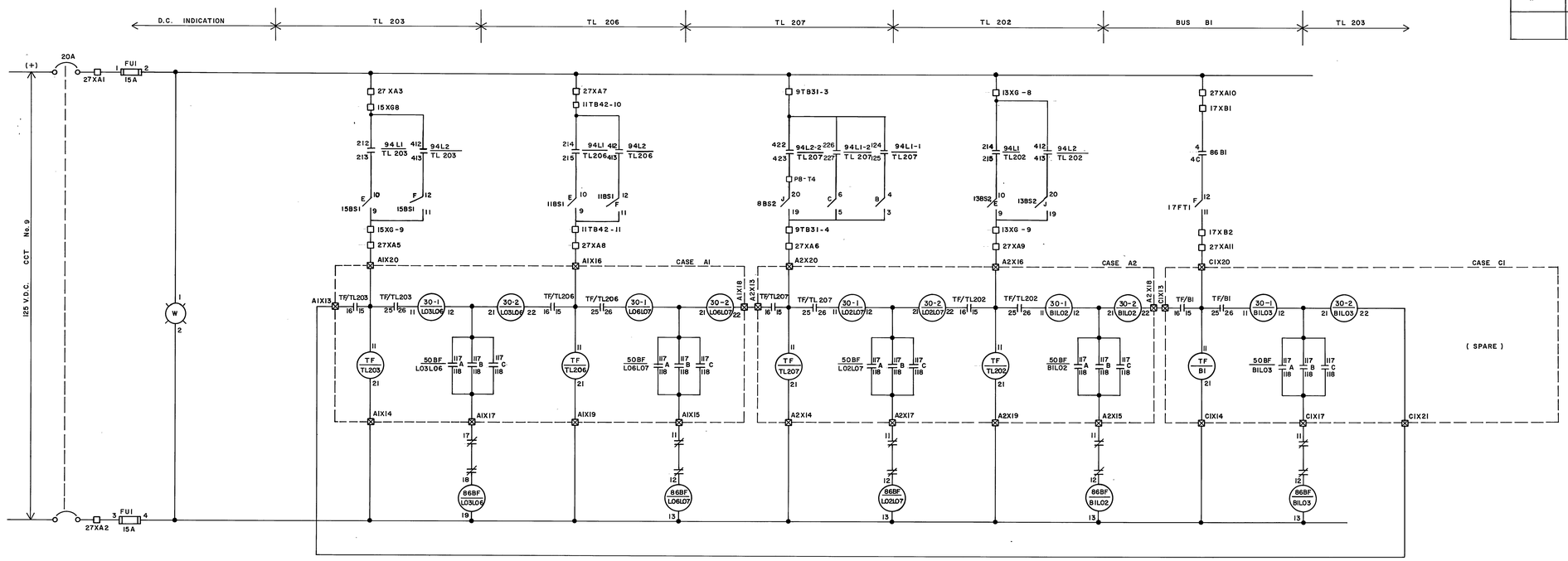
DWG. NO. A1 - 302 - E - 71

REV. 6

PLOT SCALE 1:1 C.A.D.

DEVICE	DECRIPTION	LOCATION	TYPE
50BF	DETECTOR OVERCURRENT RELAY I-2/2-4A	PNL. No 27	RXIL 23 (RK-412 114-DL)
TF	TIME LAG RELAY (20MS - 99S) - ASEA	" "	RXKEI (RK-333-001-AN)
30	SIGNAL RELAY, 2 RED FLAGS, MAN. RESET, 0.2A OPERATING - ASEA	" "	RXSFI (RK-271-007-AX)
86BF	LOCKOUT TRIPPING RELAY, 125 V.D.C. - CGE	" "	HEA-61B-237 HEA-61C-242
W	INDICATING LAMP, 125 V.D.C. WHITE CAP-WESTINGHOUSE	" "	ET-16 (169A 874002)

230 KV BREAKER FAILURE SCHEME



86BF-L03L06 (HEA 61C) - 239

27BS1

27XB1 1 1C 2/A 1 27XB2 TRIP BIL03
27XB3 2 2C 4/B 3 27XB4 TRIP L06L07
27XD-5 3 3C 27XD-6 SOE
4 4C
5 5C
6 6C
7 7C ANNUNCIATOR
8 8C
27XD-9 9 9C 27XD-10 DFR CH.# 27
10 10C BLK. CLOSE BIL03
11 11C BLK. CLOSE L06L07
12 12C OPEN L03L06 TRIP CCT.
27XD-3 13 13C 27XD-4
14 14C
15 15
16 16C
17 18
19
86BF/L03L06 CCT.

TF (RXKEI)

11 + 21 BF CCT
15 16 17 30-1 CCT.
25 26 27 30-2 CCT

86BF-L06L07 (HEA 61B)

27BS1

27XB5 1 1C 8/D 7 27XB6 TRIP L02L07
27XB3 2 2C 10/E 9 27XB4 TRIP L03L06
27YB-8 3 3C 27YB-9 SOE
27XD-11 4 4C 27XD-12 DFR CH.# 28
5 5C
6 6C
7 7C ANNUNCIATOR
8 8C BLK. CLOSE L03L06
9 9C BLK. CLOSE L02L07
10 10C OPEN L06L07 TRIP CCT.
11 12
13
86BF/L06L07 CCT

30 (RXSFI)

X: 11 12 BF CCT; 13 14; 15 16; 17 18
Y: 21 22 BF CCT; 23 24; 25 26; 27 28

86BF - L02L07 (HEA 61B)

27BS1

27XB3 1 1C 14/G 13 27XB4 TRIP L06L07
27XC3 2 2C 16/H 15 27XC4 TRIP BIL02
27YB-6 3 3C 27YB-7 SOE
27YE-5 4 4C 27YE-6 DFR CH.# 29
5 5C
6 6C
7 7C ANNUNCIATOR
8 8C BLK. CLOSE L06L07
9 9C BLK. CLOSE BIL02
27YA-11 10 10C 27YA-12 OPEN L02L07 TRIP CCT
11 12
13
86BF/L02L07 CCT

50BF (RXIL)

141 131 BF CCT
117 118 BF CCT
218

86 BF - BIL02 (HEA 61C)

27BS2

27XB1 1 1C 2/A 1 27XB2 TRIP BIL03
27XB5 2 2C 4/B 3 27XB6 TRIP L02L07
27XC5 3 3C 6/C 5 27XC6 TRIP B2T1
27XC7 4 4C 8/D 7 27XC8 TRIP B2T4
27XC9 5 5C 10/E 9 27XC10 TRIP L109T4
27XC11 6 6C 12/F 11 27XC12 86/B1 CCT
27YE-3 7 7C 27YE-4 SOE
27YE-7 8 8C 27YE-8 DFR CH.#30
9 9C
10 10C
11 11C
12 12C ANNUNCIATOR
13 13C BLK. CLOSE L02L07
14 14C OPEN TRIP CCT/BIL02
15 15C
16 16C
17 18
19
86BF/BIL02 CCT.

86 BF - BIL03 (HEA-61C)

27BS3

27XC3 1 1C 2/A 1 27XC4 TRIP BIL02
27XB7 2 2C 4/B 3 27XB8 TRIP L03L06
27XC5 3 3C 6/C 5 27XC6 TRIP B2T1
27XC7 4 4C 8/D 7 27XC8 TRIP B2T4
27XC9 5 5C 10/E 9 27XC10 TRIP L109T4
27XC11 6 6C 12/F 11 27XC12 86/B1 CCT
27XD-7 7 7C 27XD-8 SOE
8 8C
27YE-9 9 9C 27YE-10 DFR CH.# 31
10 10C
11 11C
12 12C ANNUNCIATOR
13 13C BLK CLOSE L03L06
14 14C OPEN TRIP CCT/BIL03
15 15C
16 16C
17 18
19
86BF/BIL03 CCT

TERMINAL LEGEND

- ☐ AT PANEL TERMINAL BLOCKS
- ☒ AT ASEA COMBIFLEX RELAY CASE.

APPROVED FOR CONST. 84-07-23

REFERENCE DRAWINGS		
B1-302-E-123	PANEL NO. 27	LAYOUT
B1-302-E-121	PANEL NO. 27	WIRING DIAGRAM
DWG. No.		TITLE

No	DATE	DESCRIPTION		BY	CKD.
10	97-	TL202 & TL206 21P2 ADDED		AYL	LT
9	89-04-18	SOE ADDITIONS		C.M.	
8	84-08-17	AS BUILT		C.M.	
7	91-10-21	TL203 LINE PROTECTION MODIFICATIONS		D.C.M.	
6	91-04-26	TL207 LINE IMPROVEMENT		C.M.	
5	90-11-14	TL 206 IMPROVEMENT.		W.R.L	
14	00-11-21	REVISED AS BUILT	D.D.	LT	AYL
13	00-11-21	TL207 BACK-UP RROT. UPGRADE	D.D		
12	99-	TRANSCAN DFR ADDED		AYL	LT
11	99-	TL203 21P2 ADDED		AYL	LT

REVISIONS

ELECT. | CIVIL | TRANS. | MECH. — PASSED

REGISTERED PROFESSIONAL ENGINEER — P. H. MARTIN — PROVINCE OF NEWFOUNDLAND

NEWFOUNDLAND AND LABRADOR HYDRO

SUNNYSIDE TERMINAL STATION

230 KV BREAKER FAILURE PROTECTION

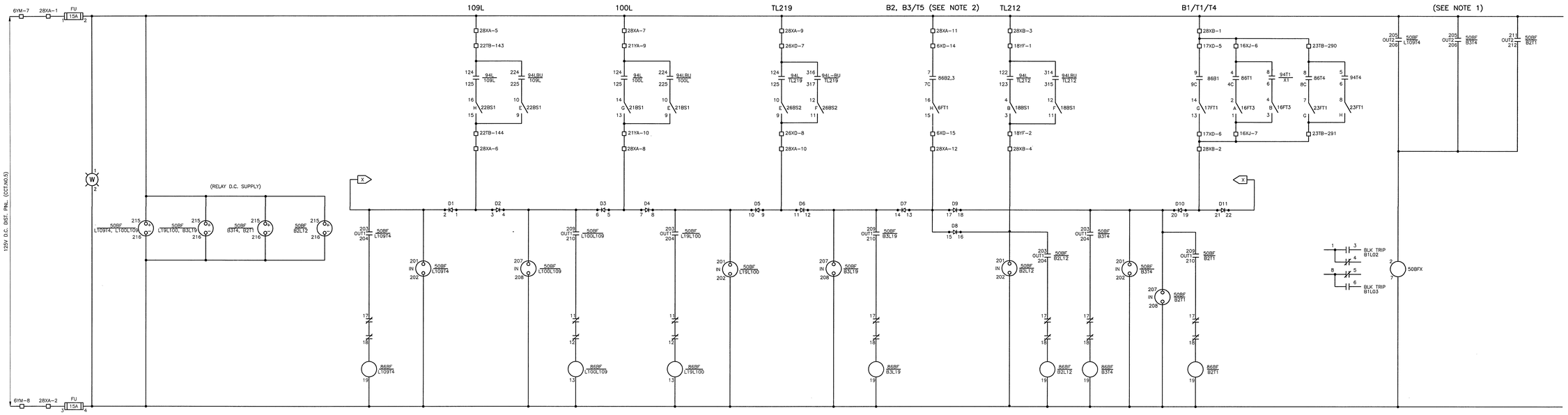
D.C. SCHEMATIC DIAGRAM

SCALE N.T.S.	DESIGNED LT	DRAWN G.W.	
CHECKED	APPROVED	DATE 84-04-15	
W.O. No.	DWG No. B1-302-E-122		REV 14

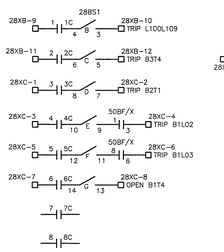
Transfer 003

DEVICE	DESCRIPTION	LOCATION	TYPE
50BF	BREAKER FAIL DUAL OVER CURRENT MONITORING RELAY – SEL	PNL 28	SEL–501
86BF	BREAKER FAIL LOCKOUT TRIP RELAY – GE	PNL 28	HEA–61C–240 OR HFA–61B–216
W	INCANDESCENT INDICATING LIGHT – GE	PNL 28	ET–16
D1 – 22	DIODE – 6A (IFM SURGE 400A, PRV 1000V)	PNL 28	ECG–5817
50BFX	OVER CURRENT MONITOR AUX. RELAY – P & B	PNL 28	KRP11DG–110
94L	TRIP RELAY – PRIMARY PROTECTION	PNL 21,22,26	ABB RXMS1
94LBU	TRIP RELAY – BACKUP PROTECTION	PNL 21,22,26	ABB RXMS1

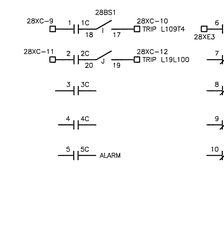
138kV BREAKER FAILURE PROTECTION CIRCUIT



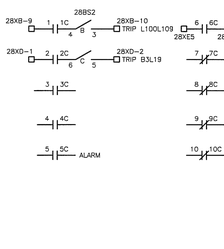
86BF / L109T4



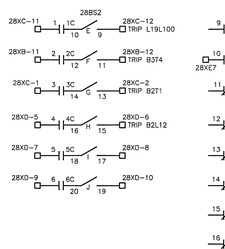
86BF / L100L109



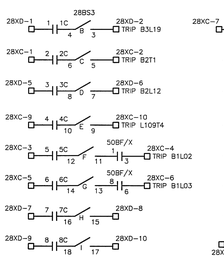
86BF / L19L100



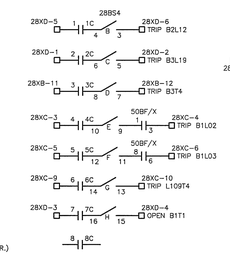
86BF / B3L19



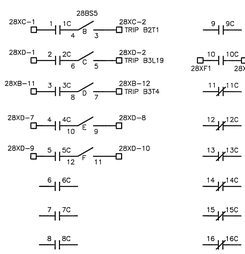
86BF / B3T4



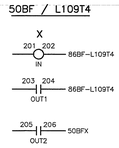
86BF / B2T1



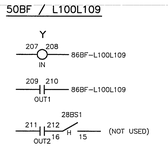
86BF / B2L12



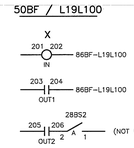
50BF / L109T4



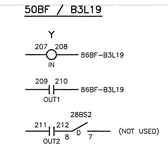
50BF / L100L109



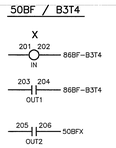
50BF / L19L100



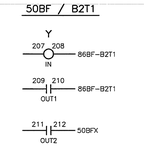
50BF / B3L19



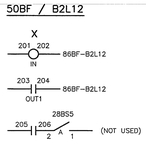
50BF / B3T4



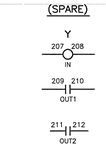
50BF / B2T1



50BF / B2L12



(SPARE)



TEMP. NOTE:

1. ALL SOE COMMON IN SJB #2 2TB5–27, –28 .

NOTE:

1. 50BF/L109T4, 50BF/B3T4, AND 50BF/B2T1 'OUT 2' ARE SET FOR RETRIP, BUT THEIR FUNCTIONS ARE TO BLOCK TRIP THE 230kV BREAKERS B1L02 OR B1L03, PERMITTING TO CLOSE BACK THE BREAKERS TO NORMAL, AFTER A 138kV BREAKER FAIL OPERATION OCCURRED.
2. T5 (NP) PROTECTION TRIPS VIA 86B2,3.

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO.

REFERENCE DRAWINGS

DWG.NO.	TITLE

REVISIONS

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
3	05–09–28	100L & 109L LINE PROTECTION UPGRADE	C.M.	AYL	PJB	
2	05–09–28	TL212 LINE PROTECTION UPGRADE	C.M.		PJB	
1	01–09–08	REVISED AS BUILT	W.B.	LT	AYL	
0	00–11–10	ISSUED FOR CONSTRUCTION	H.P.	LT	AYL	

REGISTERED PROFESSIONAL ENGINEER — PROVINCE OF NEWFOUNDLAND — L. T. TRAN — SIGNATURE — Nov.12,2000

ELECT.	SCALE:	N.T.S.
CIVIL	DESIGNED:	L. TRAN
TRANS.	DRAWN:	H. PARSONS
MECH.	DATE:	2000–08–09
P&C	CHECKED:	
TELC.	APPROVED:	

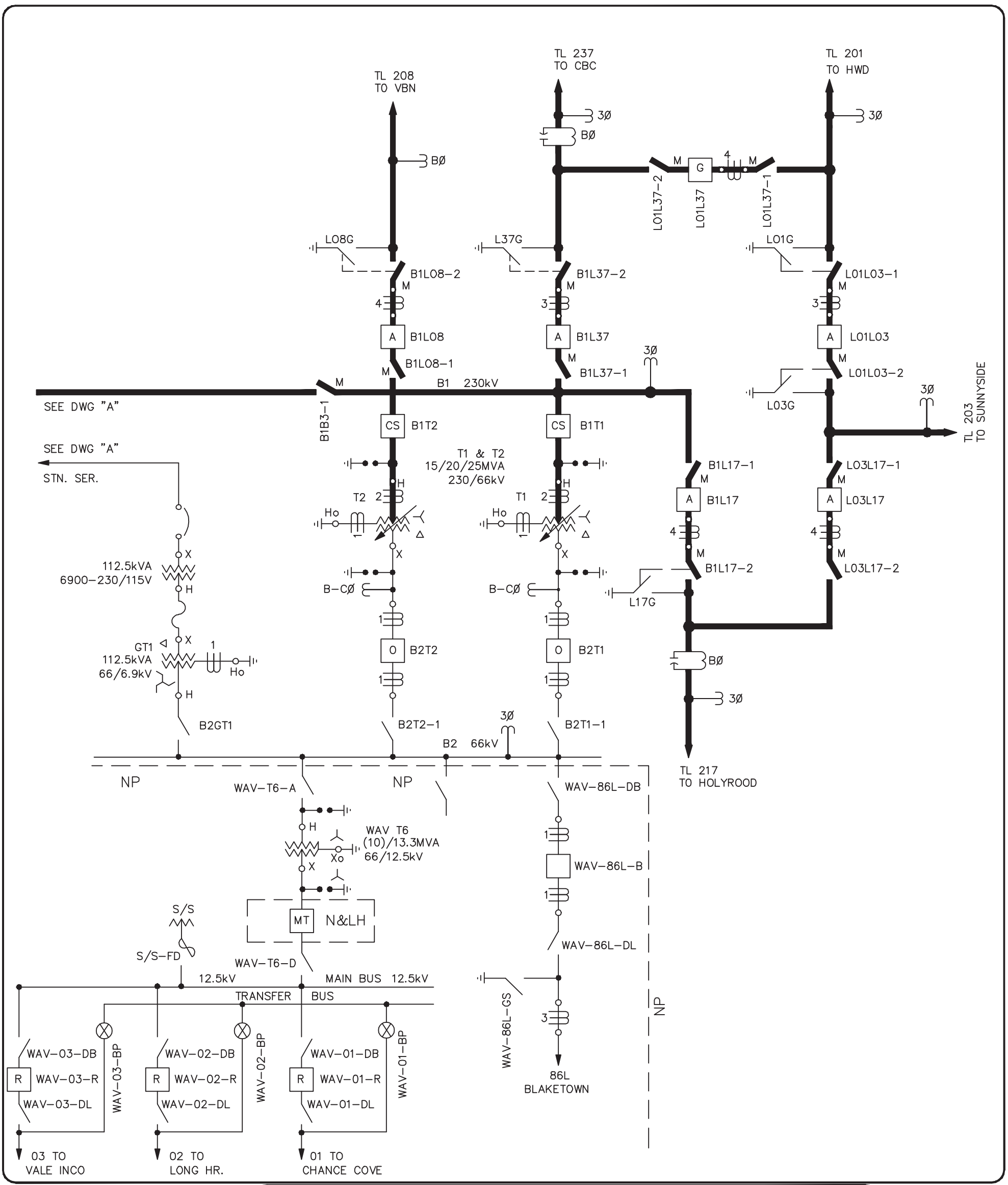
HYDRO — NEWFOUNDLAND AND LABRADOR HYDRO

SUNNYSIDE TERMINAL STATION
138kV BREAKER FAILURE
PROTECTION D.C. SCHEMATIC

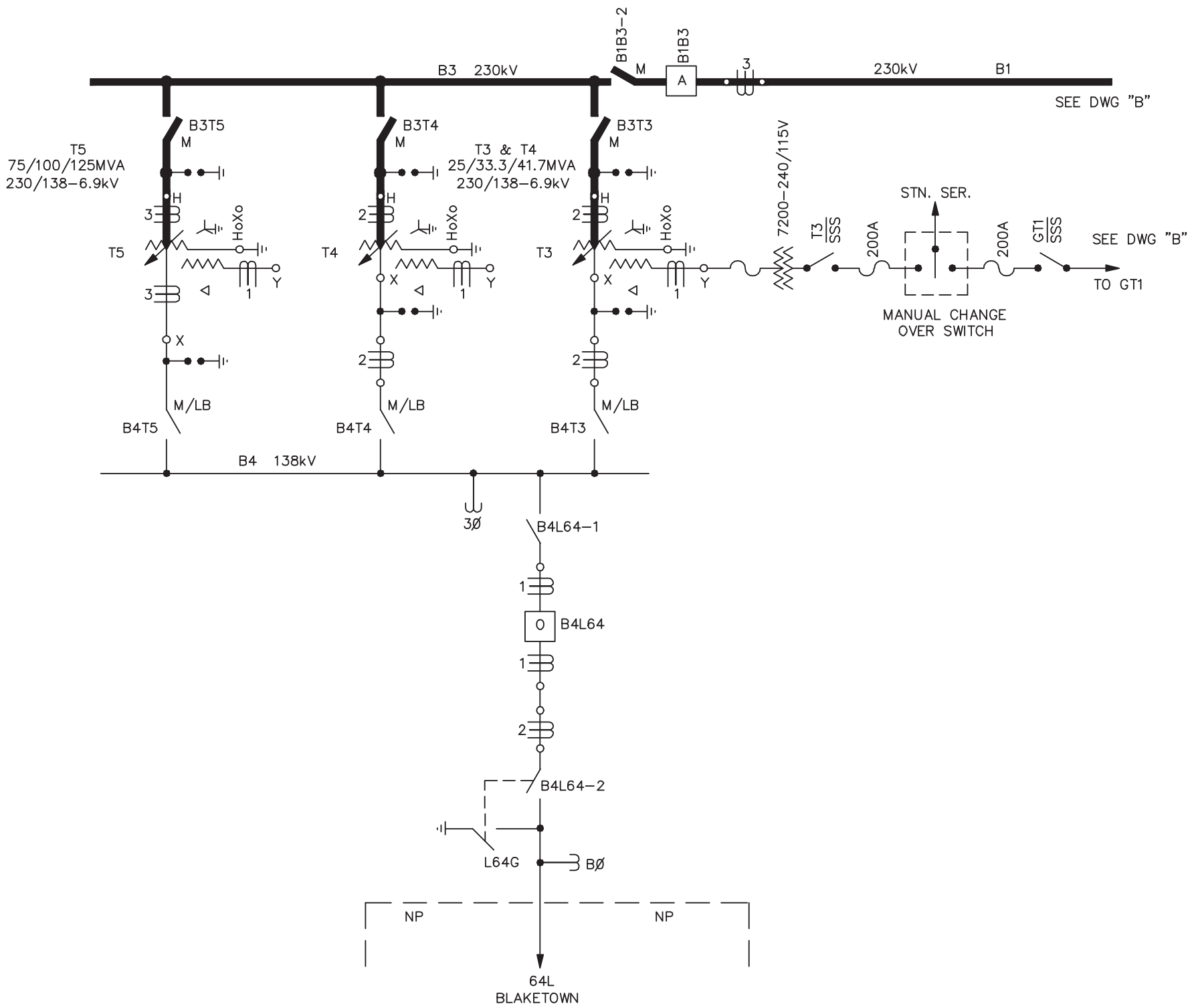
W.O. NO.

DWG. NO. A0 - 302 - E - 130 REV. 3

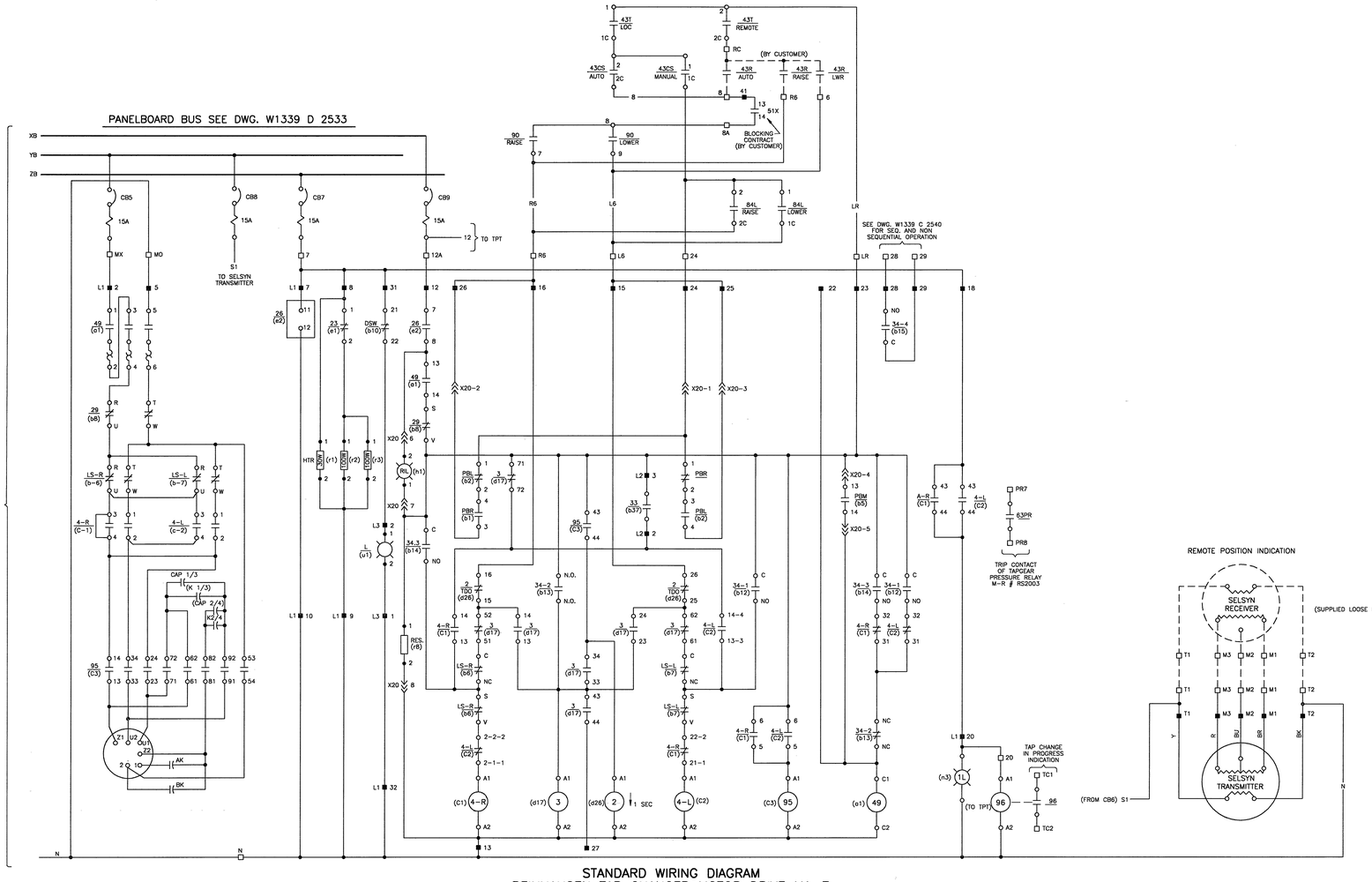
PLOT SCALE 1:1 C.A.D.



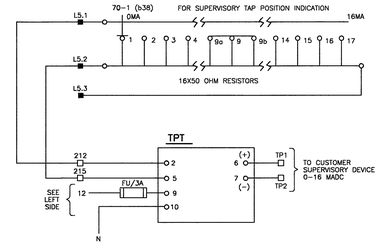
DRAWN BY: J.T.	REVISED BY: D.R.	NEWFOUNDLAND AND LABRADOR HYDRO	DWG NO WAV-B
APPROVED BY: G.B.		SYSTEM OPERATING DIAGRAM WESTERN AVALON TERMINAL STATION (B)	REV NO 15
DATE: 2012/06/12			

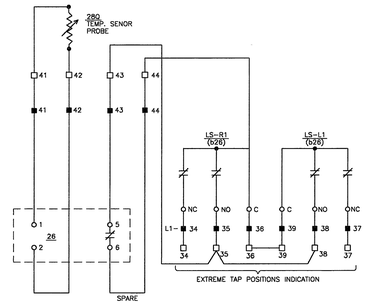


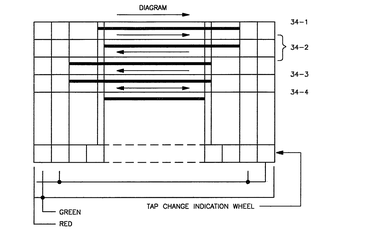
DRAWN BY: J.T.	REVISED BY: D.R.	NEWFOUNDLAND AND LABRADOR HYDRO	DWG NO WAV-A
APPROVED BY: R.S.		SYSTEM OPERATING DIAGRAM WESTERN AVALON TERMINAL STATION (A)	REV NO 6
DATE: 2010/04/29			



STANDARD WIRING DIAGRAM
REINHAUSEN TAP CHANGER MOTOR DRIVE MA-7
(FOR REFERENCE USE ONLY – REFER TO TRANSFORMER MANUAL FOR MORE DETAIL)

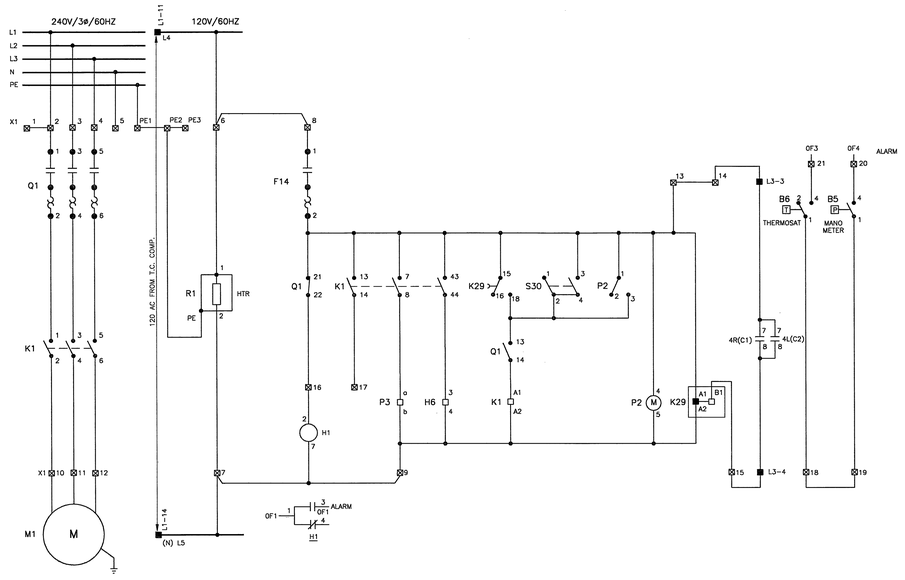




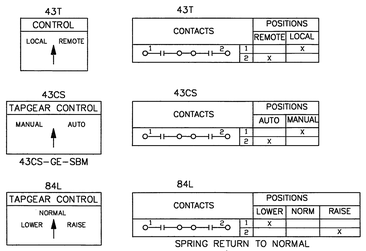


DEVICE NO.	DESCRIPTION (MOTOR CIRCUIT)
49	MOTOR PROTECTIVE SWITCH
PBR/L	OPERATING PUSH BUTTON RAISE/LOWER
PBM	PUSH BUTTON FOR TRIPPING MOTOR PROTECTIVE SWITCH
LS-R/L	POSITION LIMIT SWITCH WITH MICROSWITCH
29	SAFETY SWITCH FOR MANUAL OPERATION
DSW	DOOR CONTACT FOR HAND LAMP ON – OFF
34-1/3	CAM SWITCH OPERATES MICROSWITCH
34-2	CAM SWITCH OPERATES MICROSWITCH (STEP BY STEP)
34-4	CAM OPERATED CONTACT
33	POSITION PASSAGE CONTACT CLOSED ON POS. 9a,9b.
70-1	KPO ROW RESISTORS 16X50 OHM 1 WATT
4-R/L	MOTOR CONTACTOR RAISE/LOWER
95	BRAKE CONTACTOR FOR MOTOR OPERATING
3	AUX CONTACTOR FOR STEP BY STEP OPERATION
2	TIME RELAY OPENING RELAY DELAY 1 SEC.
23	THERMOSTAT FOR HEATERS
26Q	ELECTROSTATIC THERMO DEVICE
1L	TAPCHANGE IN PROGRESS LAMP
R1L	LAMP FOR SIGNALLING THE TRIPPING OF 49
88	DRIVING MOTOR 120VAC. 60HZ 0.75KW
HTR	HEATERS THERMOSTAT CONTROLLED 2X100W , 1X30W , 120VAC
RES	SERIES RESISTOR FOR RL
L	HAND LAMP PORTABLE SERVICE LIGHT
CAP 1/2	CONDENSERS FOR MOTOR BREAKING CIRCUIT
	AK – STARTING CONDENSER
	BK – SERVICE CONDENSER
TPT	TRANSDUCER CREWE CTH01 INPUT 0-800 OHM OUTPUT 0-16MADC 120VAC SUPPLY
RPI	REMOTE POSITION INDICATION SELSYN CGE 230123A1A 120VAC 60HZ
84L	SELECTOR SWITCH LOWER NORMAL RAISE GE SBM
90	VOLTAGE REGULATING RELAY BECKWITH No. M0067E
43	SELECTOR SWITCHES GE SBM
96,51X	AUXILIARY RELAY K-M DIL-OOL-22NA 120VAC COIL

DEVICE NO.	DESCRIPTION (FILTER CIRCUIT)
B5	MANOMETER, CLOSES ABOVE 3.3 BAR
B6	THERMOSTAT, OPENS BELOW 25° C
F14	AUTOMATIC CUT-OUT
H6	ELECTRICAL COUNTER
K1	MOTOR CONTACTOR FOR PUMP
K29	TIME RELAY
M1	MOTOR FOR PUMP
P2	TIME SWITCH
P3	SERVICE HOUR METER
Q1	MOTOR PROTECTIVE SWITCH
R1	HEATER
S30	SWITCH FOR PUMP-TEST
H1	P/B AUX RELAY



REINHAUSEN OIL FILTER TYPE 51



NOTES

- ■ – DENOTES TERMINAL BLOCKS IN TAPGEAR CONTROL BOX (MOTOR DRIVE MA-7)
- □ – DENOTES TERMINAL BLOCKS IN MAIN CONTROL BOX
- ››› – DENOTES PLUG TYPE TERMINALS
- ⊠ – DENOTES TERMINAL BLOCKS IN OIL FILTER CONTROL BOX (TYPE 51)

REFERENCE DRAWINGS			REVISIONS					
DWG.NO.	TITLE	NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
306-E-122	230/138kV TRANSFORMERS 3, 4 & 5 PARALLELING SCHEMATIC	1	97-02-05	"REVISED AS BUILT"	G.W.	A&B	AYC	

ARTHUR G. BURSEY
Licensed to Practice
PROFESSIONAL ENGINEER
NEWFOUNDLAND
97 June 05
Date
PROFESSIONAL ENGINEERS AND GEOSCIENTISTS

ELECT.	SCALE:	N.T.S.
CIVIL	DESIGNED:	A. BURSEY
TRANS.	DRAWN:	G.E.M.
MECH.	DATE:	1996-08-02
P&C	CHECKED:	
TELC.	APPROVED:	

HYDRO
NEWFOUNDLAND AND LABRADOR HYDRO

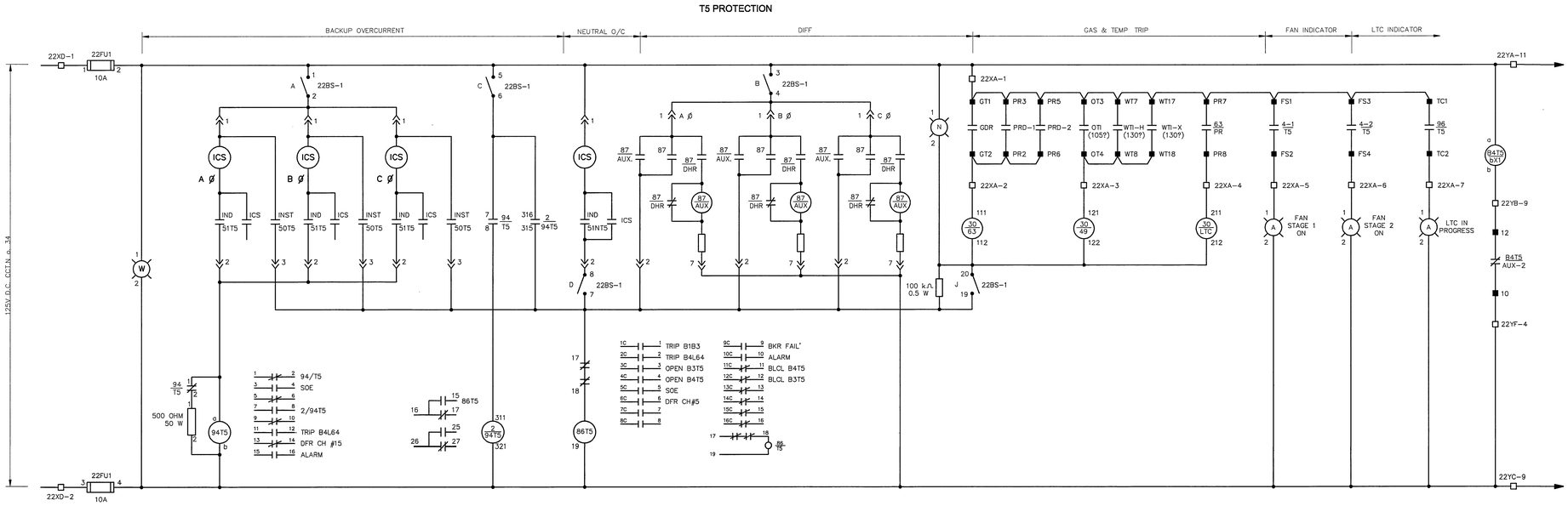
WESTERN AVALON TERMINAL STATION
T5 TAP CHANGER MOTOR AND FILTER CONTROL SCHEMATIC

W.O. NO.
DWG. NO. A0 – 306 – E – 21
REV. 1

PLOT SCALE 1:1 C.A.D.

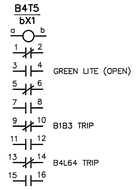
97-03-25

T5 PROTECTION

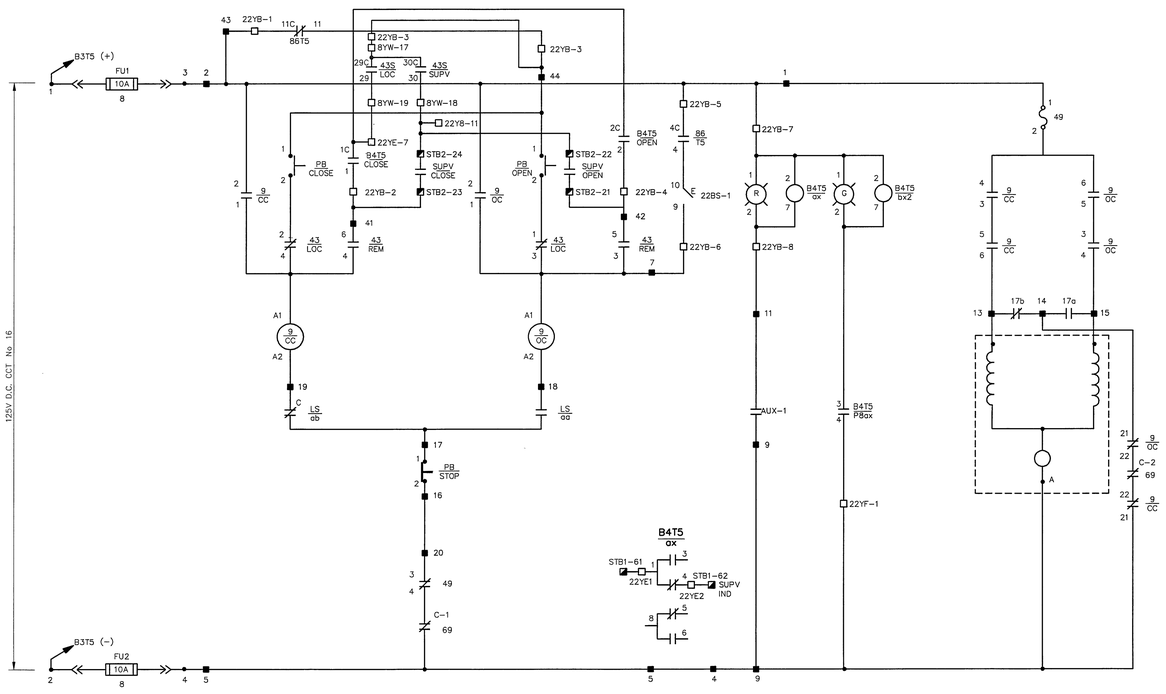


DEVICE	DESCRIPTION	LOCATION	TYPE
50/51 T5	O/C RELAY 1.5–12A IND, 10–8A INST. – CGE	PNL. 22	12IAC53BB11A
94/T5	TRIPPING RELAY – BBC	PNL. 22	P8nax
2/94T5	TIMER RELAY – ASEA RXKF1 – 0.2 – 3 SEC	PNL. 22	RK334 002–AN
51N/T5	NEUTRAL O/C RELAY 1.5–12A – CGE	PNL. 22	12IAC53AB03A
87/T5	DIFFERENTIAL RELAY – CGE	PNL. 22	12BDD15–B11A
30/63	TARGET RELAY 0.2A DC RATED CURRENT – ASEA RXSF–1	PNL. 22	RK271007–HB
30/49	"	PNL. 22	"
30/LTC	"	PNL. 22	"
86/T5	LOCKOUT RELAY – CGE	PNL. 22	HEA61C240
W,A	INDICATION LAMP – CGE ET–16	PNL. 22	169A8738G3
N	NEON LAMP – CGE ET–17	PNL. 22	169A8739G1
22BS–1	BLOCKING SWITCH – WESTINGHOUSE FT–1	PNL. 22	129A501G01
22BS–2	"	PNL. 22	"
B3T5/ax	AUXILLIARY RELAY – POTTER & BRUMFIELD	PNL. 22	KRP11DG
B4T5/ax,bX2	"	PNL. 22	"
B3T5,B4T5	CONTROL SWITCH – CGE	PNL. 22	SBM
B3T5,B4T5	"	PNL 22	"
49	MOTOR PROTECTIVE SWITCH	T5 CAB	
69	PERMISSIVE SWITCH	"	
9	REVERSING CONTACTOR	"	
B4T5/bX1	AUXILIARY RELAY – BBC	PNL. 22	P8nax

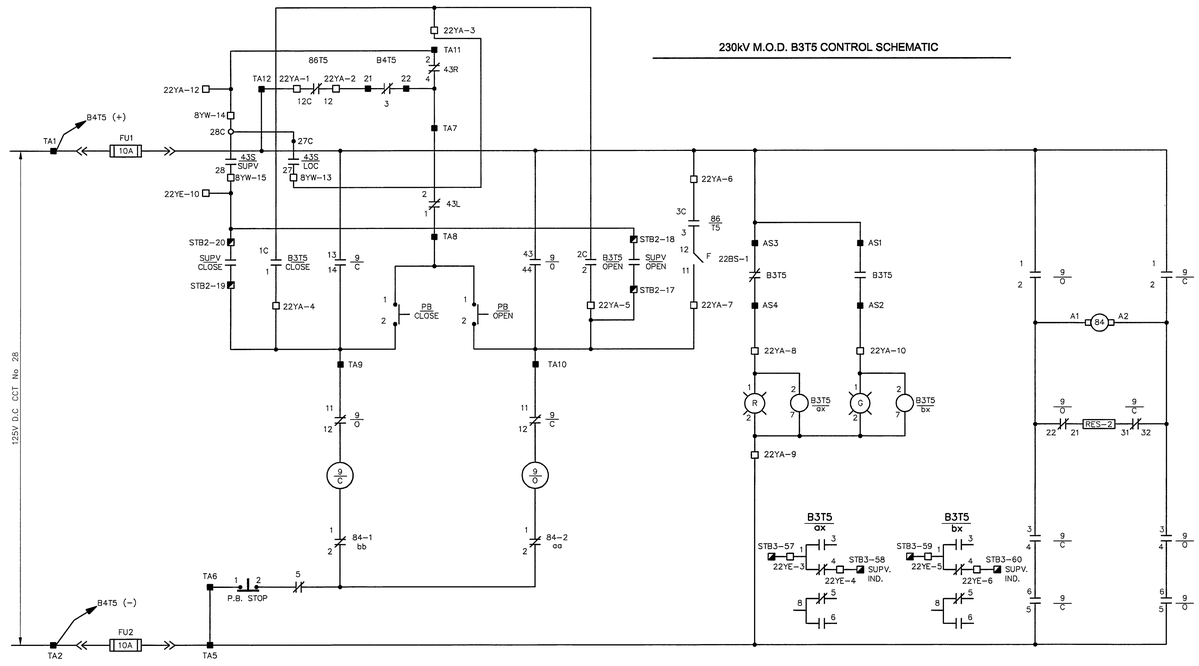
B4T5 bX1



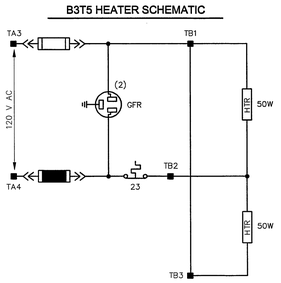
138KV LOAD BREAK SWITCH B4T5 CONTROL SCHEMATIC



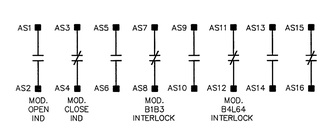
230kV M.O.D. B3T5 CONTROL SCHEMATIC



B3T5 HEATER SCHEMATIC



B3T5 AUX CONTACTS

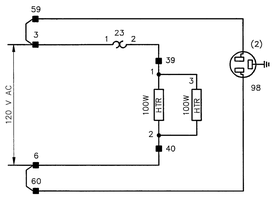


B3T5 MOD CONTROL SWITCH

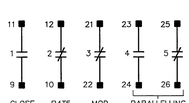
(SBM SPRING RETURN TO NORMAL, WITH TARGET)

CONTACTS HANDLE END		POSITION CLOSE	NORM	OPEN
1c	1	X		
2c	2			X
3c	3	X		
4c	4			X
5c	5	X		
6c	6			X

B4T5 HEATING SCHEMATIC



B4T5 AUX CONTACTS

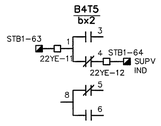


B4T5 LOAD BREAK CONTROL SWITCH

(SBM SPRING RETURN TO NORMAL, WITH TARGET)

CONTACTS HANDLE END		POSITION CLOSE	NORM	OPEN
1c	1	X		
2c	2			X
3c	3	X		
4c	4			X
5c	5	X		
6c	6			X

B4T5 bx2



NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
6	01–11–03	RELOCATION OF M.O.D. AUX. IND. RELAYS. AS BUILT	C.M.			
5	98–09–14	REVISED "AS BUILT" FOR DFR REPLACEMENT	W.B.			
4	95–04–06	SOE ADDITIONS	W.B.			
3	94–05–05	AS BUILT	W.B.			
2	92–03–07	AS BUILT	W.B.			
1	91–05–02	T5 ADDED AND REVISED AS BUILT	G.E.M.			

REVISIONS

DWG.NO.	TITLE
B1–306–E–124	T5 A.C. SCHEMATIC

REFERENCE DRAWINGS

NEWFOUNDLAND AND LABRADOR HYDRO

ELECT.	
CIVIL	
TRANS.	
MECH.	
P&C	
TELC.	
SCALE:	N.T.S.
DESIGNED:	K.W.
DRAWN:	W.H./G.E.M.
DATE:	1989–05–01
CHECKED:	
APPROVED:	

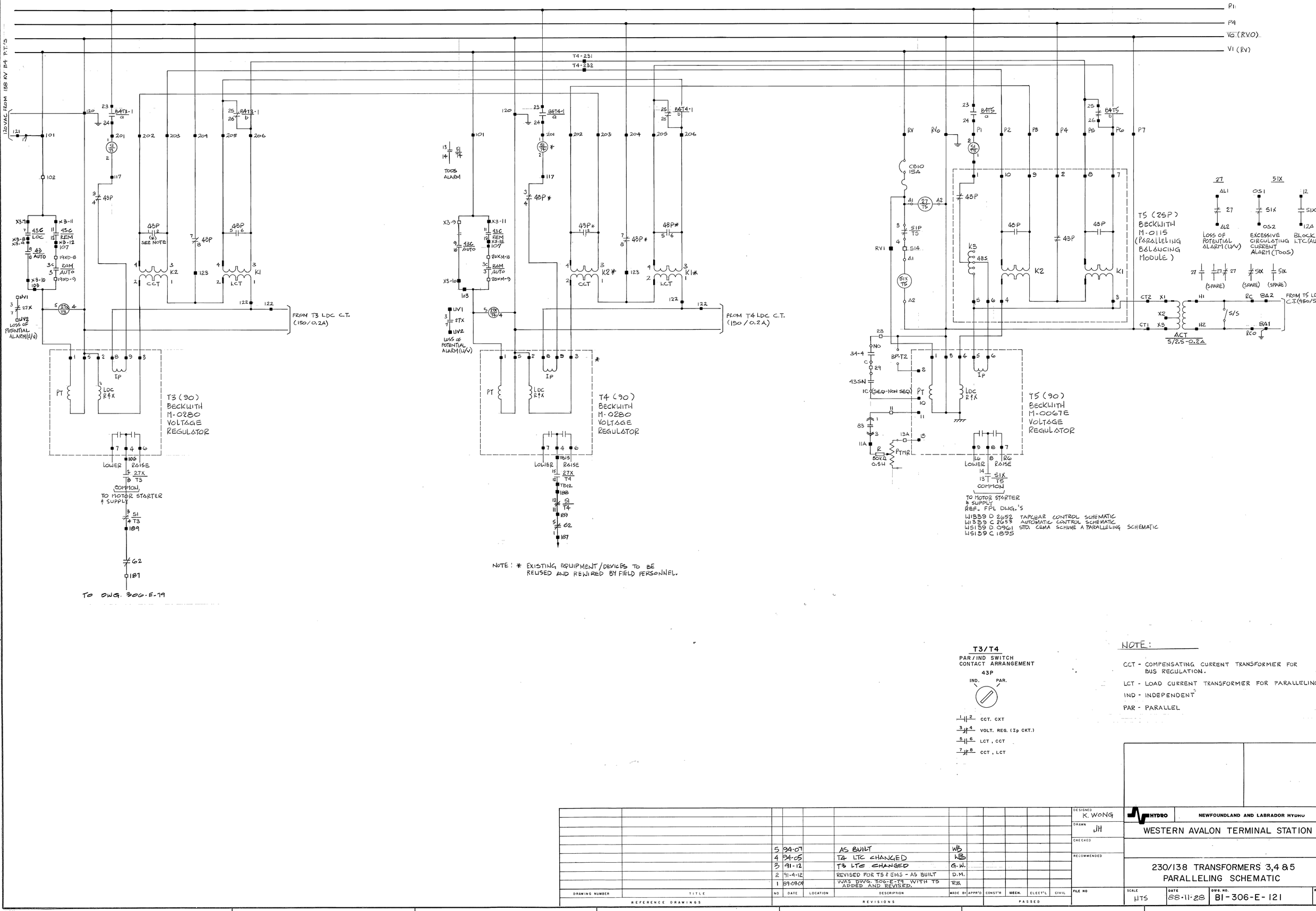
WESTERN AVALON TERMINAL STATION
T5 PROTECTION, 230kV B3T5 & 138kV B4T5 D.C. CONTROL SCHEMATICS

W.O. NO.

DWG. NO. B1- 306 - E - 120

REV. 6

PLOT SCALE 1:1 C.A.D.



T3/T4
PAR/IND SWITCH CONTACT ARRANGEMENT
43P

NOTE:

CCT - COMPENSATING CURRENT TRANSFORMER FOR BUS REGULATION.

LCT - LOAD CURRENT TRANSFORMER FOR PARALLELING.

IND - INDEPENDENT

PAR - PARALLEL

DRAWING NUMBER	TITLE	NO	DATE	LOCATION	DESCRIPTION	MADE BY	APPR'D
REFERENCE DRAWINGS		5	94-07		AS BUILT	WB	
		4	94-05		T4 LTC CHANGED	WB	
		3	91-12		T3 LTC CHANGED	G.W.	
		2	91-04-12		REVISED FOR T5 & EMS - AS BUILT	D.M.	
		1	89-09-01		WAS DWG. 306-E-79 WITH T5 ADDED AND REVISED.	RB	

CONST'N	MECH.	ELECT'L	CIVIL
PASSED			

DESIGNED K. WONG
DRAWN JH
CHECKED
RECOMMENDED
FILE NO

NEWFOUNDLAND AND LABRADOR HYDRO

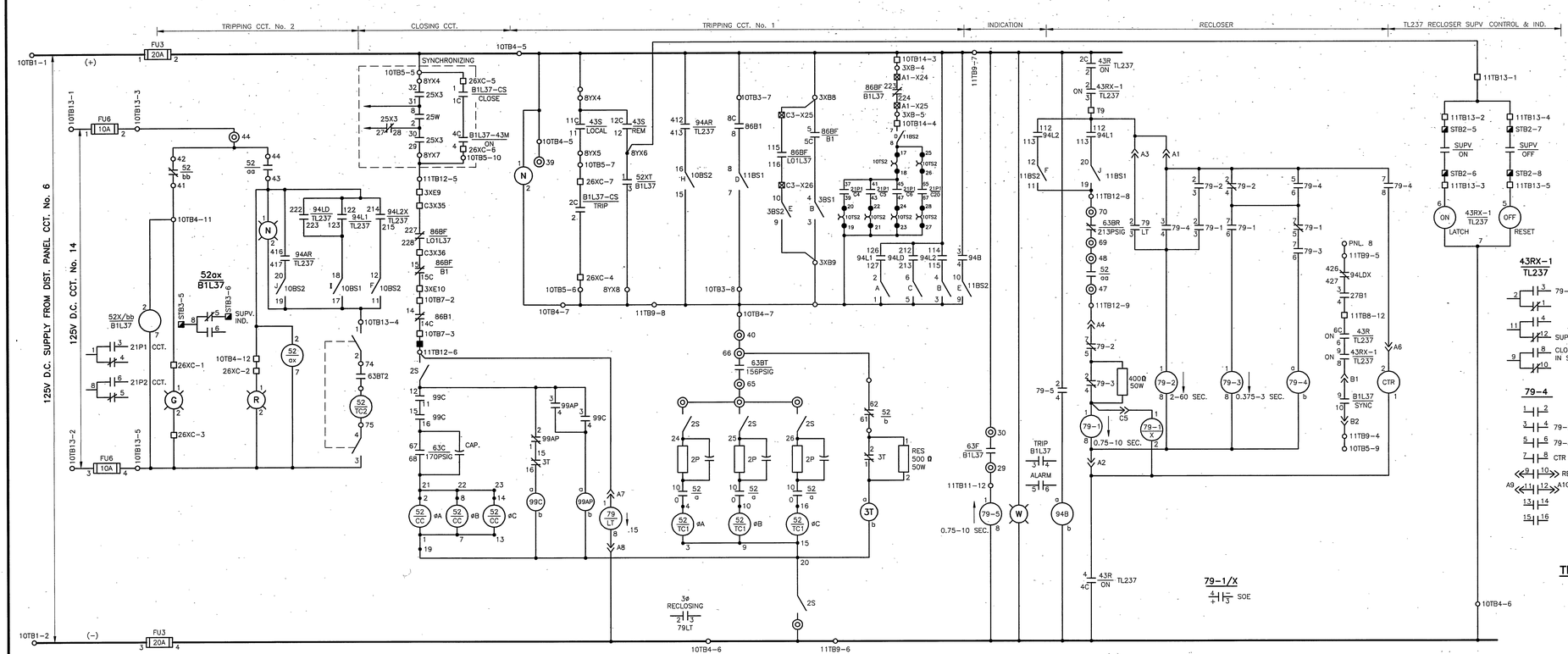
WESTERN AVALON TERMINAL STATION

230/138 TRANSFORMERS 3,4 & 5 PARALLELING SCHEMATIC

SCALE NTS | DATE 88-11-28 | DWG. NO. BI-306-E-121 | REV 5

NORMAN WADE

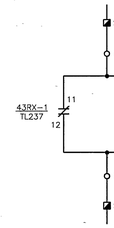
B1L37 CONTROL



DEVICE TABLE

DEVICE No.	DESCRIPTION AND FUNCTION	REFERENCE DRAWING	LOCATION	DEVICE TYPE
21P1	DISTANCE PROTECTION RELAY – PRIMARY No.1		PANEL No. 10	OPTIMHO – LFZP111
21P2	DISTANCE PROTECTION RELAY – PRIMARY No.2		PANEL No. 10	SEL–321–1
30TT1–TT2	TRANSFER TRIP RECEIVE TARGET RELAYS			RRSH
50	OVERCURRENT SUPERVISION RELAY			BCD
43TT	CARRIER SELECTOR SWITCH			SBM
43R	RECLOSER SELECTOR SWITCH			SBM
43S	LOCAL/REMOTE SWITCH (2 STACKS)	306–E–117	PANEL No. 8	SB–1 CGE
85–1	CAR. DIRECT TRANSFER TRIP		TL237 CAR. CAB.	
85–2	CAR. PERMISSIVE TRANSFER TRIP		TL237 CAR. CAB.	
94L1, L2, LD	AUXILIARY TRIP RELAYS		PANEL No. 11	ASEA – RXMS1
TS1–3	TEST BLOCKS		PANEL No. 10	GEC – MMLG
T3	TIME RELAY 0.3–2 SEC.			RRKH23
79–1	3ø RECLOSER AUX. RELAY			AGASTAT 2122 (0.75–10 SEC.)
79–2	3ø RECLOSER AUX. RELAY			AGASTAT 2122 (2–60 SEC.)
79–3	3ø RECLOSER AUX. RELAY			AGASTAT 2122 (0.375–3 SEC.)
79–4	3ø RECLOSER AUX. RELAY			B.B.–PB
79–LT	BLOCK RECLOSER RELAY			AGASTAT 2122 (0.15–1 SEC.)
K1	KIRK INTERLOCK			
25W	SYNC. RELAY		PANEL No. 8	
25X3	SYNC. AUX. RELAY			
50–51N	LINE BACK–UP GND. PROT. RELAY			IAC53
B1L37–CS	BREAKER CONTROL SWITCH			SBM
63BR	PRESSURE SWITCH RECLOSING INTERLOCK		230kV BKR.	
6EBT	PRESSURE SWITCH TRIPPING INTERLOCK		230kV BKR.	
63C	PRESSURE SWITCH CLOSING INTERLOCK		230kV BKR.	
86T1X	TRF. No. 1 PROT. LOCKOUT RELAY	306–E–34	PANEL No. 16	
CTR	COUNTER FOR 3ø RECLOSING			
79–5	TIMER FOR DISAGREEMENT TRIP			
94B	AUX.–TRIP RELAY			B.B–PB
63F	PNEUMATIC BACK–UP TRIP CONTACT		B1L37 BKR.	AGASTAT 2112 (0.75–10 SEC.)
86T2X	TRF. No. 2 PROT. LOCKOUT RELAY		PANEL No. 18	HEA
86B	BUS DIFF. LOCKOUT RELAY		PANEL No. 11	HEA
43RX–1	LATCH RELAY FOR RECLOSER SUPV. CONT.	THIS DRAWING	PANEL No. 11	S&D 255XCXP
43RX–2	AUX. RELAY FOR RECLOSER SUPV. IND.	THIS DRAWING	PANEL No. 11	P&B KRP11DG
3T	TRIP CHECK RELAY		B1L37 BKR.	B. BOV PB, 24 VDC
99C	BREAKER CLOSING RELAY		B1L37 BKR.	B. BOV PB, 125 VDC
99AP	BREAKER ANTI–PUMP RELAY		B1L37 BKR.	B. BOV PB, 125 VDC
94AR/TL237	AUX. RELAY FOR TL202/6 AUTO RESTORATION		PANEL No. 10	ASEA–RXMS1
27A,B,C/TL237	VOLTAGE RELAY FOR TL202/6 AUTO RESTORATION		PANEL No. 10	B. BOV PB, 125 VDC

TL237 RECLOSER IND. TO ECC



43RX–1 UNLATCHED OR 43R OFF
TL237 RECLOSER OFF INDICATION TO ECC

BREAKER CONTROL SWITCH

B1L37–CS: TRIP / CLOSE

CONTACTS HANDLE END		POSITIONS		
		CLOSE	NORMAL	TRIP
1 1C 2C 2	1	X		
	2			X
3 3C 4C 4	3	X		
	4			X
5 5C 6C 6	1	X		
	2			X
7 7C 8C 8	3	X		
	4			X

TARGET TYPE WITH PISTOL GRIP HANDLE
SPRING RETURN TO NORMAL POSITION

RECLOSER SWITCH

43R: OFF / ON

CONTACTS HANDLE END		POSITION	
		ON	OFF
1 1C 2C 2	1		X
	2	X	
3 3C 4C 4	3		X
	4	X	
5 5C 6C 6	5		X
	6	X	
7 7C 8C 8	7		X
	8	X	

OVAL HANDLE
MAINTAINED CONTACTS

X CLOSED CONTACT

TRANSFER TRIP SWITCH

43TT: OFF / ON

CONTACTS HANDLE END		IND. POS. OFF	IND. POS. ON	FUNCTION
1 1C 2C 2	1		X	
	2	X		21P1 & DIRECT T.T. RECEIVED
3 3C 4C 4	3		X	
	4	X		PERM. T.T. SEND
5 5C 6C 6	5		X	
	6	X		21P2 T.T. RECEIVED
7 7C 8C 8	7		X	ALARM
	8	X		

OVAL HANDLE
MAINTAINED CONTACTS

X CLOSED CONTACT

NOTES :

1. BREAKER PRESSURE SWITCHES SHOWN AT NORMAL OPERATING PRESSURE.
2. ■ DENOTES TERMINALS AT OPTIMHO DISTANCE RELAY CASE

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO

DWG.NO.	TITLE
REFERENCE DRAWINGS	

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
33	07–07–12	REVISED AS BUILT	W.B.	F. REV.	RL	RL
32	01–11–03	TL237 BACKUP PROTECTION UPGRADE/AS BUILT	W.B.	AVL		
31	98–09–02	REVISED "AS BUILT" FOR DFR REPLACEMENT	W.B.			
30	97–11–06	TL202/6 AUTO RESTORATION ADDITIONS	G.E.M.			
29	95–03–31	SOE ADDITIONS	W.B.			
28	94–04–14	ANTI–PUMP/CLOSED ADDED TO B1L37/AS BUILT	W.B.			
27	93–09–18	RING BUS MODS 1	K.B.R.			

REVISIONS

ELECT.	SCALE: NONE
CIVIL	DESIGNED: J. FOLEY
TRANS.	DRAWN: D. MONTAGUE
MECH.	DATE: 1991–04–12
P&C	CHECKED:
TELC.	APPROVED:

NEWFOUNDLAND AND LABRADOR HYDRO

WESTERN AVALON TERMINAL STATION
230kV ABCB B1L37 CONTROL SCHEMATIC

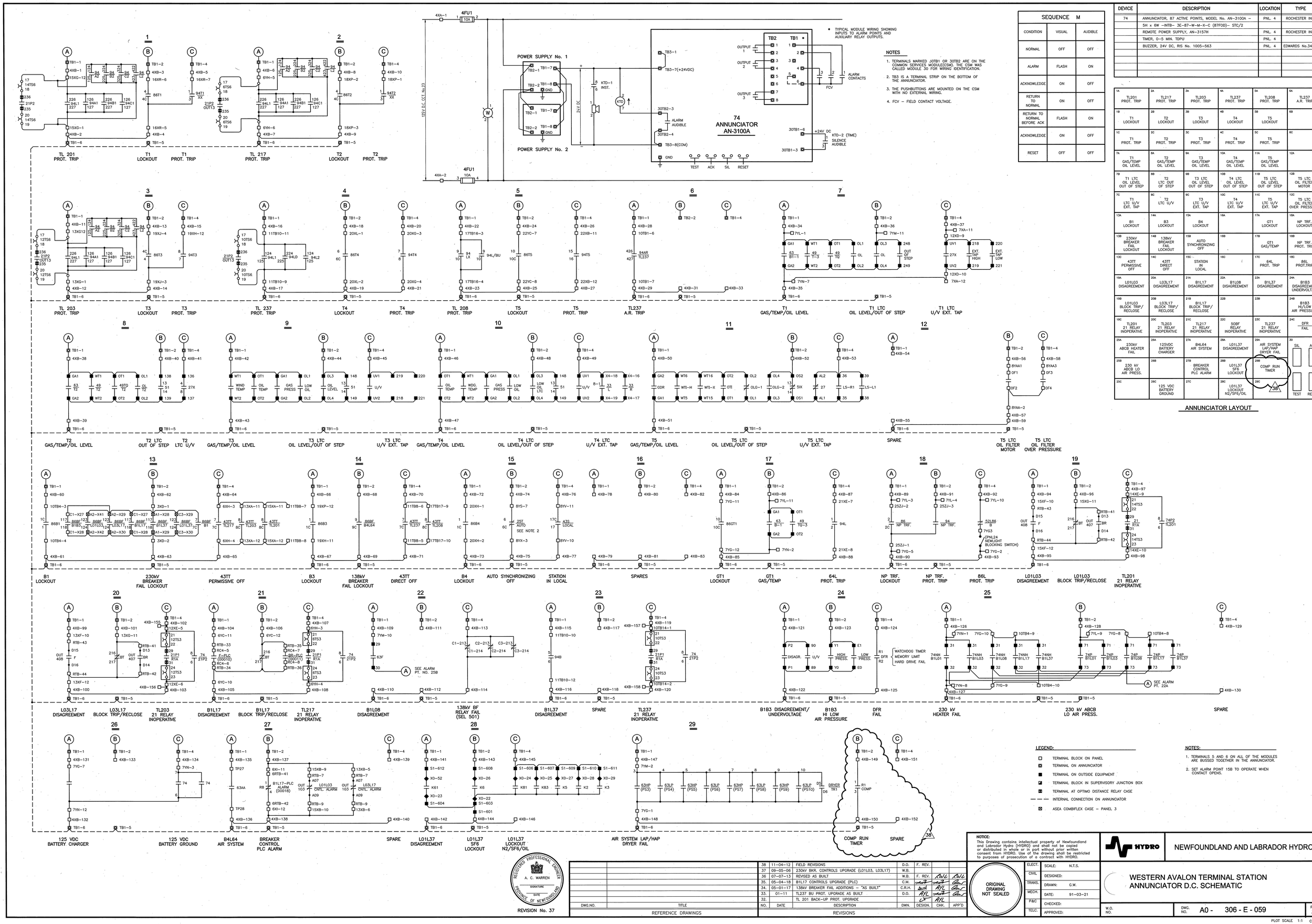
W.O. NO.

DWG. NO. B1- 306 - E - 018

REV. 33

PLOT SCALE 1:1 C.A.D.

Feb 05, 2008 – 4:02pm



SEQUENCE M		
CONDITION	VISUAL	AUDIBLE
NORMAL	OFF	OFF
ALARM	FLASH	ON
ACKNOWLEDGE	ON	OFF
RETURN TO NORMAL	ON	OFF
RETURN TO NORMAL BEFORE ACK	FLASH	ON
ACKNOWLEDGE	ON	OFF
RESET	OFF	OFF

NOTES

1. TERMINALS MARKED 30TB1 OR 30TB2 ARE ON THE COMMON SERVICES MODULE(CSM). THE CSM WAS CALLED MODULE 30 FOR WIRING IDENTIFICATION.
2. TB3 IS A TERMINAL STRIP ON THE BOTTOM OF THE ANNUNCIATOR.
3. THE PUSHBUTTONS ARE MOUNTED ON THE CSM WITH NO EXTERNAL WIRING.
4. FCV – FIELD CONTACT VOLTAGE.

DEVICE	DESCRIPTION	LOCATION	TYPE
74	ANNUNCIATOR, 87 ACTIVE POINTS, MODEL No. AN–3100A –	PNL. 4	ROCHESTER INST.
	5H x 6W –INTB– 3E–87–W–M–X–C (B7F0D)– STC/2		
	REMOTE POWER SUPPLY, AN–3157H	PNL. 4	ROCHESTER INST.
	TIMER, 0–5 MIN. TDPU	PNL. 4	
	BUZZER, 24V DC, RIS No. 1005–563	PNL. 4	EDWARDS No.343–A

1A TL201 PROT. TRIP	2A TL217 PROT. TRIP	3A TL203 PROT. TRIP	4A TL237 PROT. TRIP	5A TL208 PROT. TRIP	6A TL237 A.R. TRIP	
1B T1 LOCKOUT	2B T2 LOCKOUT	3B T3 LOCKOUT	4B T4 LOCKOUT	5B T5 LOCKOUT	6B	
1C T1 PROT. TRIP	2C T2 PROT. TRIP	3C T3 PROT. TRIP	4C T4 PROT. TRIP	5C T5 PROT. TRIP	6C	
7A T1 GAS/TEMP OIL LEVEL	8A T2 GAS/TEMP OIL LEVEL	9A T3 GAS/TEMP OIL LEVEL	10A T4 GAS/TEMP OIL LEVEL	11A T5 GAS/TEMP OIL LEVEL	12A	
7B T1 LTC OIL LEVEL OUT OF STEP	8B T2 LTC OUT OF STEP	9B T3 LTC OIL LEVEL OUT OF STEP	10B T4 LTC OIL LEVEL OUT OF STEP	11B T5 LTC OIL LEVEL OUT OF STEP	12B T5 LTC OIL FILTER MOTOR	
7C T1 LTC U/V EXT. TAP	8C T2 LTC U/V	9C T3 LTC U/V EXT. TAP	10C T4 LTC U/V EXT. TAP	11C T5 LTC U/V EXT. TAP	12C T5 LTC OIL FILTER OVER PRESSURE	
13A B1 LOCKOUT	14A B3 LOCKOUT	15A B4 LOCKOUT	16A	17A GT1 LOCKOUT	18A NP TRF. LOCKOUT	
13B 230kV BREAKER FAIL LOCKOUT	14B 138kV BREAKER FAIL LOCKOUT	15B AUTO SYNCHRONIZING OFF	16B	17B GT1 GAS/TEMP	18B NP TRF. PROT. TRIP	
13C 43TT PERMISSIVE OFF	14C 43TT DIRECT OFF	15C STATION IN LOCAL	16C	17C 64L PROT. TRIP	18C 86L PROT.TRIP	
19A L01L03 DISAGREEMENT	20A L03L17 DISAGREEMENT	21A B1L17 DISAGREEMENT	22A B1L08 DISAGREEMENT	23A B1L37 DISAGREEMENT	24A B1B3 DISAGREEMENT UNDERVOLTAGE	
19B L01L03 BLOCK TRIP/ RECLOSE	20B L03L17 BLOCK TRIP/ RECLOSE	21B B1L17 BLOCK TRIP/ RECLOSE	22B	23B	24B B1B3 HI/LOW AIR PRESSURE	
19C TL201 21 RELAY INOPERATIVE	20C TL203 21 RELAY INOPERATIVE	21C TL217 21 RELAY INOPERATIVE	22C 50BF RELAY INOPERATIVE	23C TL237 21 RELAY INOPERATIVE	24C DFR FAIL	
25A 230kV ABCB HEATER FAIL	26A 125VDC BATTERY CHARGER	27A B4L64 AIR SYSTEM	28A L01L37 DISAGREEMENT	29A AIR SYSTEM LAP/HAP DRYER FAIL	30 SIL ACK	
25B 230 kV ABCB LO AIR PRESS.	26B	27B BREAKER CONTROL PLC ALARM	28B L01L37 SF6 LOCKOUT	29B COMP RUN TIMER	TEST RESET	
25C	26C 125 VDC BATTERY GROUND	27C	28C L01L37 LOCKOUT N2/SF6/OIL	29C 38		

ANNUNCIATOR LAYOUT

LEGEND:

- TERMINAL BLOCK ON PANEL
- TERMINAL ON ANNUNCIATOR
- TERMINAL ON OUTSIDE EQUIPMENT
- TERMINAL BLOCK IN SUPERVISORY JUNCTION BOX
- TERMINAL AT OPTIMO DISTANCE RELAY CASE
- INTERNAL CONNECTION ON ANNUNCIATOR
- ASEA COMBIFLEX CASE – PANEL 3

NOTES:

1. TERMINALS 5 AND 6 ON ALL OF THE MODULES ARE BUSSED TOGETHER IN THE ANNUNCIATOR.
2. SET ALARM POINT 15B TO OPERATE WHEN CONTACT OPENS.

REVISION No. 37

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
38	11–04–12	FIELD REVISIONS	D.O.	F. REV.		
37	09–05–06	230kV BKR. CONTROLS UPGRADE (L01L03, L03L17)	W.B.			
36	07–07–13	REVISED AS BUILT	W.B.	F. REV.		
35.	05–04–18	B1L17 CONTROLS UPGRADE (PLC)	C.M.			
34.	05–01–17	138kV BREAKER FAIL ADDITIONS – "AS BUILT"	C.R.H.			
33.	01–11	TL237 BU PROT. UPGRADE AS BUILT	D.O.			
32.		TL 201 BACK–UP PROT. UPGRADE				

REVISIONS

REFERENCE DRAWINGS

DWG.NO. TITLE

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO.

ORIGINAL DRAWING NOT SEALED

HYDRO

NEWFOUNDLAND AND LABRADOR HYDRO

WESTERN AVALON TERMINAL STATION
ANNUNCIATOR D.C. SCHEMATIC

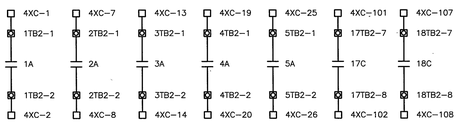
ELECT.	SCALE: N.T.S.
CIVIL	DESIGNED:
TRANS.	DRAWN: G.W.
MECH.	DATE: 91–03–21
P&C	CHECKED:
TELC.	APPROVED:

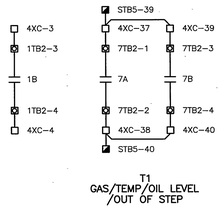
W.O. NO.

DWG. NO. A0 - 306 - E - 059

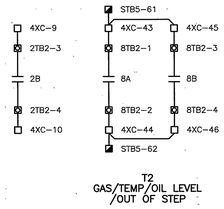
REV. 38

PLOT SCALE 1:1 C.A.D.

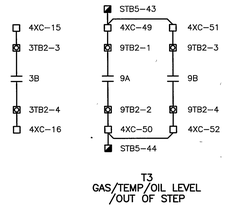




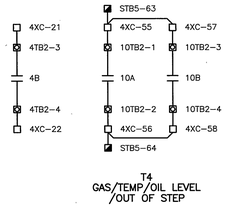
T1
GAS/TEMP/OIL LEVEL
/OUT OF STEP



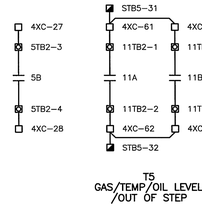
T2
GAS/TEMP/OIL LEVEL
/OUT OF STEP



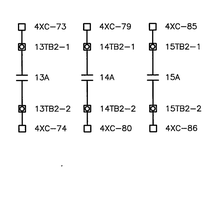
T3
GAS/TEMP/OIL LEVEL
/OUT OF STEP

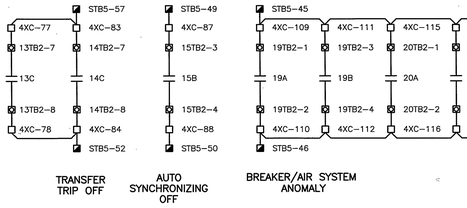


T4
GAS/TEMP/OIL LEVEL
/OUT OF STEP



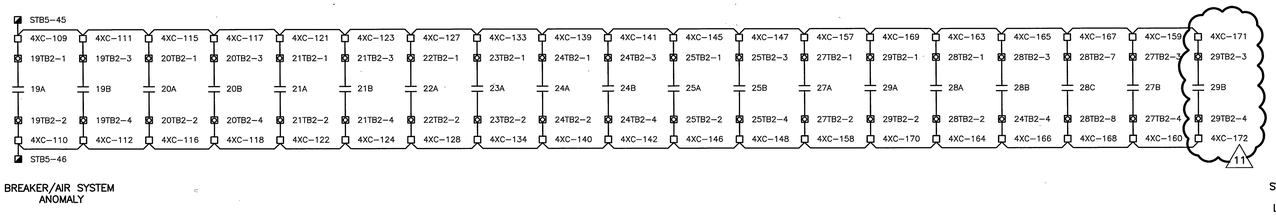
T5
GAS/TEMP/OIL LEVEL
/OUT OF STEP



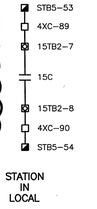


TRANSFER
TRIP OFF

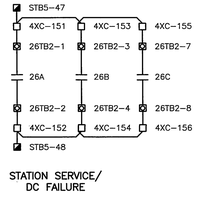
AUTO
SYNCHRONIZING
OFF



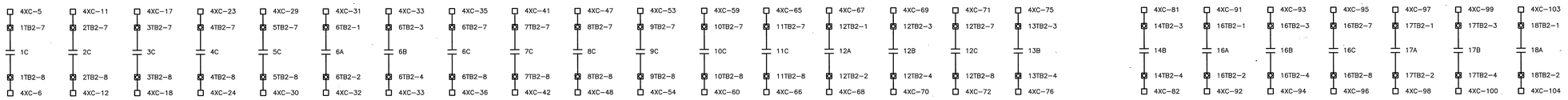
BREAKER/AIR SYSTEM
ANOMALY

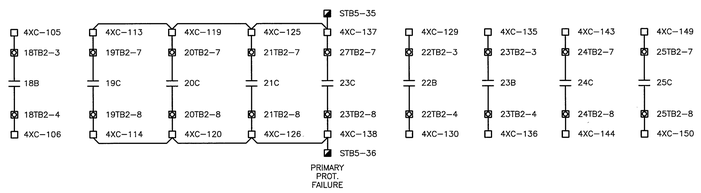


STATION
IN
LOCAL

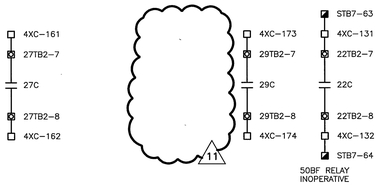


STATION SERVICE/
DC FAILURE





PRIMARY
PROT.
FAILURE



50BF RELAY
INOPERATIVE

POINT	ANNUNCIATOR POINT DESCRIPTION	SUPERVISORY ALARM DESCRIPTION
1A	TL 201 PROT. TRIP	
1B	T1 LOCKOUT	
1C	T1 PROT. TRIP	
2A	TL 217 PROT. TRIP	
2B	T2 LOCKOUT	
2C	T2 PROT. TRIP	
3A	TL 203 PROT. TRIP	
3B	T3 LOCKOUT	
3C	T3 PROT. TRIP	
4A	TL 237 PROT. TRIP	
4B	T4 LOCKOUT	
4C	T4 PROT. TRIP	
5A	TL 208 PROT. TRIP	
5B	T5 LOCKOUT	
5C	T5 PROT. TRIP	
6A	TL237 AR TRIP	
6B		
6C		
7A	T1 GAS/TEMP/OIL LEVEL	T1 GAS/TEMP/OIL LEVEL/OUT OF STEP
7B	T1 LTC OIL LEVEL/OUT OF STEP	T1 GAS/TEMP/OIL LEVEL/OUT OF STEP
7C	T1 LTC U/V EXT. TAP	–
8A	T2 GAS/TEMP/OIL LEVEL	T2 GAS/TEMP/OIL LEVEL/OUT OF STEP
8B	T2 LTC OUT OF STEP	T2 GAS/TEMP/OIL LEVEL/OUT OF STEP
8C	T2 LTC U/V	–
9A	T3 GAS/TEMP/OIL LEVEL	T3 GAS/TEMP/OIL LEVEL/OUT OF STEP
9B	T3 LTC OIL LEVEL/OUT OF STEP	T3 GAS/TEMP/OIL LEVEL/OUT OF STEP
9C	T3 LTC U/V, EXT. TAP	–
10A	T4 GAS/TEMP/OIL LEVEL	T4 GAS/TEMP/OIL LEVEL/OUT OF STEP
10B	T4 LTC OIL LEVEL/OUT OF STEP	T4 GAS/TEMP/OIL LEVEL/OUT OF STEP
10C	T4 LTC U/V, EXT. TAP	–
11A	T5 GAS/TEMP/OIL/ LEVEL	T5 GAS/TEMP/OIL LEVEL/OUT OF STEP
11B	T5 LTC OIL LEVEL/OUT OF STEP	T5 GAS/TEMP/OIL LEVEL/OUT OF STEP
11C	T5 LTC U/V, EXT. TAP	–
12A	SPARE	
12B	SPARE	–
12C	SPARE	–
13A	B1 LOCKOUT	
13B	BREAKER FAIL LOCKOUT	–
13C	43TT PERMISSIVE OFF	–
14A	B3 LOCKOUT	
14B	SERVICE RESTORER LOCKOUT	–
14C	43TT DIRECT OFF	TRANSFER TRIP OFF
15A	B4 LOCKOUT	
15B	AUTO SYNCHRONIZING OFF	AUTO SYNCHRONIZING OFF
15C	STATION IN LOCAL	STATION IN LOCAL
16A	SPARE	–
16B	SPARE	–
16C	SPARE	–
17A	GT1 LOCKOUT	–
17B	GT1 GAS/TEMP	–
17C	64L PROT. TRIP	
18A	NP TRF. LOCKOUT	–
18B	NP TRF. PROT. TRIP	–
18C	86L PROT. TRIP	
19A	L01L03 DISAGREEMENT	BREAKER/AIR SYSTEM ANOMALY
19B	L01L03 BLOCK TRIP/RECLOSE	BREAKER/AIR SYSTEM ANOMALY
19C	TL201 RELAY 21 INOPERATIVE	PRIMARY PROTECTION FAILURE
20A	L03L17 DISAGREEMENT	BREAKER/AIR SYSTEM ANOMALY
20B	L03L17 BLOCK TRIP/RECLOSE	BREAKER/AIR SYSTEM ANOMALY
20C	TL203 RELAY 21 INOPERATIVE	PRIMARY PROTECTION FAILURE
21A	B1L17 DISAGREEMENT	BREAKER/AIR SYSTEM ANOMALY
21B	B1L17 BLOCK TRIP/RECLOSE	BREAKER/AIR SYSTEM ANOMALY
21C	TL217 RELAY 21 INOPERATIVE	PRIMARY PROTECTION FAILURE
22A	B1L08 DISAGREEMENT	BREAKER/AIR SYSTEM ANOMALY
22B	SPARE	–
22C	SPARE	–
23A	B1L37 DISAGREEMENT	BREAKER/AIR SYSTEM ANOMALY
23B	SPARE	–
23C	TL237 RELAY 21 INOPERATIVE	PRIMARY PROTECTION FAILURE
24A	B1B3 DISAGREEMENT, UNDERVOLTAGE	BREAKER/AIR SYSTEM ANOMALY
24B	B1B3 HI/LOW AIR PRESSURE	BREAKER/AIR SYSTEM ANOMALY
24C	HATHAWAY RECORDER	–
25A	230KV ABCB HEATER FAIL	BREAKER/AIR SYSTEM ANOMALY
25B	230KV ABCB LO AIR PRESS.	BREAKER/AIR SYSTEM ANOMALY
25C	SPARE	–
26A	125VDC BATTERY CHARGER	STATION SERVICE/DC FAILURE
26B	125V DC CB OPEN	STATION SERVICE/DC FAILURE
26C	125V DC BATTERY GROUND	STATION SERVICE/DC FAILURE
27A	B4L64 AIR SYSTEM	BREAKER/AIR SYSTEM ANOMALY
27B	BREAKER CONTROL PLC ALARM	BREAKER/AIR SYSTEM ANOMALY
27C	SPARE	–
28A	L01L37 DISAGREEMENT	–
28B	L01L37 SF6 LOCKOUT	–
28C	L01L37 N2/SF6/OIL LOCKOUT	–
29A	AIR SYSTEM LAP/HAP DRYER FAIL	BREAKER/AIR SYSTEM ANOMALY
11 29B	COMP RUN TIMER	BREAKER/AIR SYSTEM ANOMALY
29C		

L E G E N D :

- ◪ — TERMINAL BLOCK IN SUPERVISORY JUNCTION BOX
- □ — TERMINAL BLOCK ON CONTROL PANEL
- ⊠ — TERMINAL ON BACK OF ANNUNCIATOR

REGISTERED PROFESSIONAL ENGINEER
A. C. WARREN
SIGNATURE
DATE
PROVINCE OF NEWFOUNDLAND

REVISION No. 10

NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D
11	11-04-12	FIELD REVISIONS	D.O.	F. REV.		
10	09-05-14	230kV BKR. CONTROLS UPGRADE (L01L03, L03L17)	W.B.			
9	05-04-19	B1L17 CONTROLS UPGRADE (PLC)	C.M.			
8	00-05-27	REVISED "AS BUILT"	G.W.			
7	00-05-27	TL203 & TL217 BACKUP PROTECTION MOD.	G.W.			
6	95-04-06	REMOVED REM. LOCKOUT & LINE PROT. TRIPS (SOE)	W.B.			
5	94-05-05	AS BUILT	W.B.			

REVISIONS

DWG.NO.	TITLE
A0-306-E-69	ANNUNCIATOR PANEL NO. 4 WIRING DIAGRAM
A0-306-E-67	SUPERVISORY JUNCTION BOX WIRING DIAGRAM

REFERENCE DRAWINGS

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO.

ORIGINAL
DRAWING
NOT SEALED

ELECT.	SCALE:	N.T.S.
CIVIL	DESIGNED:	R.L.
TRANS.	DRAWN:	W.B.
MECH.	DATE:	1991-03-01
P&C	CHECKED:	
TELC.	APPROVED:	

HYDRO

NEWFOUNDLAND AND LABRADOR HYDRO

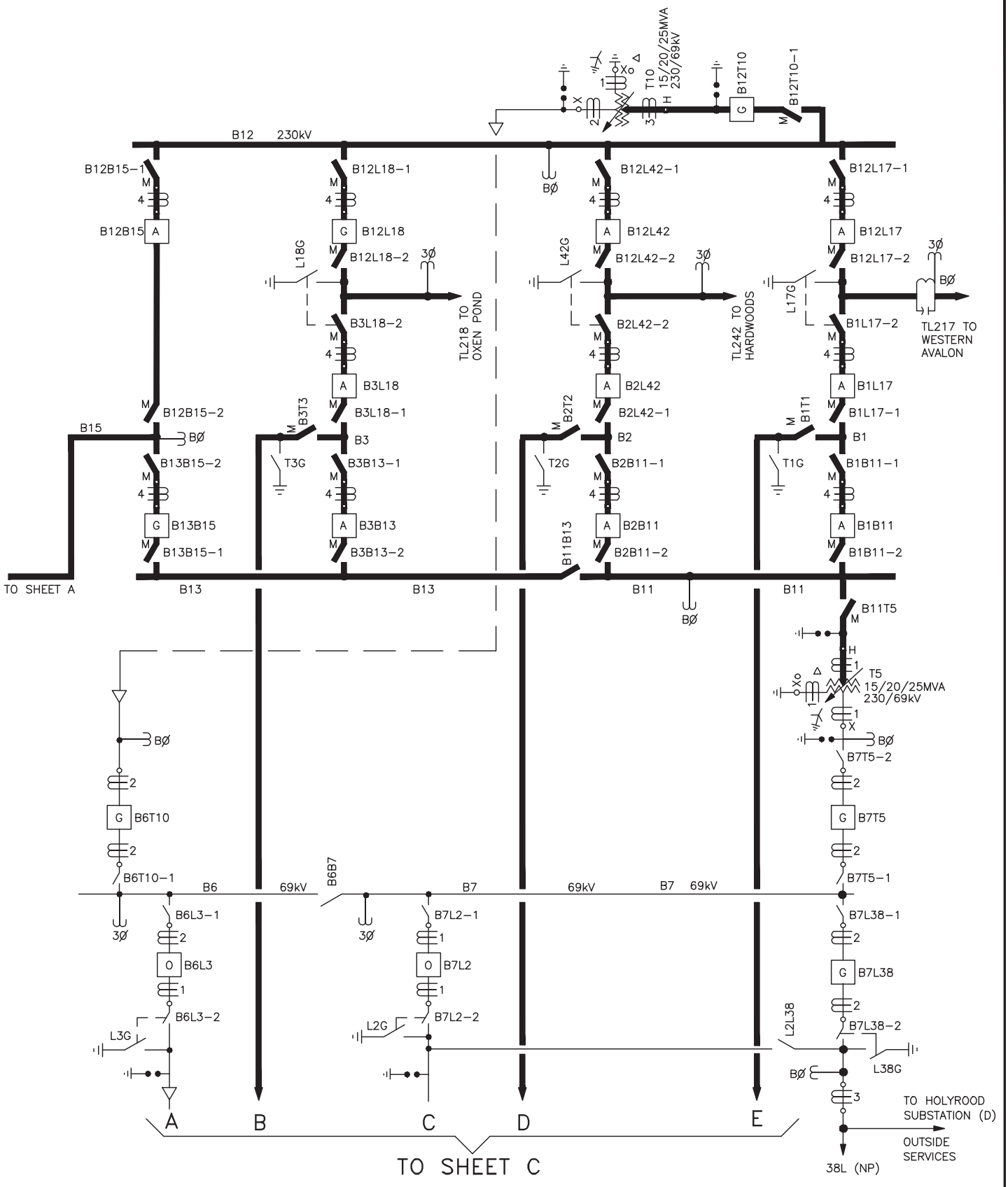
WESTERN AVALON TERMINAL STATION ANNUNCIATOR REMOTE AUXILIARY CONTACTS GROUPING SCHEMATIC

W.O. NO.

DWG. NO. B1- 306 - E - 127

REV. 11

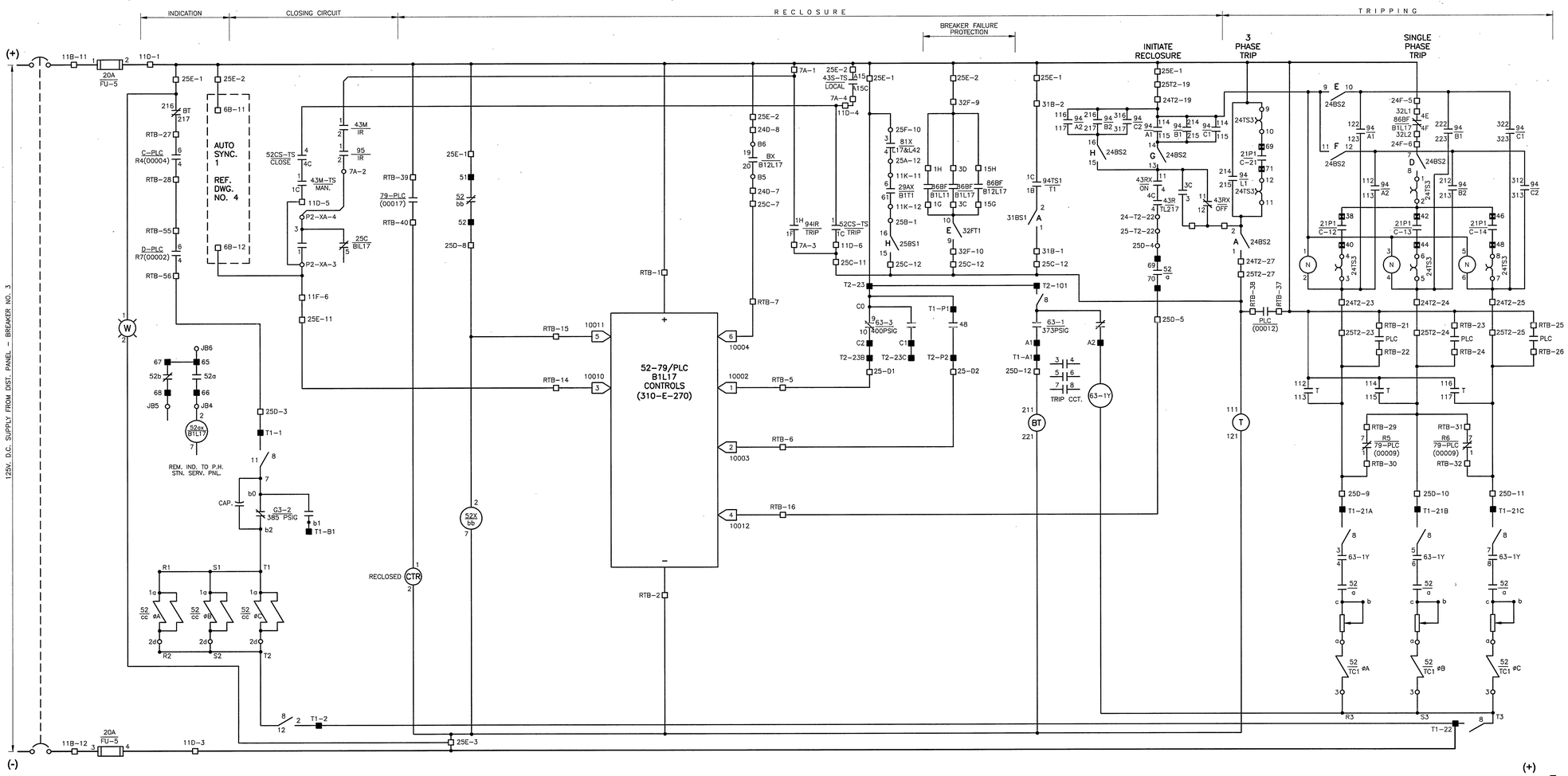
PLOT SCALE 1:1 C.A.D.

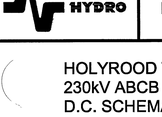


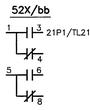
DRAWN BY: J.T.	REVISED BY: D.R.	NEWFOUNDLAND AND LABRADOR HYDRO	DWG. NO. HRD–B
APPROVED BY: D. KING		SYSTEM OPERATING DIAGRAM HOLYROOD TERMINAL STATION (B)	REV. NO. 11
DATE: 2013/11/22			

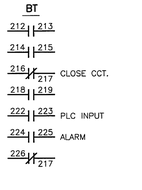
BREAKER NO. B1L17

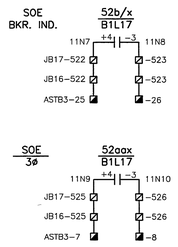
DEVICE	DESCRIPTION	LOCATION	TYPE
T	3 PHASE TRIP AUX. RELAY	PNL. 25	ABB RXMS1
KI	KIRK INTERLOCK	230kV BKR.	
81X	OVER FREQUENCY AUX. RELAY	PNL. 25	B.B.–P8
43R	RECLOSE "OFF & ON SWITCH"	PNL. 11	S.B.M.
43S	SUPERVISORY TRANSFER SWITCH	PNL. 7	
52CS	BREAKER CONTROL SWITCH	PNL. 11	EXTRA STAGE
86	BKR. FAILURE PROT. LOCKOUT RELAY REFER TO 310–E–18	PNL. 32	
FC	FORCE CLOSE AUX. RELAY	BKR. CAB.	
LC	LOW PRESS. BLOCKING RELAY, TRIP & CLOSE	BKR. CAB.	
BT	BLOCK TRIP RELAY	PNL. 25	ABB RXMA1
RE–1	52CS LOCATED IN GEN. STATION		
RE–2	52CS LOCATED IN BAY D'ESPOIR		
CTR	COUNTER FOR SINGLE PHASE	PNL. 24	4Y9434–PS
UT–1	GENERATOR UNIT TRANSFORMER NO. 1		SBM10AA106 &
T–2	TIME RELAY	PNL. 24	ASEA–RRKN
94A,B,C(1,2)	PHASE TRIP RELAY	PNL. 24	ABB–RXMS–1
94L(1,2)	LOCKOUT TRIP RELAY	PNL. 24	ABB–RXMS–1
TS	INDICATES EQUIPMENT LOCATED IN TERMINAL STATION		
P	INDICATES EQUIPMENT LOCATED IN POWERHOUSE		
IR	INTERPOSING RELAY	PNL. 7	CR120A
25C/B1L17	SYNCH. CHECK RELAY FOR MANUAL SYNCH.	PNL. 2	GEC MAVSO3
63–1Y	BLOCK TRIP AUX. RELAY	230kV BKR.	P8 a x m.
52bx1	AUX. TRIP RELAY FOR BREAKER OPEN	PNL. 11	P&B KRPA–11DC
21P2	LINE PROT. DISTANCE RELAY – PRIMARY # 2	PNL. 24	SEL 321–1
52–79/PLC	PROGRAMMABLE LOGIC CONTROLLER (BKR. CONTROL)	PNL. 25	COMPACT 984











BIL17 52CS–TS

TRIP CLOSE

BREAKER CONTROL SWITCH

CONTACTS HANDLE END		IND. POS. CLOSE	NOR.	TRIP	FUNCTION
1C 2C	1			X	TRIP
	2			X	
3C 4C	3		X	X	25X
	4	X			CLOSE
5C 6C	5	X	X		25X
	6	X	X		
7C 8C	7	X			25X
	8				

RECL. SEL. SW.

OFF ON

RECLOSER SWITCH

CONTACTS HANDLE END		IND. POS. ON	OFF
1C 1C	1		X
2C 2C	2	X	
3C 3C	3		X
4C 4C	4	X	
5C 5C	5		X
6C 6C	6	X	
7C 7C	7		X
8C 8C	8	X	

OVAL HANDLE
MAINTAINED CONTACTS

NOTE:

1. ABCB IS SHOWN IN OPEN POSITION AND AT NORMAL PRESSURE (426 PSIG) WITH D.C. SUPPLY CIRCUIT SWITCHED OFF.

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO

HYDRO

NEWFOUNDLAND AND LABRADOR HYDRO

HOLYROOD TERMINAL STATION
230kV ABCB B1L17 CONTROL
D.C. SCHEMATIC DIAGRAM

REFERENCE DRAWINGS		REVISIONS						
		24	07–07–25	REVISED AS BUILT	W.B.	F. REV.		
		23	05–04–20	B1L17 CONTROLS UPGRADE (PLC). AS BUILT	D.O.	—		
310–E–198	BREAKER FAILURE PROTECTION DIA.	22.	05–02–08	REVISED "AS BUILT"	C.R.H.			
310–E–188	125V D.C. DISTRIBUTION SCHEMATIC	21	03–04–04	REVISED AS BUILT (LINE SWAP)	D.O.	A/L	BTB	
310–E–191	SYNCHRONIZING D.C. SCHEMATIC DIAGRAM	20	00–10–02	TL217 21P2 ADDED. AS BUILT	D.O.	A/L	LT	
310–E–29	ANNUNCIATOR SCHEMATIC DIAGRAM	19	97–03–20	REVISED AS BUILT	W.B.			
310–E–207	REL. & MET. SINGLE LINE DIAGRAM	18	95–11–02	SOE ADDITIONS & TRIP COIL 2	W.B.			
DWG.NO.	TITLE	NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D

ORIGINAL DRAWING NOT SEALED

ELECT.	SCALE: N.T.S.
CIVIL	DESIGNED:
TRANS.	DRAWN: C. R. HARNUM
MECH.	DATE: 1992–01–22
P&C	CHECKED:
TELC.	APPROVED:

W.O. NO.

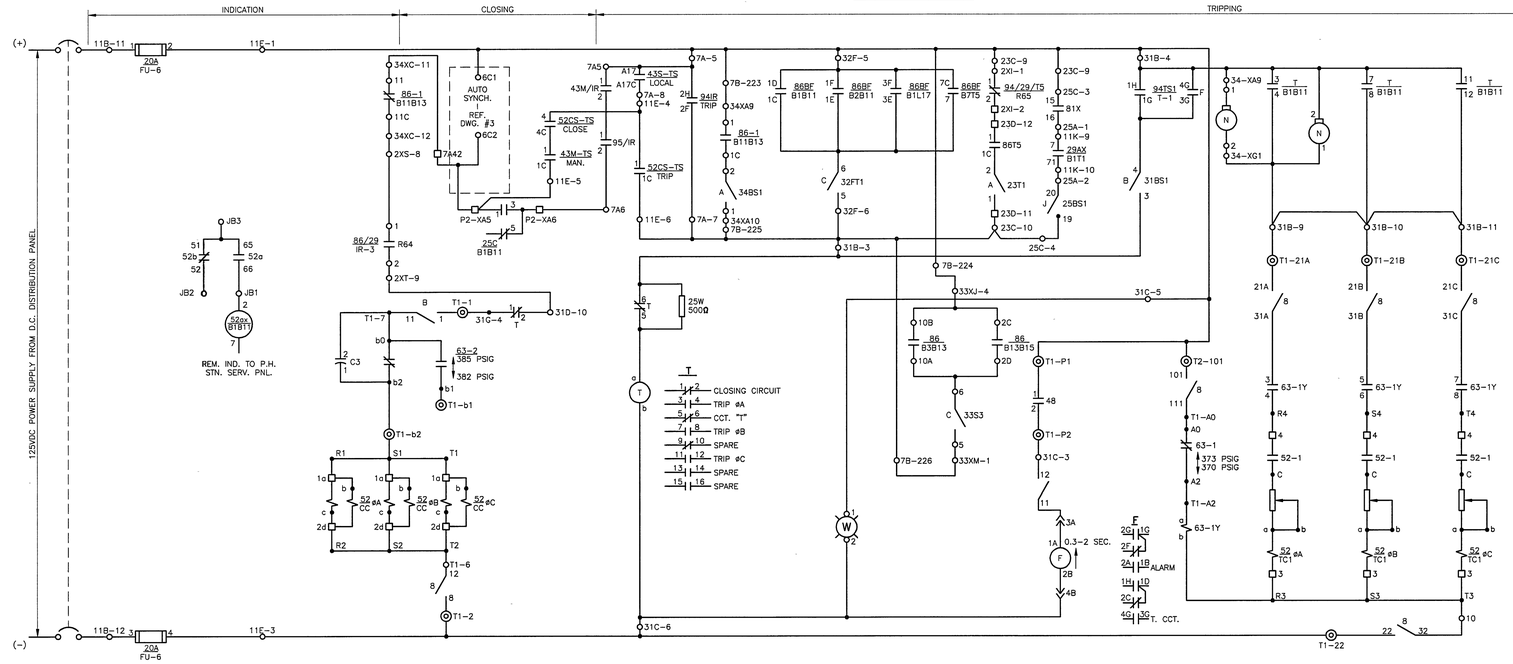
DWG. NO. B1- 310 - E - 034

REV. 24

PLOT SCALE 1:1 C.A.D.

Jul 25, 2007 – 9.08am

BKR. NO. B1B11

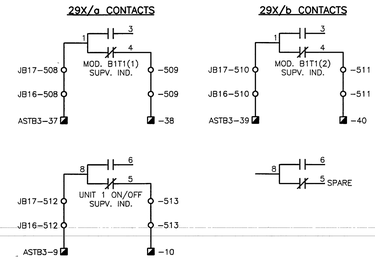


DEVICE	DESCRIPTION	LOCATION	TYPE
F.C.	FORCE CLOSE AUX. RELAY		
K.I.	KIRK INTERLOCK	230kV BKR.	
T	3 PHASE AUX. TRIP RELAY	PNL. 31	B.B.–PB
.5	M.O.D. SPEED SWITCH FOR BRACKING	M.O.D. B1T1	
29 OPEN/CLOSE	M.O. DISC SWITCH OPERATING COILS	M.O.D. B1T1	
L.S.	M.O. DISC LIMIT SWITCHES	M.O.D. B1T1	
43ES	LOCAL TRANSFER SWITCH	M.O.D. B1T1	
43S–TS	SUPERVISORY TRANSFER SWITCH "TERMINAL STA."	PNL. 7	
50–51TS T1	TRF. OVERCURRENT STBY. PROT. RELAY	PNL. 31	IAC 53
F	DISAGREEMENT TRIP RELAY	PNL. 31	AESA RRKH 23
FX	DISAGREEMENT AUX. TRIP RELAY	PNL. 31	ASEA RRMH–2(2306)
52 a–b	BREAKER AUX. CONTACTS	230kV BKR.	
52 C.C.	BREAKER CLOSING COILS	230kV BKR.	
52 TC1	BREAKER TRIPPING COILS	230kV BKR.	
52C–1 TC	BREAKER AUX. TRIPPING COILS "NOT USED"	230kV BKR.	
52ELCS	BREAKER CONTROL SWITCH "LOCAL"	230kV BKR.	SBM
52CS–TS	BREAKER CONTROL SWITCH "TERMINAL STA."	PNL. 11	SBM
52/aX	BREAKER IND. AUX. RELAY	PNL. 11	P&B KRPA
52/TC2	BREAKER 2ND TRIP COIL		BBC
63 O.P.	PRESSURE SWITCH "LOCKOUT CONTACTOR"	230kV BKR.	
81X	OVER FREQUENCY AUX. RELAY	PNL. 25	B.B.–PB
84/29 IR–1, –3	CLOSING COIL LOCKOUT RELAY – ALLAN BRADLEY	PNL. 2	700DC–N400
86/B11B13	BUS B11B13 PROT. LOCKOUT RELAY – CGE	PNL. 34	HEA 61C
86T	TRF. LOCKOUT TRIP RELAY	P.H.	GE HEA
86 BKR. NO.	BREAKER FAILURE PROTECTION LOCKOUT RELAY – ASEA	PNLS. 32,33	RRMVB–4 RRMVB–2
25C/B1B11	SYNCH. CHECK RELAY FOR MAN. SYNCH.	PNL. 2	GEC. MAVS03
94–TS	PHASE TRIP RELAY "TERMINAL STA."	PNL. 31	ASEA RRMS–2(2606)
94 IR	INTERPOSING TRIP RELAYS	PNL. 7	A.B.
95 IR	INTERPOSING CLOSE RELAYS	PNL. 7	A.B.
48	DISAGREEMENT TRIP RELAY	230kV BKR.	
63–1	PRESSURE SWITCH INTERLOCK FOR TRIPPING CCT.	230kV BKR.	
63–2	PRESSURE SWITCH INTERLOCK FOR CLOSING CCT.	230kV BKR.	
63–1Y	AUXILIARY RELAY FOR 63–1	230kV BKR.	
29AX	AUXILIARY RELAY FOR AUX. CONTACTS	PNL. 11	AGASTAT GPD

2ND TRIP COIL CCT.

29 B1T1 AUX. CONTACTS (OPEN POS.)

CONTACTS	FUNCTION	
G G1	IND. LIGHT (GREEN) TS	DWG. NO. 310–E–035
R R1	IND. LIGHT (RED) TS	
1 2	IND (G) PH	
3 4	IND (R) PH	
5 6	SYNC. AC CKT. B11	B1L17 DWG. NO. 310–E–192
7 8	SYNC. AC CKT. G1	
9 10	SYNC. AC CKT. L17	B1B11 DWG. NO. 310–E–192
11 12	SYNC. AC CKT. G1	
13 14	D.C. AUTO SYNC UNIT 1	DWG. NO. 550–E–008
15 16	P/U 29AX P.H.	DWG. NO. 310–E–191
17 18	D.C. AUTO SYNC UNIT 1	DWG. NO. 550–E–008
O1 S	OPEN LIMIT B1T1	DWG. NO. 310–E–035
C1 S	CLOSE LIMIT B1T1	



BREAKER CONTROL SWITCH

CONTACTS HANDLE END		POSITION			
		CLOSE	NORMAL		TRIP
1 1C 2C 2	1				X
	2				X
3 3C 4C 4	3		X	X	
	4	X			
5 5C 6C 6	5	X	X		
	6	X	X		
7 7C 8C 8	7	X			
	8	X			

TARGET TYPE WITH PISTOL GRIP HANDLE SPRING RETURN TO NORMAL POSITION

NOTES:

1. ◎ DENOTES TERMINALS ON ABCB.
2. BREAKER IS SHOWN IN OPEN POSITION AND NORMAL AIR PRESSURE (426 psig) WITH D.C. SUPPLY OFF.
3. ⊠ TERMINAL IN SUPERVISORY JUNCTION BOX.
4. ◪ AGC SUPERVISORY JUNCTION BOX IN POWERHOUSE.

NOTICE:
This Drawing contains intellectual property of Newfoundland and Labrador Hydro (HYDRO) and shall not be copied or distributed in whole or in part without prior written consent from HYDRO. Use of the drawing shall be restricted to purposes of prosecution of a contract with HYDRO

WAS ORIGINALLY SIGNED BY R.M. JOST FEB. 19, 1969

REFERENCE DRAWINGS			REVISIONS					
DWG.NO.	TITLE	NO.	DATE	DESCRIPTION	DWN.	DESIGN.	CHK.	APP'D.
310–E–38	230/69kV T5 D.C. SCHEMATIC & B11T5	24.	05–02–08	REVISED"AS BUILT"	C.R.H.	FW/KeL	AYL	AYL
310–E–114	230/138kV T6 A.C., D.C. SCHEMATIC	23	03–04–04	REVISED AS BUILT	D.O.		AYL	Clear
310–E–205	BUS B11B13 A.C., D.C. SCHEMATIC	22	97–03–20	REVISED AS BUILT	W.B.			
310–E–203	T1,T2,T3 TRANSFORMER BACKUP PROT.	21	96–02–01	AS BUILT & REDRAWN ON CAD	C.M.			
310–E–191	SYNCHRONIZING D.C. SCHEMATIC	20	92–07–16	ADD 2ND TRIP COILS				
310–E–188	125V D.C. DISTRIBUTION SCHEMATIC	19	92–01–10	T10 EXT., EMS, TL217 PROT. MOD.	C.R.H.			
310–E–207	RELAYING & METERING SINGLE LINE	18	90–10–20	T10 ADDITION	D.C.M.			

HYDRO — NEWFOUNDLAND AND LABRADOR HYDRO

HOLYROOD TERMINAL STATION
230kV ABCB #B1B11 & MOD. #B1T1
CONTROL D.C. SCHEMATIC DIAGRAM

ELECT.	SCALE: N.T.S.		
CIVIL	DESIGNED:		
TRANS.	DRAWN: C. MURPHY		
MECH.	DATE: 1996–01–29		
P&C	CHECKED:		
TELC.	APPROVED:		

W.O. NO.

DWG. NO. B1- 310 - E - 35

REV. 24.

PLOT SCALE 1:1 C.A.D.

Feb 08, 2005 – 1 34pm

Verbal Safety Talk _____

THINK SAFETY FIRST

WO TYPE : 2 PM Wo SSDTS,T1,XFMR PM MTNCE PARENT #: 00601395
STATUS : 45 PRIORITY: 3 Plann
ITEM # : 00005810 UNIT #: SSDT1 TRANSFORMER T1,SSD TS
PLT COND: SD B.U. #: 1325 SUPV: WHB Station Mtce Dept
LOCN: SSDTS SSD Term Stn, Sunnyside ORIG: Lyver, Gerard J.
W/H : 1829 Bishop Falls Warehouse PLNR: Lyver, Gerard J.
EMPL: W.O.#: 601395 W.O. SUBCODE: PMN

--- Full Description of Request ----------

1. PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK SHEET.
2. RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK ORDER REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A LATER DATE.
3. CONSIDER & REPORT ANY ENVIROMENTAL IMPACTS.

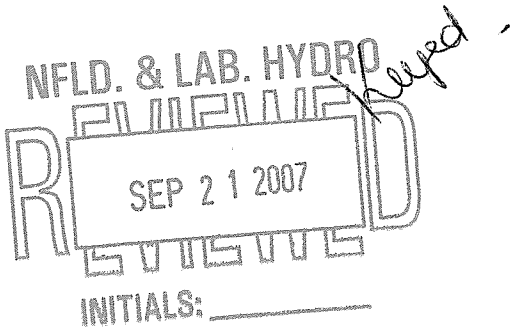
OP#	CRAFT	DESCRIPTION	SIZE	MHRS
1.00	WHBCRSEM	WHB ELEC Term. Stn Mtce. Crew	2.0	
2.00	WHBCRTM	WHB Term. Stn Mtce	1.0	

--- Safety Provisions ----------

1. ENSURE NECESSARY WORK PROTECTION IS IN PLACE BEFORE STARTING WORK.
2. COMPLETE TAILBOARD SAFETY TALK BEFORE BEGINNING WORK.

--- Maintenance Loops ----------

00005810 TRANSFORMER T1,SSD TS Y06A



T A I L B O A R D S A F E T Y T A L K
RISK ASSESSMENT

FORM # 30-0266

REV. DATE 06/05/01

TASK PM T1 @ SSD T.S.

PEOPLE: (Have I/We Considered)

Crew members know who is in charge?
How missing crew members will be briefed?
Workers capabilities adequate?
Other work groups/general public that may affect this work?
Personal Protective Equipment?
Hazards within the work area?

HARDWARE/EQUIP: (Have I/We Considered)

Safe working loads/rigging?
Tool conditions/adequacy?
Climbing hazards?
Temporary support of structure?
Equipment pre-use checks?
Communications?

PROCEDURES: (Have I/We Considered)

Scope of work?
The work method?
Work Protections/Hold-Off/Special Permits?
Limits of approach?(_____)
Back feeds?
Temporary grounding?
Test for isolation?
Fall Arrest?
Controlled products/data sheets?
Transportation of Dangerous Goods?
Confined space entry?
Rescue methods?
Cover up required?
Applicable engineering standards?

ENVIRO/OTHER: (Have I/We Considered)

Overhead power line hazards?
Underground uitlities?
Trenching/excavation hazards?
Traffic control/barricades/signs?
Weather conditions?
Hazardous products spills?
Terrain?
Deteriorated Plant?
ENV SOP's?
Other?_____

PARTICIPANTS:

W. Downing
S. Tucker

HAZARDS IDENTIFIED	CONTROLS
Falling	PPE
Cherry picker	Care & caution

(use back if necessary)

Supervisor/Lead Hand/Worker

2007/09/04
Date

FORM II - TRANSFORMER MAINTENANCE HISTORY

System ID: Station:Serial No.: T1 SSDTS # 289147
Manufacturer: Type: M.V.A:
Test Date: 2007/09/05 Test Completed By: WM/ST J.D.E. W/O #: _____

NOTE: All TESTS MUST BE COMPLETED OR MARKED N/A (unless otherwise Instructed).

☐ ☐ ☐

WEATHER CONDITIONS: dry: rain: humidity: ambient temperature: ^{0}C 15

DIELECTRIC OIL TEST ASTM D-1816 (kV): Conservator Main Tank: 40 Conservator Diverter Switches: –
Diverter Switch # 1 _____ Diverter Switch # 2 ____ Diverter switch # 3 _____ Transformer main tank 45

WINDING TEMP RELAY: (Check if Applicable)					
First Stage Fans: Setting: ____ °C	Found	75	°C	Left 75	°C
Second Stage Fans: Setting: ____ °C	Found	80	°C	Left 80	°C
Alarm: Setting: ____ °C	Found	105	°C	Left 105	°C
Trip: Setting: ____ °C	Found	120	°C	Left 120	°C

LIQUID TEMP RELAY: (Check if Applicable)					
Alarm: Setting: ____ °C	Found	90	°C	Left 90	°C
Trip: Setting: ____ °C	Found	/	°C	Left /	°C

FAULT PRESSURE RELAY: (GAS DETECTOR) Main Tank					
Alarm:	Found	200	(cc)	Left 200	(cc)
Trip;	Found	OK	(kpa)	Left OK	(kpa)

FAULT PRESSURE RELAY: (IN LINE GAS DETECTOR) diverter Switches (Check if Applicable)
(Function test Control Circuits) Tested OK ____ N/A ____ NA

FAULT PRESSURE RELEASE RELAYS: (Function test Control Circuit if Applicable)
Main Tank: Tested Ok ____ N/A ✓

Diverter Sw: A ph:Tested OK ✓ N/A ____	**Diverter Sw: B ph:Tested OK ✓ N/A ____**	**Diverter Sw: C ph:Tested OK ✓ N/A ____**

CONSERVATOR MAIN TANK: (Function Test Low-level Alarm) OK ✓
CONSERVATOR DIVERTER SWITCHES: (Function Test Low level Alarm) OK ✓

RESISTANCE CHECKS: (including Wiring to Terminal Boards) **500 Volt Test**
Test & record in Mega Ohms or N/A

	Line 1 – Line 2	Line 1 / 2 - GND		Line 1 – Line 2	Line 1 / 2 GND
Winding Temp Relay: **Alarm**	80 mΩ	80 mΩ	**Trip**	95 mΩ	105 mΩ
Liquid Temp Relay: **Alarm**	1064 mΩ		**Trip**		

FORM II - TRANSFORMER MAINTENANCE HISTORY

2.28
3.46

System ID: Station:Serial No.:
Manufacturer: Type: M.V.A:
Test Date: 2007/09/05 Test Completed By: GH J.D.E. W/O #:

Y - HL Grounded	1 min - 1.84	10 min 5.95	3.18 %
~~[redacted]~~	1 min	10 min	
~~T-HG~~	1 Min. Mega Ω	10 Min. Mega Ω	Index. %
HL-G Y Grounded Tert - Grounded	1 Min. 2.28 Mega Ω	10 Min. 3.46 Mega Ω	Index. 1.52 %

CORE GROUND: (500 Volt test)	
Externally Connected Yes ____ No ____	
RESISTOR: (Ohms)	CORE GROUND: (Mega Ohms)

Cabinet Heater - 2.1 Amp.

RUST/PAINT CONDITION (A - Minor , B – Moderate , C – Severe)

MAIN TANK:	B good condition	RADIATORS:	B - good condition
CONTROL CABINET:	B good condition	OTHER:	—

CHECKS COMPLETED:

- ✓ Check Explosion Vent
- ✓ Check HV & LV Connections
- ✓ Ladder Guards
- Check porcelain insulators for chips or cracks
- ✓ Manually Operate Fans
- n/a Check Oil Filtering Unit (type 51) { check Oil Pressure gauge } Replace Filter if Required (Pumps Located on BBKTS T3, HRDTS T8 & WAVTS T5 ONLY)
- Silica Gel Checked replace if 50% or more Contaimated
- Silica Gel Replaced NO
- Visual Check For Dirty Insulators & Clean if required ✓
- Check ConservatorTanks For Water, Drain if Necessary

CHECKS COMPLETED ONLY IF INSTRUCTED:

- Obtain Gas Analysis Sample
- Transformer Ratio Readings (Form III)
- Capacitive Bridge Testing
- ✓ Doble Test

COMMENTS: Ladder door needs new Hinges — " compl "

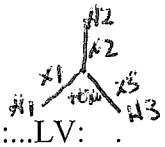
Auto. Transformer - 230 K.V. - 138 K.V - Tert. winding 6.9 K.

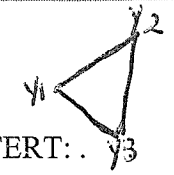
System ID: Station:Serial No.:
Manufacturer: Type: M.V.A:
Test Date: _____ Test Completed By: ___ J.D.E. W/O #: _____

FORM IV – TRANSFORMER WINDING RESISTANCE

System ID: T1 Station: 5075 Serial No: 289147 Manufacture: CGE
Type: OLTC ✓ TC ____ High voltage 230 KV Low Voltage 138 KV Tester Serial No: ____
Test Date: 2007 08 08 Test Completed By: JW WD J.D.E. W/O #:

VECTORS: HV:...LV: . . . TERT: . . .





NOTE: 1. Complete Winding Resistance Test on Tap Position **Found**.
2. Complete Winding Resistance Test on Maximum Tap Position **Raise**.
3. Complete Winding Resistance Test on Maximum Tap Position **Lower**.
4. Confirm Mechanical Center (Off Load Tap Changers).
5. Complete Winding Resistance Test on Tap Position **Left**.

TAP CHANGER LOCATION: HV _____ LV _____

TAP POSITION	WINDING TESTED	CURRENT RANGE	RESISTANCE RANGE	% CURRENT	RESISTANCE	RESISTANCE DELTA x 1.5
Found 6	6 Ø A	500mA	2	106.6%	.405	
Found 6	6 Ø B	500mA	2	106.5%	.442	
Found 6	6 Ø C	500mA	2	106.6%	.412	
Max. Raise 17	Ø A	500mA	2	106.4	.485	
Max. Raise 17	Ø B	500 mA	2	106.5%	.461	
Max. Raise 17	Ø C	500mA	2	x 106.5%	.464	
Max. Lower 1	Ø A	500mA	2	* 106.4%	.452	
Max. Lower 1	Ø B	500mA	2	106.4%	.458	
Max. Lower 1	Ø C	500 mA	2	106.4%	.458	
Left 6	Ø A	500mA	2	106.5%	.407	
Left 6	Ø B	500mA	2	106.4%	.437	
Left 6	Ø C	500mA	2	X 106.5%	.407	
Non Tap Winding	Ø A	500mA	2	104%	.570	
Non Tap Winding	Ø B	500mA	2	104.1%	.577	
Non Tap Winding	Ø C	500mA	2	104.1%	.570	
Tertiary Winding	Ø A B gnd	500mA	200m	107.2	5.7	
Tertiary Winding	Ø B C gnd	500 mA	200m	107.2	5.5	
Tertiary Winding	Ø A C gnd	500 mA	200m	107.2	5.3	

Note: Observe Indicator Light & Record OHMS or MILLI-OHMS

REMARKS:

A .562 – .577

Nameplate - Autotransformer with Tertiary

Company	Newfoundland & Labrador Hydro	**Serial Number**	289147
Location	SSD	**Special ID**	SSD T1
Division	EASTERN	**Circuit Designation**	T1
Manufacturer	CGE	**Configuration**	Y-Y-D
Year Manufactured	1977	**Tank Type**	OPEN-CONSER
Mfr Location	GUELPH ONTARIO CCANADA	**Oil Volume**	12300 IG
Phases	3	**BIL**	900 kV
Class	ONAN/ONAF/ONAF	**Coolant**	OIL
Weight	263000 LB		
kV	230, 138, 6.9	**VA Rating**	75, 100, 125, MVA
Note			

Test Date	8/16/2007	**Test Time**	12:00:00 PM	**Weather**	PTCLDY
Air Temperature	17 °C	**Tank Temperature**	°C	**Rel. Humidity**	42 %
Tested by	P&C	**Work Order #**	S	**Last Test Date**	
Checked by		**Test Set Type**	M4K	**Retest Date**	
Checked Date		**Set Top S/N**		**Reason**	ROUTINE
Last Sheet #		**Set Bottom S/N**		**Travel Time**	
P.O. #		**Ins. Book #**		**Duration**	
Copies		**Sheet #**		**Crew Size**	

Arrester Nameplate

Location	Serial #	Mfr	Overall Catalog	Unit Catalog	Type	Rated kV	Order
H1 TOP	D-3708	OB	219652	215920-3013	VN	82.000	TOP
H1 - BOTTOM	D-3709	OB	219652	215920-3008	VN	70.000	BOTTOM
H2 TOP	89m5037	JOS	8110D0001J192	<None>	ZS	51.000	TOP
H2 MID	89m5037-2	JOS	8110D0001J192	<None>	ZS	51.000	MIDDLE
H2 BOT	89m5037-1	JOS	8110D0001J192	<None>	ZS	51.000	BOTTOM
X1 TOP	D-8963	OB	219598	215920-3005	VN	56.000	TOP
H3 TOP	89M5038-2	JOS	8110D0001J192	<None>	ZS	51.000	TOP
H3 MID	89M5038-1	JOS	8110D0001J192	<None>	ZS	51.000	MIDDLE
H3 BOT	89M5038	JOS	8110D0001J192	<None>	ZS	51.000	BOTTOM
X1 BOT	D-8964	OB	219598	215920-3001	VN	42.000	BOTTOM
X2 TOP	28440	MC-ED	ATZ11A60	<None>		48.000	TOP
X2 BOT	28431	MC-ED	ATZ11A60	<None>		48.000	BOT
X3 TOP	28444	MC-ED	ATZ11A60	<None>		48.000	TOP
X3 BOT	28442	MC-	ATZ11A60	<None>		48.000	BOT

ED

Bushing Nameplate

Desig.	Serial #	Mfr	Type	C1 % PF	C1 Cap	C2 % PF	C2 Cap	kV	Amps	Year
H1	250663	CGE	U	.28	431		379	196	600	
H2	250881	CGE	U	.27	422		384	196	600	
H3	251439	CGE	U	.27	420		390	196	600	
X1	251307	CGE	U	.24	359		339	115	800	
X2	251308	CGE	U	.24	359		341	115	800	
X3	251311	CGE	U	.24	344		366	115	800	
Y1	251458	CGE	LC	.82				15	1200	
Y2	251459	CGE	LC	.84				15	1200	
Y3	251457	CGE	LC	.78				15	1200	
N	251456	CGE	LC	.76				15	1200	

Overall Tests

Meas.	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
CH + CHT	10.016	116.87	3.600	0.31	1.00	31000.6		
CH	10.010	116.15	3.605	0.31	1.00	30808.1	G	
CHT(UST)	10.008	0.7090	-000.02	-0.28	1.00	188.02	I	
CHT		0.720	-0.005	-0.07	1.00	192.500	I	
CT + CHT	5.001	132.63	5.960	0.45	1.00	35180.3		
CT	5.003	131.92	5.973	0.45	1.00	34991.9	G	
CHT(UST)	5.004	0.7070	-000.02	-0.28	1.00	187.58	I	
CHT		0.710	-0.013	-0.18	1.00	188.400	I	

Bushing C1

ID	Serial #	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap (pF)	IR_{auto}	IR_{man}
H1	250663	.28	431	10.006	1.599	0.0400	0.25	1.00	424.25	G	
H2	250881	.27	422	10.005	1.571	0.0350	0.22	1.00	416.75	G	
H3	251439	.27	420	10.005	1.564	0.0330	0.21	1.00	414.79	G	
X1	251307	.24	359	10.005	1.348	0.0310	0.23	1.00	357.50	G	
X2	251308	.24	359	10.005	1.350	0.0300	0.22	1.00	358.05	G	
X3	251311	.24	344	10.006	1.295	0.0180	0.14	1.00	343.54	G	

Bushing C2

ID	Serial #	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap (pF)	IR_{auto}	IR_{man}
H1	250663		379	2.001	1.606	0.0750	0.47	1.00	425.88	I	
H2	250881		384	2.000	1.613	0.0910	0.56	1.00	427.82	I	

H3	251439		390	2.000	1.643	0.0890	0.54	1.00	435.76	I	
X1	251307		339	2.000	1.432	0.0950	0.66	1.00	379.89	I	
X2	251308		341	2.000	1.434	0.0980	0.68	1.00	380.48	I	
X3	251311		366	2.000	1.535	0.1250	0.81	1.00	407.20	I	

Hot Collar Tests

Serial #	ID	Test Mode	Skirt #	Test kV	mA	Watts	IR_{auto}	IR_{man}
251458	Y1	GROUND	1	10.003	0.1170	0.0360	G	
251459	Y2	GROUND	1	10.004	0.1210	0.0370	G	
251457	Y3	GROUND	1	10.003	0.1210	0.0450	G	
251456	N	GROUND	1	10.003	0.1180	0.0790	G	

Insulating Fluid Tests

Sample Location	Deg C	Test kV	mA	Watts	%PF corr	Corr Fctr	IR_{auto}	IR_{man}
TANK BOTTOM		10.00	0.8790	0.0060	0.07	1.00	G	
LTC		10						

Surge Arrester Tests

Location	Test Mode	Test kV	mA	Watts	IR_{auto}	IR_{man}
H1 TOP	UST RB	10.004	0.1370	0.0660	G	
H1 - BOTTOM	GAR RB	10.004	0.2450	0.1120	G	
H2 TOP	UST RB	10.004	0.2970	0.2560	G	
H2 MID	UST RB	10.003	0.2820	0.2570	G	
H2 BOT	GAR RB	10.003	0.3540	0.2610	G	
H3 TOP	UST RB	10.004	0.3000	0.2610	G	
H3 MID	GAR RB	10.017	0.4090	0.6470	I	
H3 BOT	GAR RB	10.004	0.3540	0.2700	G	
X1 TOP	UST RB	10.004	0.1830	0.0890	G	
X1 BOT	GAR RB	10.011	0.3610	0.2000	I	
X2 TOP	UST RB	10.004	0.2220	0.0640	G	
X2 BOT	GAR RB	10.004	0.3440	0.1050	G	
X3 TOP	UST RB	10.004	0.2250	0.0690	G	
X3 BOT	GAR RB	10.005	0.3220	0.0950	G	

Exciting Current Tests

	Mfr	Type	Steps	Boost %	Buck %	Position Found	Position Left	Oil Volume
De-Energized Tap Changer	CGE							
On-Load Tap Changer	CGE	C2	16	5	15			

	H1 - H0		H2 - H0		H3 - H0		

DETC	LTC	Test kV	mA	Watts	X	mA	Watts	X	mA	Watts	X	IR_{auto}	IR_{man}
	1	10.018	16.391	160.41	L	10.096	100.62	C	15.702	154.98	L	G	
	5	9.995	17.782	172.67	L	10.996	109.95	C	17.073	167.32	L	G	
	9	10.011	19.436	188.16	L	12.059	120.59	L	18.687	182.66	L	G	
	13	10.011	21.338	205.56	L	13.347	133.12	L	20.553	199.73	L	G	
	17	10.018	23.595	226.91	L	14.837	147.66	L	22.763	220.82	L	G	

Fluid Analysis Report

Equipment	289147	*MVA ratings*	125
Serial No.	289147	*Rated kV*	230.000
Apparatus type	TRN	*Oil preservation type*	CONSERVATOR
Owner	N.F.L.D HYDRO	*Cooling*	OA/FA/FA
Region	WHITBOURNE	*Fluid volume*	14662
Substation	SSD	*Tank*	Main
Designation	T1	*Norms used*	TRN_IEEE_69_288KV
Norms	TRN_IEEE_69_288KV	*DGA result*	2/3
Fluid type	OIL	*Fluid condition*	1/1
Description	POWER TRANSFORMER	*Moisture code*	1/1
Manufacturer	CGE	*PCB result code*	0/1
Year manufactured	1978	*Oil test status*	UNREVIEWED
Model	AUTO		

Gas Analysis

Lab Report Number	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Sample date	2013-09-11	2012-03-13	2012-02-24	2010-03-22 14:31:00	2009-05-05 14:46:00
Fluid temp	35	20	20	25	30
Hydrogen (H2)	30	10	20	25	25
Methane (CH4)	0	0	0	0	0
Ethane (C2H6)	4.0	4.0	3.0	4.0	4.0
Ethylene (C2H4)	52.0	47.0	49.0	50.0	50.0
Acetylene (C2H2)	11.0	7.0	8.0	8.0	7.0
Carbon Monoxide (CO)	373	267	310	341	327
Propylene (C3H6)	0	0	0	0	0
Carbon Dioxide (CO2)	3160	2610	2640	3070	3020
Oxygen (O2)	26600	26400	25900	27400	21700
Nitrogen (N2)	64100	62100	61100	65200	62100
Total heat gas	56	51	52	54	54
TDCG	470	335	390	428	413
Equivalent TCG	0.414	0.277	0.346	0.364	0.382
Total partial press	85.6	88.4	87.0	90.7	82.1
Est. safe handling limit	9.1	10.2	9.4	9.2	9.1
Calculated monitor ppm	99	59	77	88	85
CO2/CO	8.472	9.775	8.516	9.003	9.235
Oxygen/Nitrogen (O2/N2)	0.415	0.425	0.424	0.420	0.349
DGA retest days	30	90	90	90	90
DGA retest date	2013-10-11	2012-06-11	2012-05-24	2010-06-20	2009-08-03
DGA reference days	547.0	18.0	703.4	321.0	336.6
DGA result	3	2	2	2	2
DGA diagnosis	DT	T3	T3	T3	T3

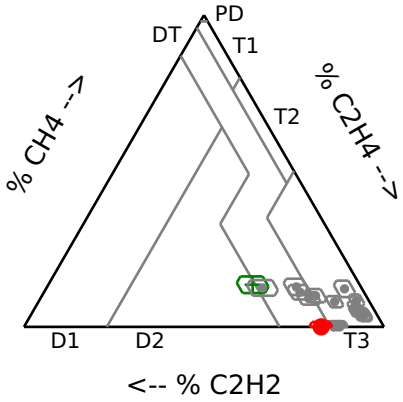
Gas Analysis Remarks

One or more combustible gases have a positive long-term average rate. (C2H2) Significant increase (^). High level (*). Electrical discharge or thermal fault. Consider investigative sampling.

Gas Analysis Summary

```
c2h4* c2h2*^ co*!
```

Diagnosis



Triangle Diagnosis: DT

Rogers Diagnosis: ?

Fluid Quality

Lab Report Number	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Sample date	2013-09-11	2012-03-13	2012-02-24	2010-03-22 14:31:00	2009-05-05 14:46:00
Fluid temp	35	20	20	25	30
Dielectric breakdown D877	52.0	49.0	59.0	45.0	55.0
PF at 25 C	0.166	0.115	0.123	0.035	0.062
PF at 100 C	2.940	3.280	2.620	1.280	1.380
Acid number	0.030	0.030	0.030	0.030	0.030
Interfacial tension	28.1	27.5	26.9	27.8	28.6
Specific Gravity	0.860	0.859	0.858	0.858	0.862
Color	1.5	1.5	1.5	2.0	1.5
Oil quality index	1.1	1.1	1.1	1.1	1.0
PF100/PF25	17.711	28.522	21.301	36.571	22.258
Visual	CLEAR	CLEAR	CLEAR	CLEAR	CLEAR
Fluid quality retest days	365	365	365	365	365
Fluid quality retest date	2014-09-11	2013-03-13	2013-02-23	2011-03-22	2010-05-05
Fluid condition	1	1	1	1	1

Fluid Quality Analysis Remarks

No oil quality problems were detected.

Moisture Analysis

Lab Report Number	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*
Sample date	2013-09-11	2012-03-13	2012-02-24	2010-03-22 14:31:00	2009-05-05 14:46:00
Fluid temp	35	20	20	25	30
Moisture	3	2	2	5	2
Relative saturation	3	4	4	7	2
Dew point	-34	-40	-40	-26	-40
Solubility parameter A	7.3000	7.3000	7.3000	7.3000	7.3000
Solubility parameter B	1630	1630	1630	1630	1630
Moisture code	1	1	1	1	1

Moisture Remarks

The water content of the oil seems acceptable.

Furans

Lab Report Number	*N/A*
Sample date	2009-05-05 14:46:00
Fluid temp	30
2-furfural (2FAL)	0
5-methyl-2-furfural (5M2F)	0
5-hydroxymethyl-2-furfural (5H2F)	0
Furfuryl alcohol (2FOL)	0
2-acetylfuran (2ACF)	0

PCB Analysis

Lab Report Number	*N/A*
Sample date	2009-05-05 14:46:00
Fluid temp	30
Aroclor 1221	0.0
Aroclor 1242	0.0
Aroclor 1254	0.0
Aroclor 1260	0.0
Total PCB	0.0
PCB result code	1

PCB Remarks

Not PCB contaminated.

OIL ANALYSIS REPORT

REFERENCE

Client:	Mr Dave Hicks (CNH04)	Sample No:	M008242
E-mail:		Authorized by:	R.P.
Company:	Nfld. & Labrador Hydro	Sent Date:	2009-05-28

EQUIPMENT

Apparatus Type:	TRN	KV:	230	Sampling Point:	MAIN
Location:	SSD	MVA:	125	Oil Temp. (°C):	30
Equipment No:	289147	Oil type:	OIL	Sampled by:	POG
Serial No.:	289147	Year built:	1978	Sampling Date:	2009-05-05 14:46
Additional info:	POWER TRANSFORMER				
Description:	T1				

DGA

Previous	2009-05-05	Parameter	Screening Code(T/R)	Test Method
	25	Hydrogen		D3612-02
	7	Acetylene		ppm (V/V)
	4	Ethane		at 273 K
	50	Ethylene		and 760 Torr
	< 5	Methane		
	327	Carbon Monoxide		
	3020	Carbon Dioxide		
	62100	Nitrogen		
	21700	Oxygen + Argon		
	8.67	Total Dissolved Gas (%)		

OIL QUALITY

Previous	2009-05-05	Parameter	Screening Code(T/R)	Test Method
	2	Moisture in Oil (ppm)		SOP 5.5-03-01
		Moisture in Oil (ppm)		D 1533-00
	28.6	Interfacial Tension (dynes/cm)		D 971-99
	0.03	Acid Number (mg KOH/g)		D 974-07
	1.5	Color Number		D 1500-04
	None	Free Water		D 1524-94
	Clear	Visual Examination		D 1524-94
	None	Sediment Examination		D 1524-94
	55	Dielectric Breakdown (kV)		D 877-02
		Dielectric Breakdown 2 mm (kV)		D 1816-04
	0.062	Power Factor @ 25 °C (%)		D 924-04
	1.38	Power Factor @ 100 °C (%)		D 924-04
	0.8615	Specific Gravity		D 1298-99
		Oxidation Inhibitor DBP (wt. %)		D 4768-03
		Oxidation Inhibitor DBPC (wt. %)		D 4768-03
	< 1	PCB - Total Arochlor Content (ppm)		D 4059-00
		Corrosive Sulphur Method B		D 1275-06
	< 5	5-hydroxymethyl-2-furaldehyde (ppb)		D 5837-99
	< 5	furfuryl alcohol (ppb)		D 5837-99
	< 5	2-furaldehyde (ppb)		D 5837-99
	< 5	2-acetylfuran (ppb)		D 5837-99
	< 5	5-methyl-2-furaldehyde (ppb)		D 5837-99

COMMENTS:
NCR 1415 - This report replaces the previous report. A typo occured on the name of methyl-2-furaldehyde. It should read 5-methyl instead of 2-methyl.

**** Morgan Schaffer is an ISO/IEC 17025 certified laboratory ****

The analyses and screening codes contained in this report are based upon material and information supplied by the client. Morgan Schaffer Inc does not imply that the contents of the sample received at its laboratory are the same as all such material in the environment from which the sample was taken. Our test results relate only to the sample or samples tested. Morgan Schaffer Inc assumes no responsibility and makes no warranty or representation, expressed or implied as to the condition, productivity or proper operation of any equipment or other property for which this report may be used or relied upon for any reason whatsoever. This report must not be reproduced, unless in its entirely, without the written consent of Morgan Schaffer Inc.(* Subcontracted, † Non-accredited test)

TJ | H2b ANALYTICAL SERVICES INCORPORATED

Tapchanger Activity Signature Analysis TASA™

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400
St John's, NF A1B 4K7

Location : SSDTS
Bank & Phase : T1-A
Serial Number : 289147-LTC-A
Ventilation :
Compartment : Common

Date : 11/7/2012
Report Number : 5042845
Purchase Order Number: 847577
Manufacturer : CGE
Model :

		Sample Date :	10/2/2012	4/29/2008	6/27/2007
		Laboratory No. :	5042845	5019672	5016462
		Container No. :	201177	40377	8887
		Temperature :	35	45	30
H2	Hydrogen	(ppm) :	33016	29115	28078
CH4	Methane	(ppm) :	2833	3857	3961
C2H6	Ethane	(ppm) :	257	240	355
C2H4	Ethylene	(ppm) :	4605	5441	4430
C2H2	Acetylene	(ppm) :	33979	38919	29282
CO	Carbon monoxide	(ppm) :	246	388	517
CO2	Carbon dioxide	(ppm) :	2497	3753	3289
N2	Nitrogen	(ppm) :	39837	52562	63895
O2	Oxygen	(ppm) :	7690	13115	5572
		Total (ppm) :	124960	147390	139379
		TDCG (ppm) :	74936	77960	66623
		SHL (%) :	3.91	3.89	3.93
		ETCG (% in blanket) :	58.01	47.87	43.90
Particles		5 to 15 um :	5658800	1162305	26948834
Particles		15 to 25 um :	345800	86990	4029760
Particles		25 to 50 um :	81900	6230	680695
Particles		50 to 100 um :	11100	165	39325
Particles		> 100 um :	400	0	2500
D1533	Moisture	(ppm) :	26	14	43
D1816	Dielectric BV	(kV) :	22	25	14
D974	Acid Number	(mg KOH/g) :	0.011	0.016	0.012
D971	Interfacial Tension	(dynes/cm) :	38.7	36.3	35.0
D1500	Color Number	:	<4.0	<2.0	<3.0

Tapchanger Activity Signature Analysis Diagnostic Evaluation

TASA Assessment : 2
Sampling Interval : Recommend retest within 150 days (5 months) for trending.
Operating Procedure : Monitor for increased arcing. Evaluate for worn or damaged components.
Comments : A moderately abnormal dissipation of energy is noted. This is an advancing indication of fault or wear activity.
Partial discharge is indicated.
Heating is indicated.
Abnormal arcing is indicated.
Follow guidelines for oils with high flammable gas content.

TJ | H2b ANALYTICAL SERVICES INCORPORATED

Tapchanger Activity Signature Analysis TASA™

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400
St John's, NF A1B 4K7

Location : SSDTS
Bank & Phase : T1-B
Serial Number : 289147-LTC-B
Ventilation : Desiccant
Compartment : Common

Date : 11/7/2012
Report Number : 5042842
Purchase Order Number: 847577
Manufacturer : CGE
Model :

		Sample Date :	10/2/2012	4/29/2008
		Laboratory No. :	5042842	5019677
		Container No. :	19603	10371
		Temperature :	35	35
H2	Hydrogen	(ppm) :	15155	33228
CH4	Methane	(ppm) :	2801	3578
C2H6	Ethane	(ppm) :	215	199
C2H4	Ethylene	(ppm) :	4554	4815
C2H2	Acetylene	(ppm) :	31921	35549
CO	Carbon monoxide	(ppm) :	274	458
CO2	Carbon dioxide	(ppm) :	2714	3560
N2	Nitrogen	(ppm) :	59648	63393
O2	Oxygen	(ppm) :	10885	15427
		Total (ppm) :	128167	160207
		TDCG (ppm) :	54920	77827
		SHL (%) :	3.83	3.91
		ETCG (% in blanket) :	31.27	46.21
Particles		5 to 15 um :	1302900	1120400
Particles		15 to 25 um :	64000	38850
Particles		25 to 50 um :	13100	4520
Particles		50 to 100 um :	2500	330
Particles		> 100 um :	0	0
D1533	Moisture	(ppm) :	16	13
D1816	Dielectric BV	(kV) :	22	22
D974	Acid Number	(mg KOH/g) :	0.015	0.014
D971	Interfacial Tension	(dynes/cm) :	38.1	35.5
D1500	Color Number	:	<2.5	<2.5

Tapchanger Activity Signature Analysis Diagnostic Evaluation

TASA Assessment : 2
Sampling Interval : Recommend retest within 150 days (5 months) for trending.
Operating Procedure : Monitor for increased arcing. Evaluate for worn or damaged components.
Comments : A moderately abnormal dissipation of energy is noted. This is an advancing indication of fault or wear activity.
Partial discharge is indicated.
Heating is indicated.
Abnormal arcing is indicated.
Follow guidelines for oils with high flammable gas content.

H2b ANALYTICAL SERVICES INCORPORATED

Tapchanger Activity Signature Analysis TASA™

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400
St John's, NF A1B 4K7

Location : SSDTS
Bank & Phase : T1-C
Serial Number : 289147-LTC-C
Ventilation :
Compartment : Common

Date : 11/7/2012
Report Number : 5042841
Purchase Order Number: 847577
Manufacturer : CGE
Model :

		Sample Date :	10/2/2012	4/29/2008
		Laboratory No. :	5042841	5019675
		Container No. :	201171	10372
		Temperature :	35	35
H2	Hydrogen	(ppm) :	28622	29198
CH4	Methane	(ppm) :	1974	2955
C2H6	Ethane	(ppm) :	129	160
C2H4	Ethylene	(ppm) :	3264	3609
C2H2	Acetylene	(ppm) :	23263	28735
CO	Carbon monoxide	(ppm) :	222	404
CO2	Carbon dioxide	(ppm) :	2051	3076
N2	Nitrogen	(ppm) :	59035	71575
O2	Oxygen	(ppm) :	12810	20495
		Total (ppm) :	131370	160207
		TDCG (ppm) :	57474	65061
		SHL (%) :	3.93	3.92
		ETCG (% in blanket) :	44.16	39.49
Particles		5 to 15 um :	6934700	870130
Particles		15 to 25 um :	295900	24520
Particles		25 to 50 um :	55500	1125
Particles		50 to 100 um :	5500	35
Particles		> 100 um :	0	0
D1533	Moisture	(ppm) :	18	9
D1816	Dielectric BV	(kV) :	23	22
D974	Acid Number	(mg KOH/g) :	0.014	0.016
D971	Interfacial Tension	(dynes/cm) :	38.3	36.8
D1500	Color Number	:	<4.0	<2.5

Tapchanger Activity Signature Analysis Diagnostic Evaluation

TASA Assessment : 2
Sampling Interval : Recommend retest within 150 days (5 months) for trending.
Operating Procedure : Monitor for increased arcing. Evaluate for worn or damaged components.
Comments : A moderately abnormal dissipation of energy is noted. This is an advancing indication of fault or wear activity.
Partial discharge is indicated.
Heating is indicated.
Abnormal arcing is indicated.
Follow guidelines for oils with high flammable gas content.

H2b ANALYTICAL SERVICES INCORPORATED

Tapchanger Activity Signature Analysis TASA™

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400
St John's, NF A1B 4K7

Location : SSDTS
Bank & Phase : T1-A
Serial Number : 289147-LTC
Ventilation :
Compartment : LTCMain

Date : 8/21/2007
Report Number : 5016461
Purchase Order Number:
Manufacturer : CGE
Model :

		Sample Date :	6/28/2007
		Laboratory No. :	5016461
		Container No. :	8702
		Temperature :	30
H2	Hydrogen	(ppm) :	30141
CH4	Methane	(ppm) :	3602
C2H6	Ethane	(ppm) :	244
C2H4	Ethylene	(ppm) :	4216
C2H2	Acetylene	(ppm) :	29357
CO	Carbon monoxide	(ppm) :	494
CO2	Carbon dioxide	(ppm) :	3381
N2	Nitrogen	(ppm) :	68190
O2	Oxygen	(ppm) :	7764
		Total (ppm) :	147389
		TDCG (ppm) :	68054
		SHL (%) :	3.93
		ETCG (% in blanket) :	43.54
Particles		5 to 15 um :	13739700
Particles		15 to 25 um :	3849250
Particles		25 to 50 um :	486115
Particles		50 to 100 um :	8650
Particles		> 100 um :	250
D1533	Moisture	(ppm) :	61
D1816	Dielectric BV	(kV) :	12
D974	Acid Number	(mg KOH/g) :	0.012
D971	Interfacial Tension	(dynes/cm) :	35.0
D1500	Color Number	:	<3.0

Tapchanger Activity Signature Analysis Diagnostic Evaluation

TASA Assessment : 3
Sampling Interval : Recommend retest within in 90 days.
Operating Procedure : Monitor for increased arcing. Evaluate for worn or damaged components.
Comments : A moderately abnormal dissipation of energy is noted. This is an advancing indication of fault or wear activity.
Partial discharge is indicated.
Heating is indicated. Counter: 125541
Abnormal arcing is indicated.
ETCG is 90% of SHL. Plan to follow guidelines for oils with high flammable gas content.

TJ | H2b ANALYTICAL SERVICES INCORPORATED

Tapchanger Activity Signature Analysis TASA™

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400
St John's, NF A1B 4K7

Location : SSDTS
Bank & Phase : T1-B
Serial Number : 289147-LTC-A
Ventilation :
Compartment : LTCMain

Date : 8/21/2007
Report Number : 5016462
Purchase Order Number:
Manufacturer : CGE
Model :

		Sample Date :	6/27/2007
		Laboratory No. :	5016462
		Container No. :	8887
		Temperature :	30
H2	Hydrogen	(ppm) :	28078
CH4	Methane	(ppm) :	3961
C2H6	Ethane	(ppm) :	355
C2H4	Ethylene	(ppm) :	4430
C2H2	Acetylene	(ppm) :	29282
CO	Carbon monoxide	(ppm) :	517
CO2	Carbon dioxide	(ppm) :	3289
N2	Nitrogen	(ppm) :	63895
O2	Oxygen	(ppm) :	5572
		Total (ppm) :	139379
		TDCG (ppm) :	66623
		SHL (%) :	3.93
		ETCG (% in blanket) :	43.90
Particles		5 to 15 um :	26948834
Particles		15 to 25 um :	4029760
Particles		25 to 50 um :	680695
Particles		50 to 100 um :	39325
Particles		> 100 um :	2500
D1533	Moisture	(ppm) :	43
D1816	Dielectric BV	(kV) :	14
D974	Acid Number	(mg KOH/g) :	0.012
D971	Interfacial Tension	(dynes/cm) :	35.0
D1500	Color Number	:	<3.0

Tapchanger Activity Signature Analysis Diagnostic Evaluation

TASA Assessment : 3
Sampling Interval : Recommend retest within in 90 days.
Operating Procedure : Monitor for increased arcing. Evaluate for worn or damaged components.
Comments : A moderately abnormal dissipation of energy is noted. This is an advancing indication of fault or wear activity.
Partial discharge is indicated.
Heating is indicated. Counter: 125541
Abnormal arcing is indicated.
ETCG is 90% of SHL. Plan to follow guidelines for oils with high flammable gas content.

H2b ANALYTICAL SERVICES INCORPORATED

Tapchanger Activity Signature Analysis TASA™

David Hicks
Newfoundland Labrador Hydro

P.O. Box 12400
St John's, NF A1B 4K7

Location : SSDTS
Bank & Phase : T1-C
Serial Number : 289147-LTC-S
Ventilation :
Compartment : LTCMain

Date : 8/21/2007
Report Number : 5016465
Purchase Order Number:
Manufacturer : CGE
Model :

		Sample Date :	6/28/2007
		Laboratory No. :	5016465
		Container No. :	8884
		Temperature :	30
H2	Hydrogen	(ppm) :	21034
CH4	Methane	(ppm) :	2614
C2H6	Ethane	(ppm) :	322
C2H4	Ethylene	(ppm) :	3606
C2H2	Acetylene	(ppm) :	22687
CO	Carbon monoxide	(ppm) :	385
CO2	Carbon dioxide	(ppm) :	2599
N2	Nitrogen	(ppm) :	74506
O2	Oxygen	(ppm) :	19637
		Total (ppm) :	147390
		TDCG (ppm) :	50648
		SHL (%) :	3.92
		ETCG (% in blanket) :	31.57
Particles		5 to 15 um :	20745970
Particles		15 to 25 um :	1324640
Particles		25 to 50 um :	182050
Particles		50 to 100 um :	12730
Particles		> 100 um :	1600
D1533	Moisture	(ppm) :	21
D1816	Dielectric BV	(kV) :	16
D974	Acid Number	(mg KOH/g) :	0.012
D971	Interfacial Tension	(dynes/cm) :	35.8
D1500	Color Number	:	<2.0

Tapchanger Activity Signature Analysis Diagnostic Evaluation

TASA Assessment : 3
Sampling Interval : Recommend retest within in 90 days.
Operating Procedure : Monitor for increased arcing. Evaluate for worn or damaged components.
Comments : A moderately abnormal dissipation of energy is noted. This is an advancing indication of fault or wear activity.
Partial discharge is indicated.
Heating is indicated. Counter: 125541
Abnormal arcing is indicated.
ETCG is 90% of SHL. Plan to follow guidelines for oils with high flammable gas content.

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
93146	8/27/1999	Change Selica Gel T1,SSDTS	Change Selica Gel T1,SSDTS CHANGED SELICA GEL ON MAIN TANK AND TAP CHANGER T1 COMPLETED BY: M. REID DATE: 99-08-27	10187	90
138811	4/28/2000	SSDTS,T1,FUSE BLOWN,REPLACED	T1,FUSE BLOWN,REQUIRES REPLACEMENT, OUTAGE REQUIRED ON B PHASE TERITARY 2000/04/28 COMPLETED BY: G.BRODERICK MODIFIED & REPLACED FUSE HOLDER & FUSE.	47825	90
144225	6/8/2000	SSDTS,T1,OIL LEAK,INSPECT	INSPECT OIL LEAK ON THE TOP OF T1. LOCATION: SUNNYSIDE TERMINAL STATION. 2000/06/08 COMPLETED BY: G.BRODERICK REPAIRED LEAKING VALVE ON RADIATOR & CLEANED UP OIL AROUND TRANSFORMER RADIATORS.	47825	90
184259	2/21/2002	SSDTS,T1,CONTACT ALARM,REPL	SSDTS,T1,CONTACT ALARM,REPLACE WINDING TEMPERATURE RELAY. ALARM CONTACT NEEDS TO REPLACED. needs a 8cond. cable ran from control cabinet to the relay NAME PLATE DATA: 75/100/125 MVA - 230 KV H/S 138 KV L/S BY G.E. SER. #289147. REPLACED WINDING TEMP. GUAGE. PULLED NEW CONDUCTORS FOR GUAGE. CHANGED BRACKET TO ACCOMONDATE NEW NEW GUAGE OK. COMPLETED BY: G. BRODERICK ON 2002-02-20	47825	90
189041	1/11/2001	SSDTS,T1,SILICA GEL,REPLACE	SSDTS,T1,SILICA GEL,REPLACE NO OUTAGE REQUIRED (VERBAL PERMISSION) FOLLOW SAFETY STANDARDS 01/01/11 COMPLETED BY: M.REID CHANGED SILICA GEL ON MAIN CONSERVATOR & TAP	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
199354	2/22/2001	SSDTS,T1,LTC,CHECK	SUNNYSIDE TERMINAL STATION: T1 T1 LTC DOESN'T APPEAR TO BE OPERATING IN AUTO; BOTH TRIES PLACED IN MAN. PRIORITY "B" 01/02/21 COMPLETED BY: J.MCDONALD CHECKED ALL PTS FOR VOLTAGE & ALL SEEMED OK. PUT FORMERS IN AUTO & TESTED 2 TAPS APART ALL OK.	47826	90
258362	6/18/2002	SSDTS,T1,SANDING & PAINTING	SSDTS,T1,SANDING & PAINTING SANDED, PRIMED AND PAINTED. T1 SSD SANDED PRIMED & PAINTED. STATION SERVICE CABINET AND COMPLETED BY: C. SMITH ON 2002-06-18	47825	90
263965	2/28/2002	SSDTS,T1,SILICA-GEL,REPLA	SSDTS,T1,SILICA-GEL,REPLACE FOR CONSERVATOR TANK. SILICA GEL REPLACED ON T1 CONSERVER COMPLETED BY: G. BRODERICK ON 02-02-28	47825	90
264013	3/1/2002	SSDTS,T1,FAN,REPAIR/REPLACE	SSDTS,T1,FAN,REPAIR/REPLACE RAD COOLING FAN (SEIZED) (MIDDLE ROW, FAR RIGHT FAN). POSSIBLE MOTOR REPLACEMENT, POSSIBLE BEARING REPAIRED AND REPLACED ONE FAN AND MOTOR THAT WAS RUSTED AND FULL OF WATER. ALSO ASSESSED OTHER FAN MOTOR ON T1 AND T2. COMPLETED BY: D. BLAKE/S. TUCKER ON 2002-03-01 WORK REMAINING: WORK ORDER NEEDED FOR T1 - FAN RIGHT MOTOR T1 AND T4	47825	90
264284	2/25/2002	SSDTS,T1,OIL TEMP RELAY,REPL	SSDTS,T1,RELAY,REPLACE LIQUID TEMP. RELAY THE PART ORDERED ON THIS WORK ORDER BELONGS TO W/O MAX : ENSURE THIS PART IS ASSIGNED TO PROPER W/O WHEN ARRIVES NEW OIL TEMP GUAGE INSTALLED AND CHECK FOR SETTINGS. COMPLETED BY: G. BRODERICK & W. DOWNING ON 2002-02-25	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
265667	3/14/2002	SSDTS,T1,FANS,INSP & REPAIR	SSDTS,T1,FANS,INSPECT ASSESS & REPAIR FAN MOTOR WIRING INSTALL ELECTRICAL GROUND TO ALL MOTORS REPLACE EXISTING CAB TIRE . RAN GROUND WIRE #2 AWG FROM GROUND GRID GROUND TO INSTALLED GROUNDING BAR IN XFMR CONTROL CABINET. RAN GROUND WIRE FROM GROUNDING BAR TO EACH OF TWO RAD J-BOXES. RAN NEW #14/4 AWG CABTIRE (500W) FROM BOTH TO THE APPLICABLE MOTORS, 9 IN ALL, AND CONNECTED UP MOTORS WITH AN ELECTRICAL GROUND. REMOVED ONE DISSASSEMBLED, CLEANED UP, AND PUT BACK TOGETHER WAS FULL OF WATER WHEN CHECKED. COMPLETED BY: D. BLAKE, S. TUCKER & G. HILLIER COMPLETED ON: 2002-03-13	47825	90
280171	6/5/2002	SSDTS,T1,PM MAINT/DOBLE TRF	DOBLE TRANSFORMER EVERY 6 YEARS. 1. ATTACH TRANSFORMER CHECK SHEETS TO RECORD TEST 2. RECORD ANY DEFICIENCIES ON WORK REQUEST SO THAT CAN GET CORRECTED IF NOT CORRECTED DURING 3. CHECK NAME PLATE FOR ACCURACY,RECORD ANY 4. DOBLE ANY CTS THAT MAY BE ASSOCIATED WITH 5. CHECK LATEST DOBLE TEST RESULTS TO SEE WHEN LAST CTS WERE TESTED. WORK PERFORMED AS PER CHECK SHEET. COMPLETED BY: P. O'GRADY & CREW ON 2002-05-29	47825	90
309966	12/11/2002	SSDTS,T1,SILICA GEL,CHANGE	SSDTS,T1,SILICA GEL,CHANGE REPLACED SILICA-GEL ON MAIN CONSERVATOR AND TAP COMPLETED BY: G. HILLIER & S. TUCKER ON 2002-12-11	47825	90
400483	5/10/2004	SSD,T1 LTC SCREEN FOR PCB	SUNNYSIDE TERMINAL STATION TEST T1 DIVERTER SWITCH OIL FOR PCB'S T1, LTD TESTED FOR PCB. UNDER 50 PARTS PER MILLION. COMPLETED BY: S. TUCKER ON 2004-05-10	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
412731	7/13/2004	SSD T1 INVISTIGATE ALARM	SSD T1 INVISTIGATE ALARM RESTORED STATION SERVICE TO CLEAR ALARMS ON AIR SYSTEM AND D.C. BATTERY CHARGER. T1 ALARMS CLEARED. CHECKED RESISTANCE ACROSS CONTACTS ON GAS, WINDING, AND OIL LEVEL GAUGES. GAS RELAY ALARM CONTACT SOME RESISTANCE BUT CLEARED ON PANEL. RESTORED T1 TO SERVICE. COMPLETED BY: W. DOWNING ON 2004-07-12	47825	90
413126	8/24/2004	SSDTS,T1,GAS RELAY CIR,INVES	SSDTS,T1,RELAY CIRCUIT,INVES INVESTIGATE GAS RELAY CIRCUIT ON T1 CORD MAY NEED TO BE REPLACED. SPARE CORD TO SHORT MADE UP BEFORE OUTAGE. T1 TRANSFORMER TAKEN FROM SERVICE ALARM CONTACTS RELAY OR SHOW LOW RESISTANCE. MAY ALSO BE CABLE GAS RELAY. COMPLETED BY: W.D & B. WALSH ON 2004-07-19 NOTE: INSTALL NEW GAS RELAY OR NEW CABLE FROM JB TO RELAY. CABLE THAT COMES WITH GAS RELAY IS TO SHORT. INSTALLED NEW GAS RELAY CABLE. TESTED THE ALARM AND CIRCUIT WITH PUMP - ALL OK. COMPLETED BY: G. HILLIER ON 2004-08-23	47825	90
450258	5/11/2005	SSDTS. T1 GAS RELAY	EMERGENCY USE GAS RELAY INSTALLED ON T1 IN 2004 THIS W/O IS TO REPLACE THE EMERGENCY USE STOCK	47825	90
494823	8/9/2006	SSDTS,T1,OIL TEMP GAUGE	SSDTS,T1,OIL TEMP GAUGE GAUGE NOT WORKING RELAY INSTALLED ON T1 AT SSDTS. CONTACTS MEGGARED - 1000 TO GROUND 75 BETWEEN WIRES. CONTACT CHECKED AND CLOSES AT 90 DEGREES AM. TEMP COMPLETED BY: W. DOWNING & B. WALSH ON 2006-08-09	47825	90
583571	4/20/2007	SSDTS,T1,SILICA GEL NEEDED	SSDTS,T1,SILICA GEL NEEDED MAIN TANK AND TAP CHARGERS NEED SILCA GEL REPLACED	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
583571	4/20/2007	SSDTS,T1,SILICA GEL NEEDED	SILICONE REPLACED IN MAIN TRANSFORMER AND COMPLETED BY: W. DOWING/S. TUCKER ON 2007-04-17	47825	90
584713	8/17/2007	SSDTS, T1 TAPCHANGER OIL SAM	SSDTS, T1 TAP CHANGER OIL SAMPLE (OUTAGE REQUIRED) OBTAIN OIL SAMPLE FOR AS PER T.SHAVE'S INSTRUCTIONS QUOTE WORK ORDER ON INVOICE 1) If oil volume in the equipment is less than 250 gallons (1200 L) flush 1 quart of oil, otherwise flush a gallon into waste oil container. 2) Bottle Samples: rinse bottle by partially filling and gently swirling and emptying the oil into the waste container. Fill bottle to within an inch of the top, to allow for expansion. Visually examine fluid for water droplets or foreign particles. If present, re-sample. If not, attach the cap securely, identify the sampled unit on the bottle's label. Do not tape the cap. 3) Syringe Samples: the plastic stopcock, which comes with the syringe must remain firmly affixed to the syringe to prevent leaks. Flushing the syringe: a) Move the handle toward the sampling valve. b) Open sampling valve and move the handle toward the syringe allowing oil to flush the tube and stopcock. c) Move the handle towards the side port, allowing oil pressure to enter the syringe barrel, forcing the plunger out. Until the inside of the syringe has been wetted with oil, it may be necessary to pull the plunger. d) When oil reaches the 50 cc mark, move the handle towards the sampling valve and eject oil from ssyringe by pushing in the plunger. Catch this ejected oil in waste container Draw the Sample: a) Move the handle towards the side port and allow oil pressure to fill the syringe. DO NOT PULL ON THE PLUNGER When oil reaches the 40-45cc mark, move the handle towards the syringe. Do not over fill the syringe to avoid gas escape from the plunger side.	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
584713	8/17/2007	SSDTS, T1 TAPCHANGER OIL SAM	b) Examine sample to ensure it is free of bubbles and foreign particles. If sample is good, move handle towards the syringe, close drain valve and remove the syringe with stopcock still firmly attached to the syringe. If sample is not clear, repeat sample procedure. c) Record info: on sample bottle check sheet as per enclosed instructions.	47825	90
595483	7/5/2007	SSDTS,PROTECTION,FAIL,ALARM	SSDTS,PROTECTION,FAIL,ALARM,INVESTIGATE PROTECTION FAIL ALARM CAME UP WHEN RESTORING 138 KV B2, T1 AND BUS 3. ISOLATED BURNED AUX. TRANSFORMER IN T1 CABINET TRANSFORMER ASSOCIATED WITH VOLTAGE STEPPING SWITCH ALSO AUX ACT 5/.7 A HAD TO BE REPLACED DAMAGED BY CHECKED REPLACEMENT C.T., OK, REPLACED WIRING AND INTO SERVICE. TESTED BY ECC, OK, BOTH TRANSFORMERS RETURNED TO PARALLEL AND AUTO. COMPLETED BY: J. MCDONALD ON 2007-07-05	47826	90
601394	9/6/2007	SSDTS,T1,TRF DOBLE PM	DOBLE TRANSFORMER EVERY 6 YEARS. 1. CHECK LATEST DOBLE TEST RESULTS TO SEE WHEN LAST TRANSFORMER WAS TESTED. 2. DOBLE TRANSFORMER AS PER CHECK SHEET AND RECORD 3. ANY VARIATIONS FROM INITIAL DOBLE RESULTS SHOULD BE BROUGHT TO THE ATTENTION OF THE P AND C SUPERVISOR. ALL DOBLING COMPLETED EXCEPT FOR LIGHTNING ARRESTERS. RESULTS DISCUSSED WITH J. WHEELER. TO BE DISCUSSED WITH R. STOYLES AFTER RETURN FROM HOLIDAYS. LIGHTNING ARRESTERS DONE SEPT 5, 2007 COMPLETED BY: L. HOPKINS/G. PARSONS ON 2007-08-17 SEE W/O 601397.	47826	90
601395	9/7/2007	SSDTS,T1,XFMR PM MTNCE	1.PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK 2.RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
601395	9/7/2007	SSDTS,T1,XFMR PM MTNCE	DATE. 3.CONSIDER & REPORT ANY ENVIROMENTAL IMPACTS. MAINTENANCE PERFORMED AS PER CHECK SHEETS. COMPLETED BY: P. O'GRADY & CREW ON 2007-09-07	47825	90
603694	5/30/2008	SSDTS,T1 TAP CHANGER OIL SAMPL	SSDTS,T1 RETEST TAP CHANGER OIL SAMPLE RETEST IN 90 DAYS AS PER LAB REPORT 3 SAMPLES REQUIRED T1-A, T1-B, T1-C QUOTE WORK ORDER ON INVOICE (OUTAGE REQUIRED) 3 TAP CHANGER OIL SAMPLES TAKEN. COMPLETED BY: W. DOWNING & B. WALSH ON 2008-04-28	47825	90
657773	2/22/2010	SSDTS,T1,LEAK,RAD VALVE,REPAIR	SSDTS: Eastern Terminal Station Equipment T1 - Rad valve has a small leak. Need to be repaired. SWOP#2008002855 OUTAGE REQUIRED TO PERFORM PROPER INSPECTION BOTH UP DOWN VALVE ON THE RAD OF T1 SSD. COMPLETED BY: P. O'GRADY NOT ADVISABLE TO ADJUST OR TIGHTEN GLAND NUT OR UNLESS PREPARED TO DRAIN RAD. COMPLETED BY: H. MOORES & W. DEAN ON 2008-11-25	47825	90
821736	12/29/2010	SSDTS HIGH PT VOLTAGE TL206	SSDTS HIGH PT VOLTAGE TL206 LOW P.T. VOLTAGE AND PROTECTION INOPRATIVE ALARM A PHASE FUSE BLOWN REPLACED FUSE WITH GLASS TYPE OK COMPLETED BY: L. HOPKINS ON 2010-12-29	47825	80
847577	10/2/2012	SSDTS,T1 TAPCHANGER OIL SAM	SSDTS, T1 TAP CHANGER OIL SAMPLE (OUTAGE REQUIRED) OBTAIN OIL SAMPLE FOR AS PER T.SHAVE'S INSTRUCTIONS QUOTE WORK ORDER ON INVOICE SAMPLE EACH PHASE (3) 1) If oil volume in the equipment is less than 250 gallons (1200 L) flush 1 quart of oil, otherwise flush a gallon into waste oil container. 2) Bottle Samples: rinse bottle by partially filling and	47825	80

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
847577	10/2/2012	SSDTS,T1 TAPCHANGER OIL SAM	gently swirling and emptying the oil into the waste container. Fill bottle to within an inch of the top, to allow for expansion. Visually examine fluid for water droplets or foreign particles. If present, re-sample. If not, attach the cap securely, identify the sampled unit on the bottle's label. Do not tape the cap. 3) Syringe Samples: the plastic stopcock, which comes with the syringe must remain firmly affixed to the syringe to prevent leaks. Flushing the syringe: a) Move the handle toward the sampling valve. b) Open sampling valve and move the handle toward the syringe allowing oil to flush the tube and stopcock. c) Move the handle towards the side port, allowing oil pressure to enter the syringe barrel, forcing the plunger out. Until the inside of the syringe has been wetted with oil, it may be necessary to pull the plunger. d) When oil reaches the 50 cc mark, move the handle towards the sampling valve and eject oil from ssyringe by pushing in the plunger. Catch this ejected oil in waste container Draw the Sample: a) Move the handle towards the side port and allow oil pressure to fill the syringe. DO NOT PULL ON THE PLUNGER When oil reaches the 40-45cc mark, move the handle towards the syringe. Do not over fill the syringe to avoid gas escape from the plunger side. b) Examine sample to ensure it is free of bubbles and foreign particles. If sample is good, move handle towards the syringe, close drain valve and remove the syringe with stopcock still firmly attached to the syringe. If sample is not clear, repeat sample procedure. c) Record info: on sample bottle check sheet as per enclosed instructions. --- ENSURE THAT LAB RESULTS ARE FORWARDED TO JIM HUGHIE IRELAND IN BISHOP'S FALLS AND A COPY OF THE	47825	80

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
847577	10/2/2012	SSDTS,T1 TAPCHANGER OIL SAM	ORDER BE SENT WITH THE LAB SAMPLE.CONTACT FOLLOWS.JIM:258-2331,JWHEELER@NLH.NL.CA,HUGHIE:258-23 HIRELAND@NLH.NL.CA OIL SAMPLE TAKEN AND MADE READY FOR SHIPMENT COMPLETED BY: P. O'GRADY (ONE SAMPLE TAKEN - RESAMPLE ALL THREE PHASES) 9 OIL SAMPLES TAKEN 3 FROM EACH PHASE. COMPLETED BY: W. DOWNING & I. ORGAN ON 2012-10-02	47825	80
861948	3/20/2012	SSDTS,T1 TAP CHANGER PCB TEST	SSDTS,T1 TAP CHANGER PCB TEST OBTAIN OIL SAMPLE(S) FROM TAP CHANGER AND SEND TO LAB ANALYSIS OF PCB CONTENT.PLEASE RECORD THE FOLLOWING ON SAMPLE BOTTLE LABELS: SAMPLE TKEN AND MADE READY FOR SHIPMENT COMPLETED BY: P. O'GRADY ON 2012-03-20	47825	80
907578	3/27/2012	SSDTS,T1,SILICA GEL REPLACE	SSDTS,T1,SILICA GEL REPLACE REPLACED SILICA GEL ON T1 SSD T.S COMPLETED BY: P. O'GRADY ON 2012-03-07	47825	80
928134	10/2/2012	SSDTS,T1 TAP CHANGER PCB TEST	SSDTS,T1 TAP CHANGER PCB TEST OBTAIN OIL SAMPLE(S) FROM TAP CHANGER AND SEND TO LAB ANALYSIS OF PCB CONTENT.PLEASE RECORD THE FOLLOWING ON SAMPLE BOTTLE LABELS: SAMPLE TKEN AND MADE READY FOR SHIPMENT COMPLETED BY: P. O'GRADY ON 2012-03-20 OIL SAMPLE TAKEN AND SENT TO LAB FOR TESTING. COMPLETED BY: W. DOWNING & I. ORGAN ON 2012-10-02	47825	80
944074	10/25/2012	SSDTS,T1,CONDUIT TO LL SWITCH	SSDTS,T1,CONDUIT TO LL SWITCH REPLACE CONDUIT REPAIRED TO CONDSERVATOR LEVEL GAUGE. CPMPLETED BY: W. DOWNING ON 2012-10-25	47825	80
944076	10/25/2012	SSDTS,T1,SS COVERS REPAIR	SSDTS,T1,SS COVERS REPAIR SS TRANSFORMER COVER REMOVED, STRAIGHTENED OUT,	47825	80

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
944076	10/25/2012	SSDTS,T1,SS COVERS REPAIR	REINSTALLED. COMPLETED BY: W. DOWNING ON 2012-10-25	47825	80
944086	10/24/2012	SSDTS,T1 TAP CHANGER PCB TEST	SSDTS,T1 TAP CHANGER PCB TEST OBTAIN OIL SAMPLE(S) FROM TAP CHANGER AND SEND TO LAB ANALYSIS OF PCB CONTENT.PLEASE RECORD THE FOLLOWING ON SAMPLE BOTTLE LABELS: SAMPLE TAKEN AND MADE READY FOR SHIPMENT. COMPLETED BY: P. O'GRADY ON 2012-03-20 OIL SAMPLES TAKEN AND SENT TO LAB FOR TESTING. COMPLETED BY: W. DOWNING & I. ORGAN ON 2012-10-02 OIL SAMPLES TAKEN. COPLETED BY: W. DOWNING ON 2012-10-24	47825	80
1027651	1/22/2014	SSDTS,B1 REMOVE JUMPERS	SSDTS,B1 REMOVE JUMPERS JUMPERS REMOVED. COMPLETED BY: R. DAY ON 2014-01-22	47825	80

AIR BLAST CIRCUIT BREAKER - FORM II

94 Jul 04

Brk. No. B1L03 Brk S/N B142569 Date 2002/12/06 Station 55A

Ambient Temp. [illegible] Type DCVP Mfg. BROWN BOVERI

Before Operating: Pressure [illegible] PSI Counter 900525

Lubricate Control Blocks: Yes ✓ No _____

Coil Resistance: Trip: A 10.7 B 10.6 C 10.6
Close: A 68.2 B 67.3 C 69

DUCTOR TEST: Results (Micro Ohms)
A Phase: Amps 100 Reading 390
B Phase: Amps 100 Reading 422 micro Ω
C Phase: Amps 100 Reading 360

CHECK PRESSURE SWITCHES On Falling Pressure:

Block Reclose:	Found	213	Left	213
Block Trip:	Found	152	Left	156
Block Close:	Found	170	Left	170
Low Pressure Alarm:	Found	195	Left	195

CLEAN AUX.. CONTACTS:
DLF Breakers(Switch # 2610) A Phase _____ B Phase _____ C Phase _____

TIMING TEST:
3 Phase Close: _____
Milliseconds
3 Phase Trip: _____
Milliseconds
Trip Free: _____
Milliseconds
Disagreement: _____
Milliseconds
Open-Close-Open _____
Milliseconds

Check All Connections: _____ 9.4G 7.35GN 2.88G

Megger (5KV) A Phase ~~3~~ B Phase ~~3~~ C Phase ~~3~~

20-Minute Pressure
Drop: 2.28 - 2.27

Heater Amps: Cabinet 1.4 Control Blocks: A .36 B .36 C .38

After Operating: Pressure 2.25 Counter 0539

ONLY IF INSTRUCTED

Clean Intake Filter	Yes _____	
Inspect One Arcing Chamber	Yes _____	Lubrication Required _____
Clean Pressure Reducing Valve	Yes _____	
Lubricate All Arcing Chambers	Yes _____	
Time Individual Heads	Yes _____	
Doble Test	Yes _____	

Remarks: B & Shack Chipped Tank Supports rusted

Test Completed By D Downing C Bradwell

THIS FORM SHOULD BE USED AS A GUIDE IN CARRYING OUT WORK

FORM [illegible] AIR BLAST CIRCUIT BREAKER INSPECTION

384 123

System ID: Station: B1203 Serial No.: 55D B-1425698 584868
Manufacturer: Brown Boveri, Type: 230 KV. Voltage:
Test Date: 2007/06/01 Test Completed By: K.H. W.D. B.W. J.D.E.W/O #:

WEATHER CONDITIONS: (dry) rain humidity temperature 6°C
BEFORE OPERATING: Pressure 230 PSI ~~kPa~~ Counter: 90146
AFTER - 230 PSI 90154

NOTE: All TESTS MUST BE COMPLETED OR MARKED N/A (unless otherwise Instructed).

DUCTOR (RESISTANCE) READING		
	% CURRENT	MICRO Ω
A ph	100	350
B ph	100	400
C ph	100	360

B1425698

TIMING TEST (milliseconds)			
	A	B	C
3-PH Close	SEE ATTACHED		SHEET 5
3-PH Trip			
Trip Free (dwell)			
Disagreement On Trip			
Resistor Contacts			

Command Current Close 4.86 amps Trip 7.06 amps

NOTE: THE BREAKER (TIMING TEST) PERFORMANCE REPORT INCLUDING ALL MAIN & RESISTOR CONTACTS SHOULD BE ATTACHED TO THE COMPLETED INSPECTION FORM. (If Applicable)

CONTROL CIRCUIT RESISTANCE (Ohms): (Tests to be Completed from Control Cabinet Terminal Board)							
Trip Coil # 1: 11.7	A ph	Ω	B ph	11.7	Ω	C ph	12 Ω
Trip Coil # 2: N/A	A ph	– Ω	B ph	–	Ω	C ph	Ω
Close:	A ph	73 Ω	B ph	74	Ω	C ph	75 Ω

INTERRUPTOR MEGGER TEST 5 KV (Breaker in Open Position) (Test Location Left/Right to be taken from Control Panel)			
A PH	1 LEFT 240 GΩ Mega Ω	2 LEFT Mega Ω	3 LEFT Mega Ω
	RIGHT Mega Ω	RIGHT Mega Ω	RIGHT Mega Ω
B PH	1 LEFT 340 GΩ Mega Ω	2 LEFT Mega Ω	3 LEFT Mega Ω
	RIGHT Mega Ω	RIGHT Megger leads heads to ground Mega Ω	RIGHT Mega Ω
C PH	1 LEFT 250 GΩ Mega Ω	2 LEFT Mega Ω	3 LEFT Mega Ω
	RIGHT Mega Ω	RIGHT Mega Ω	RIGHT Mega Ω

HEATER : AMPS		CABINET HEATER: 1.55 A.	
CONTROL BLOCKS:	A: ON 0.22 A.	B: 0.24 A.	C: 0.22 A.

FORM [illegible] AIR BLAST CIRCUIT BREAKER INSPECTION

System ID: Station:Serial No.: B1L03 55D B1425698
Manufacturer: Type: Voltage:
Test Date: _____ Test Completed By: GH WD BW. J.D.E.W/O #: ___

PRESSURE SETTINGS (kPa)		
	Found	Left
Block Reclose	213	213
Block Trip	156	156
Aux Block Trip		
Block Close	170	170
Low Pressure Alarm	195	195

AFTER OPERATING: Pressure 230 kPa Counter:

CHECKS COMPLETED:

- Air Leaks
- Lubricate Control Blocks
- Check Primary Connections
- 20 Minute Pressure Drop — Start 230. After APP 228.
- _____ Safety Relief valve operation (If Applicable)

ONLY IF INSTRUCTED

- Doble Test
- Clean Air Intake Filters
- Inspect 1 Arcing Chamber
  - Chamber Lubrication Required yes no

COMMENTS:

5994

(2)

AIR BLAST CIRCUIT BREAKER - FORM II

94 Ju

Brk. No. B1L17 Brk S/N 170-73-3/1993 Date 2001/09/12 Station HRD

Ambient Temp. 25°C Type DLF 245 NC 2 Mfg. BROWN/ BOVERI

Before Operating: Pressure _____ Counter 1462

Lubricate Control Blocks: Yes _____ No _____

Coil Resistance: Trip: A 13.2 B 13.4 C 13.2
Close: A 137 B 138 C 135

DUCTOR TEST: Results (Micro Ohms)
A Phase: Amps 100 Reading 174 U ohms
B Phase: Amps 100 Reading 94 U ohms
C Phase: Amps 100 Reading 122 U ohms

CHECK PRESSURE SWITCHES On Falling Pressure:
Block Reclose: Found 400 PSI Left 400 PSI
Block Trip: Found 382 PSI Left 382 PSI
Block Close: Found 370 PSI Left 370 PSI
Low Pressure Alarm: Found 300 PSI Left 300 PSI

CLEAN AUX.. CONTACTS:
DLF Breakers(Switch # 2610) A Phase OK B Phase OK C Phase OK

TIMING TEST:
3 Phase Close: As per test sheets. Milliseconds
3 Phase Trip: _____ Milliseconds
Trip Free: _____ Milliseconds
Disagreement: _____ Milliseconds
Open-Close-Open _____ Milliseconds

Check All Connections: ✓

Megger (5KV) A Phase 1250 mΩ B Phase 1250 mΩ C Phase 1750 mΩ

20-Minute Pressure Drop: _____

Heater Amps: Cabinet ✓ Control Blocks: A ✓ B ✓ C ✓

After Operating: Pressure _____ Counter 1469

ONLY IF INSTRUCTED
Clean Intake Filter Yes _____
Inspect One Arcing Chamber Yes _____ Lubrication Required _____
Clean Pressure Reducing Valve Yes _____
Lubricate All Arcing Chambers Yes _____
Time Individual Heads Yes _____
Doble Test Yes _____

FORM II - AIR BLAST CIRCUIT BREAKER INSPECTION

System ID: B1L17 Station: HRDTS Serial No.: 170-73-37/973
Manufacturer: Brown Boveri Can Ltd Type: AIR BLAST DLF 245 NO2 Voltage: 230 KV
Test Date: 2006-10-10 Test Completed By: B.W G.H. J.D.E.W/O #: 551787

WEATHER CONDITIONS: ✓ dry _____ rain _____ humidity 10°C temperature

NOTE: All TESTS MUST BE COMPLETED OR MARKED N/A (unless otherwise Instructed).

BEFORE OPERATING: Pressure 426 ~~kPa~~ P.S.I Counter: 1657

DUCTOR (RESISTANCE) READING		
	% CURRENT	MICRO Ω
A ph	100%	165 uΩ
B ph	100%	83 uΩ
C ph	100%	98 uΩ

TIMING TEST (milliseconds)			
	A	B	C
3-PH Close	52.1	53.1	51.2
3-PH Trip	24.3	25.3	24.8
Trip Free (dwell)	56.2	48.6	50.9
Disagreement On Trip	24.7	24.8	1599.9
Resistor Contacts			

Command Current Close _____ amps Trip _____ amps

NOTE: THE BREAKER (TIMING TEST) PERFORMANCE REPORT INCLUDING ALL MAIN CONTACTS SHOULD BE ATTACHED TO THE COMPLETED INSPECTION FORM.

CONTROL CIRCUIT RESISTANCE (Ohms): (test to be completed from the Control Cabinet Terminal Board)								
Trip Coil # 1:	A ph	13.1	Ω	B ph	13	Ω	C ph	13.4 Ω
Trip Coil # 2:	A ph	13	Ω	B ph	13	Ω	C ph	13 Ω
Close:	A ph	45	Ω	B ph	44.8	Ω	C ph	45 Ω

INTERRUPTOR MEGGER TEST 5 KV (Mega Ω) (B1B2 at WAVTS has 2 Interrupters per Phase all other DLF Breakers have 1 per phase)				
A PH	# 1 LEFT 76 GΩ	/ RIGHT	# 2 LEFT 75 GΩ	/ RIGHT
B PH	# 1 LEFT 74 "	/ RIGHT	# 2 LEFT 76 GΩ	/ RIGHT
C PH	# 1 LEFT 76 "	/ RIGHT	# 2 LEFT 74 GΩ	/ RIGHT

HEATER AMPERAGE:			
CABINET HEATER :	4.77 Amps. Total		
CONTROL BLOCKS:	A: 0.58	B: .56	C: .57

FORM II - AIR BLAST CIRCUIT BREAKER INSPECTION

System ID: BIL17 Station: HRD Serial No.: 170-73-3 | 1973
Manufacturer: Brown Boveri Type: DLF 245 n2 Voltage: 230 K.V
Test Date: 2006 | 10 | 11 Test Completed By: GH . B.W. S.T. DH J.D.E.W/O #: _____

PRESSURE SETTINGS (kPa)		
	Found	Left
Block Reclose	400	400
Block Trip	370	370
Aux Block Trip	-	-
Block Close	382	382
Low Pressure Alarm	306	306

CHECKS COMPLETED:
- OK. Air Leaks
- NO Lubricate Control Blocks
- yes Check Primary Connections
- yes 20 Minute Pressure Drop
- ✓ Safety Relief valve operation (If Applicable)

AFTER OPERATING: Pressure 435 ~~kPa~~ psi Counter: 1663

ONLY IF INSTRUCTED
- NO Doble Test
- NO Clean Air Intake Filters
- NO Inspect 1 Arcing Chamber

Chamber Lubrication Required _____ yes ✓ no

COMMENTS:

performed Megger test across contacts on Breaker

Sheet 2 of 2

DOBLE INSULATION TESTS

~~CIRCUIT~~ ~~BREAKER~~ C17

DOBLE ENGINEERING COMPANY
WATERTOWN, MASS.
FORM MH-CB178

COMPANY Hydro
LOCATION OF TESTS White River
CIRCUIT BREAKER
BREAKER MFR. TYPE
BREAKER SERIAL NO. KV AMPS.
DATE LAST INSP. DATE LAST TEST LAST TEST SHEET NO.
BUSHING MFR. BR BUSHING (TYPE-FORM-DWG.NO.)

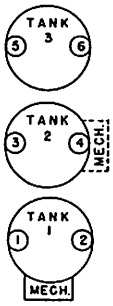
DATE July 7/82
AIR TEMP. 75°F OIL TEMP.
WEATHER % HUM.
AGE
BROWN BOVERI CAPACITORS

	BUSH. NO.	CAPACITOR BUSHING SERIAL NO.	SIDE	PHASE	FEET OF BUS	INS. IN PARLL	TEST KV	EQUIVALENT 10 KV READINGS: MICROAMPERES METER READING	MICROAMPERES MULTIPLIER	MICROAMPERES MICRO-AMPERES	WATTS METER READING	WATTS MULTIPLIER	WATTS WATTS	% POWER FACTOR MEASURED	% POWER FACTOR COR. 20°C	COLLAR TEST (WATTS/CURRENT)	CAP INSULATION RATING
OPEN CIRCUIT BREAKER	1	B1					10	1.6	10uA	660						BAD	
	2	B2					10	45	10	450	43	.002	.096	1.58			114 PF
	3	B3	OVERALL				10	43	10u	430	49	.002	.098	2.32			115 PF
	4	B4					10	46	10u	460	52	.002	.104	2.28			122
	5	B5					10	45	10uA	4.50	44	.002	.088	1.59			121
	6	B6					10	42	10uA	420	48	.002	.096	2.30			112
C.B. CLOSED	TANK 1	B7					10	44	10uA	440	48	.002	.096	2.20			117.2
	TANK 2	B8					10	42	10uA	420	80	.002	.160	3.7			113 G
	TANK 3	B9					10	40	10uA	460	90	.002	.180	4.5			106

OTHER TESTS

LINE NO.																	
1	B10											BAD				BAD	
2	B11							44	10uA	440	62	.002	.124	2.8			115
3	B12							43	10uA	430	47	.002	.094	2.2			114.8
4	B13							43	10uA	430	48	.002	.096	2.2			114.2
5	B14							43	10uA	430	62	.002	.124	2.8			114
6	B15								BAD							BAD	
7	B16															BAD	
8	B17															BAD	
9	B18															BAD	
10		New CAP.						Tested		To Complete		Set.					
11	B1						10	12	10uA	120	11.0	.002	.022	1.8			31.2 G
12	B10						10	12	10uA	120	13.5	.002	.027	2.2			30.6 G
13	B15						10	12	10uA	120	10.5	.002	.021	1.7			30.7 G
14	B16						10	12	10uA	120	11.0	.002	.022	1.8			31.0 G
15	B17						10	11	10uA	110	17	.002	.034	3.1			26.9 G
16	B18						10	12	10uA	120	10.5	.002	.021	1.7			31.2 G

KEY TO BUSHING NO.



REMARKS

KEY TO INSULATION RATING

BUSHINGS-INSULATORS-ETC.	WOOD MEMBERS-OIL-ETC.	WINDINGS
G-GOOD	XG-GOOD	WG-GOOD
D-DETERIORATED	XD-DETERIORATED	WD-DETERIORATED
I-INVESTIGATE	XI-INVESTIGATE	WI-INVESTIGATE
B-BAD (REMOVE OR RECONDITION)	XB-BAD (REMOVE OR RECONDITION)	WB-BAD (REMOVE OR RECONDITION)

TEST SET NO. _____ TEST BY _____ CHECKED BY _____ SHEET NO. _____

D.C.V.F. CAPACITOR TEST SHEET

STATION: SSD

3L203

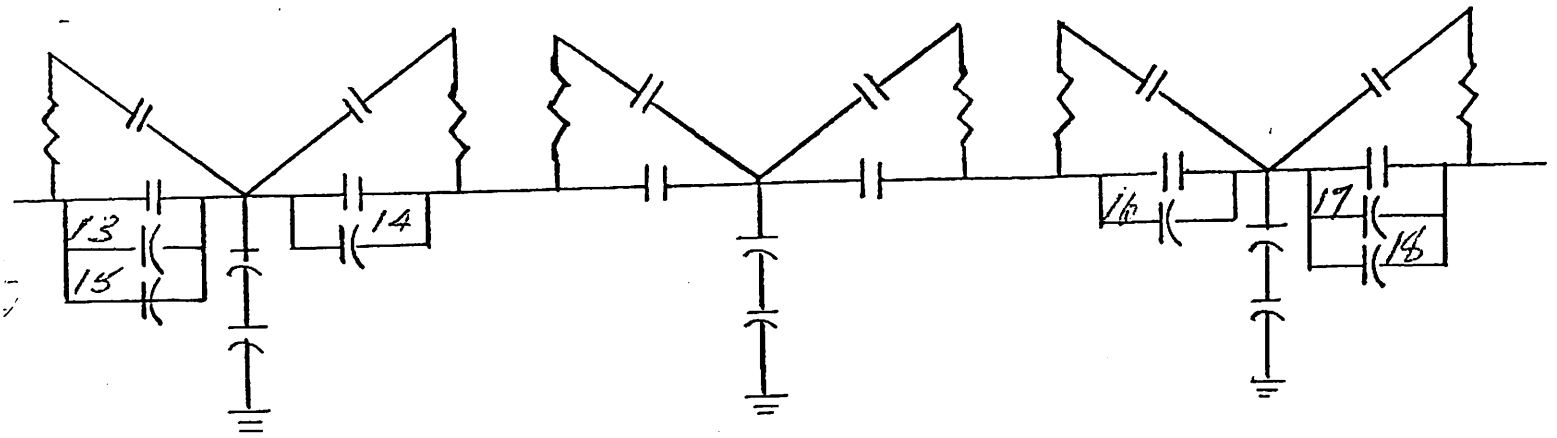
DATE: MARCH 10, 83

INSP. BY: C. MERKER

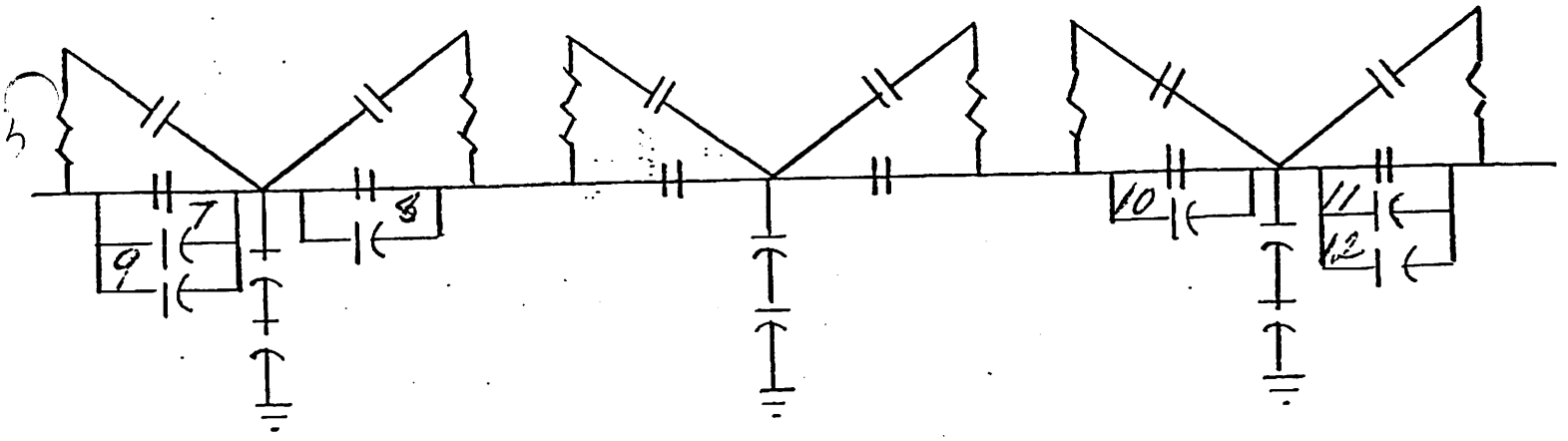
DISCONNECT NO. 3L203-2

DISCONNECT NO. 3L203-1

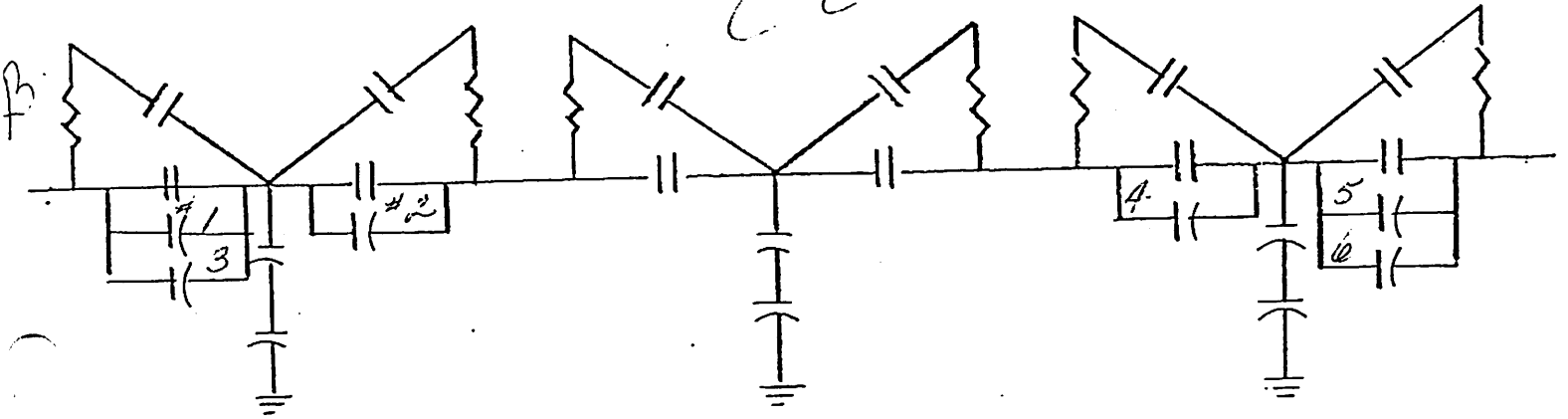
-10



-30



-50



REMARKS: Replaced Caps with ones Tested down, Cleaned Painted & dabbed

MISCELLANEOUS EQUIPMENT

(SPARE BUSHINGS, INSTRUMENT TRANSFORMERS, ETC.)

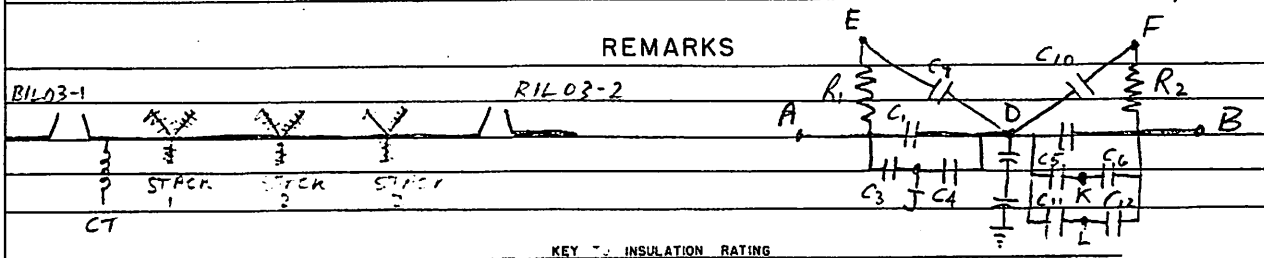
DOBLE ENGINEERING COMPANY
WATERTOWN, MASS.
FORM MH—ME178

COMPANY NFLD HYDRO — DATE 81-08-05
LOCATION OF TESTS SSD TS — AIR TEMP. 25°C — OIL TEMP.
EQUIPMENT TESTED BIL03 (ABCB) — WEATHER cloudy — % HUM. 50
MFG: BROWN BOVERI — DATE LAST TEST
Ser. # 3841 — LAST TEST SHEET NO.

COPIES TO PHASE A

	LINE NO.	STACK # SERIAL NO.	TEST KV	EQUIVALENT 10 KV READINGS MICROAMPERES METER READING	MULTIPLIER	MICROAMPERES	WATTS METER READING	MULTIPLIER	WATTS	% POWER FACTOR MEASURED	COR. 20°C	ENER	GND	Meas.	Cpf	INSULATION RATING
+31,+31	1		10	26	.02	.52	31	.01	.31	5.96		D	A,B	overall	137	G
+20,+18	2	1	10	25	.02	.50	19	.01	.19	3.8		J	A,D	C_3+C_4	134	G
+20,+24	3		10	25	.02	.50	22	.01	.22	4.4		K	D,B	C_5+C_6	128.4	G
+31,+29	4		10	22	.02	.44	30	.01	.30	6.8		L	D,B	$C_{11}+C_{12}$	114	D
+18,+16	5		10	25	.02	.50	17	.2	3.4	29.4 mΩ		A	F	R1	81	G
+17,+23	6		10	24	.02	.48	20	.2	4.0	25 mΩ		B	F	R2	78	G
	7															
	8															
+6,+2	9		10	9	.02	.18	4	.02	.08	4.4		D	A,B	overall	49	G
+33,+36	10	2	10	21	.02	.42	34.5	.1	3.45	29 mΩ		A	E	R1	70	G
+22,+22	11		10	23	.1	2.3	22	1	22	4.55 mΩ		B	F	R2	253	B
	12															
	13															
+34,+34	14		10	51	.02	1.02	34	.2	6.8	66.7		D		overall	158	I
+11,+6	15	3	10	26	.02	.52	8.5	.02	.17	3.27		J		C_3+C_4	141	G
+12,+8	16		10	25	.02	.50	10	.02	.20	4		K		C_5+C_6	128	G
	17		10	21	.1	2.1	no watts reading					L		$C_{11}+C_{12}$	—	B
+18,+20	18		10	22	.02	.44	19	.2	3.8	26.32 mΩ		A		R1	50	G
+21,+19	19		10	25	.02	.50	20	.2	4	25 mΩ		B		R2	102	G
	20															
	21			Standard test not performed, but												
	22			test indicate that												
	23			① A Ø - CENTER STACK - RESISTOR (B TO A) LOW MΩ READING												
	24			② Ø Ø - STACK #3 (NEAR BIL03-2) - BAD CAPACITOR												
	25			DESIGNATED C5 & C6												
	26															
	27															
	28															
	29															

REMARKS



KEY TO INSULATION RATING

BUSHINGS-INSULATORS-ETC.	WOOD MEMBERS-OIL-ETC.	WINDINGS
G=GOOD	XG=GOOD	WG=GOOD
D=DETERIORATED	XD=DETERIORATED	WD=DETERIORATED
I=INVESTIGATE	XI=INVESTIGATE	WI=INVESTIGATE
B=BAD (REMOVE OR RECONDITION)	XB=BAD (REMOVE OR RECONDITION)	WB=BAD (REMOVE OR RECONDITION)

TEST SET NO. M2H-122 TEST BY CA DS CHECKED BY _____ SHEET NO. NLH-SSD-BIL03-B1-1

Case # 25

DOBLE INSULATION TESTS

MISCELLANEOUS EQUIPMENT

(SPARE BUSHINGS, INSTRUMENT TRANSFORMERS, ETC.)

DOBLE ENGINEERING COMPANY
WATERTOWN, MASS
FORM MH–ME178

COMPANY NFLD HYDRO — DATE 81-08-05

LOCATION OF TESTS SSD TS — AIR TEMP. 25°C — OIL TEMP.

EQUIPMENT TESTED BIL03 (ATCB) — WEATHER Cloudy — % HUM. 50%

DATE LAST TEST

Ser# 3842 — LAST TEST SHEET NO.

COPIES TO

PHASE B

LINE NO.	STACK # SERIAL NO.	TEST KV	EQUIVALENT 10 KV READINGS MICROAMPERES METER READING	MULTIPLIER	MICRO-AMPERES	WATTS METER READING	MULTIPLIER	WATTS	% POWER FACTOR MEASURED	COR. 20°C	ENER		Cpf.	INSULATION RATING
+14,+10 — 1		10	25	.02	.50	12	.02	.24	4.8		D		130	G
+8,+8 — 2	1	10	24	.02	.48	8	.02	.16	3.3		J		130	G
+19,+9 — 3		10	20	.02	.40	13	.02	.26	6.5		K		100	D
+5,+7 — 4		10	24	.02	.48	6	.02	.12	2.5		L		128	G
+31,+37 — 5		10	21	.02	.42	34	.1	2.9	34.5	MΩ	A		79	G
+40,+40 — 6		10	24	.02	.48	40	.1	4.0	25	MΩ	B		73	G
7														
8														
+6,+8 — 9		10	9	.02	.18	7	.01	.07	3.9		D		47	G
+37,+37 — 10	2	10	22	.02	.44	37	.1	3.7	27	MΩ	A		62	G
+36,+38 — 11		10	23	.02	.46	37	.1	3.7	27	MΩ	B		58	G
12														
13														
+10,+8 — 14		10	26	.02	.52	9	.02	.18	3.5		D		140	G
+6,+10 — 15	3	10	24	.02	.48	8	.02	.16	3.3		J		130	G
+6,+10 — 16		10	24	.02	.48	8	.02	.16	3.3		K		127	G
+9,+3 — 17		10	24	.02	.48	6	.02	.12	2.5		L		125	G
+40,+40 — 18		10	25	.02	.50	40	.1	4	25	MΩ	A		62	G
+42,+38 — 19		10	24	.02	.48	40	.1	4	25	MΩ	B		65	G
20														
21														
22														
23														
24														
25														
26														
27														
28														
29														

REMARKS

KEY TO INSULATION RATING

BUSHINGS–INSULATORS–ETC.	WOOD MEMBERS–OIL–ETC.	WINDINGS
G=GOOD	XG=GOOD	WG=GOOD
D=DETERIORATED	XD=DETERIORATED	WD=DETERIORATED
I=INVESTIGATE	XI=INVESTIGATE	WI=INVESTIGATE
B=BAD (REMOVE OR RECONDITION)	XB=BAD (REMOVE OR RECONDITION)	WB=BAD (REMOVE OR RECONDITION)

TEST SET NO. _____ TEST BY CO DS CHECKED BY _____ SHEET NO. NLH-SSD-BIL03-BI-2

DOBLE INSULATION TESTS

MISCELLANEOUS EQUIPMENT

(SPARE BUSHINGS, INSTRUMENT TRANSFORMERS, ETC.)

DOBLE ENGINEERING COMPANY
WATERTOWN, MASS.
FORM MH—ME178

COMPANY NFLD HYDRO — DATE 81-08-05

LOCATION OF TESTS SSD-TS — AIR TEMP. 25°C — OIL TEMP.

EQUIPMENT TESTED BIL03 (AB3CB) — WEATHER Cloudy — % HUM. 50%

DATE LAST TEST

Ser # 3843 — LAST TEST SHEET NO.

COPIES TO PHASE C

	LINE NO.	STACK # SERIAL NO.	TEST KV	EQUIVALENT 10 KV READINGS MICROAMPERES METER READING	MULTIPLIER	MICROAMPERES	WATTS METER READING	MULTIPLIER	WATTS	% POWER FACTOR MEASURED	COR. 20°C	ENER		Cpf	INSULATION RATING
+25,+27	1		10	25	.02	.50	26	.01	.26	5.2		D		130	G
+32,+8	2	1	10	25	.02	.50	20	.01	.20	4		J		134	G
+47,+21	3		10	25	.02	.50	34	.01	.34	6.8		K		136	D
+37,+13	4		10	20	.02	.40	25	.01	.25	6.25		L		55	D
+30,+34	5		10	21	.02	.42	32	.1	3.2	31.25 MΩ		A		66	G
+38,+36	6		10	22	.02	.44	37	.1	3.7	27 MΩ		B		76	G
	7														
	8														
+12,+4	9		10	9	.02	.18	8	.01	.08	4.4		D		48	G
+36,+40	10	2	10	24	.02	.48	38	.1	3.8	26.32 MΩ		A		77	G
+39,+31	11		10	22	.02	.44	35	.1	3.5	28.6 MΩ		B		74	G
	12														
	13														
+11,+9	14		10	26	.02	.52	10	.02	.20	3.85		D		140	G
+5,+9	15	3	10	25	.02	.50	7	.02	.14	2.8		J		134	G
+7,+11	16		10	24	.02	.48	9	.02	.18	3.8		K		127	G
+13,+5	17		10	24	.02	.48	9	.02	.18	3.8		L		127	G
+68,+74	18		10	41	.02	.82	71	.1	7.1	14 MΩ		A		100	D
+43,+39	19		10	25	.02	.50	41	.1	4.1	24.4 MΩ		B		69	G
	20														
	21														
	22	[illegible]													
	23														
	24														
	25														
	26														
	27														
	28														
	29														

REMARKS

KEY TO INSULATION RATING

BUSHINGS-INSULATORS-ETC.	WOOD MEMBERS-OIL-ETC.	WINDINGS
G=GOOD	XG=GOOD	WG=GOOD
D=DETERIORATED	XD=DETERIORATED	WD=DETERIORATED
I=INVESTIGATE	XI=INVESTIGATE	WI=INVESTIGATE
B=BAD (REMOVE OR RECONDITION)	XB=BAD (REMOVE OR RECONDITION)	WB=BAD (REMOVE OR RECONDITION)

TEST SET NO. M2H-122 — TEST BY CG, DS — CHECKED BY _____ — SHEET NO. NLH-SSD-BIL03-81-3

Cas: #25

DOBLE INSULATION TESTS

MISCELLANEOUS EQUIPMENT

(SPARE BUSHINGS, INSTRUMENT TRANSFORMERS, ETC.)

DOBLE ENGINEERING COMPANY

FORM MH-ME178

COMPANY HYDRO — DATE 80-10-15

LOCATION OF TESTS SSD — AIR TEMP. 10°C — OIL TEMP.

EQUIPMENT TESTED BIL03 ABCB — WEATHER Sunny — % HUM. 70

TYPE. DCUF. - 230KV 1250 Amps — DATE LAST TEST

MFR. BROWN BOVERI — LAST TEST SHEET NO.

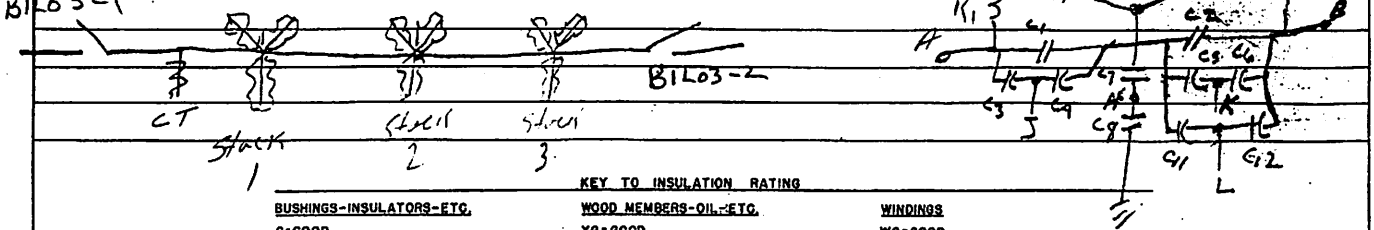
S.N. 3841

COPIES TO A phase

LINE NO.	Stacks ~~SERIAL NO.~~	TEST KV	EQUIVALENT 10 KV READINGS MICROAMPERES METER READING	MULTIPLIER	MICRO-AMPERES	EQUIVALENT 10 KV READINGS WATTS METER READING	MULTIPLIER	WATTS	% POWER FACTOR MEASURED	COR. 20°C	ENER	GND	Measure	INSULATION RATING
1		10	78	10uA	780	35	.1	3.5	45.		D	A, B	Overall	
2		10	57	10uA	570	67	.01	.67	7.3		J	A D	C_3+C_4	
3	1	10	51	10uA	510	41	.01	.41	8.0		K	D, B	C_5+C_6	
4		10	58	.02	1.16	48	.2	9.6	84		L	D, B	$C_{11}+C_{12}$	
5		10	98	10uA	900	65	.10	6.5	11.1	mA	A	E	R_1	
6		10	53	10uA	530	35	.1	3.5	18.9	"	B	F	R_2	
7														
8		10	19	10uA	190	68	.002	.136	7.2		D	AB	Overall	
9	2	10	41	10uA	410	30	.1	3.0	24.4	mA	A	E	R_1	
10		10	58	10uA	580	50	.2	10	17.5	"	B	F	R_2	
11														
12		10	53	10uA	530	58	.01	.58	11.0		D	Same as		
13		10	52	10uA	520	44	.01	.44	9.4		J	above		
14		10	51	10uA	510	58	.01	.50	9.8		K			
15	3	10	45	10uA	450	52	.01	.52	11.2		L			
16		10	42	10uA	420	35	.1	3.5	23.8	mA	A			
17		10	43	10uA	430	31	.1	3.1	22.3	"	B			
18														
19														
20														
21														
22														
23														
24														
25														
26														
27														
28														
29														

+36, +34
+77, +57
+49, +33
+48, +48
+63, +67
+35, +35
+69, +67
+30, +30
+50, +50
+57, +59
+48, +48
+50, +50
+52, +52
+35, +35
+28, +34

REMARKS



KEY TO INSULATION RATING

BUSHINGS-INSULATORS-ETC.	WOOD MEMBERS-OIL-ETC.	WINDINGS
G=GOOD	XG=GOOD	WG=GOOD
D=DETERIORATED	XD=DETERIORATED	WD=DETERIORATED
I=INVESTIGATE	XI=INVESTIGATE	WI=INVESTIGATE
B=BAD (REMOVE OR RECONDITION)	XB=BAD (REMOVE OR RECONDITION)	WB=BAD (REMOVE OR RECONDITION)

TEST SET NO. M12H-129 TEST BY R.R.V.S. CHECKED BY _____ SHEET NO. 193

DOBLE INSULATION TESTS

DOBLE ENGINEERING COMPANY

MISCELLANEOUS EQUIPMENT

FORM MH-ME178

(SPARE BUSHINGS, INSTRUMENT TRANSFORMERS, ETC.)

COMPANY HYDRO — DATE 80-10-15

LOCATION OF TESTS SSD — AIR TEMP. 10°C — OIL TEMP.

EQUIPMENT TESTED BICO 3 — WEATHER Sunny — % HUM. 70

DATE LAST TEST

LAST TEST SHEET NO.

S.N. 3842

COPIES TO B phase

LINE NO.	~~SERIAL NO.~~ stack	TEST KV	EQUIVALENT 10 KV READINGS: MICROAMPERES METER READING	MULTIPLIER	MICROAMPERES	WATTS METER READING	MULTIPLIER	WATTS	% POWER FACTOR: MEASURED	COR. 20°C	ENER.	GND measure	INSULATION RATING
1		10	60	10uA	600	18	.01	.18	3.0		D	Same as	
2		10	48	10uA	480	17	.01	.17	3.6		J	A Phase	
3	1	10	47	10uA	470	17	.01	.17	3.6		K		
4		10	47	10uA	470	15	.01	.15	3.2		L		
5		10	45	10uA	450	35	0.1	3.5	22.2	mv	A		
6		10	45	10uA	450	35	0.1	3.5	22.2	"	B		
7													
8		10	18	10	180	33	.002	.066	3.7		D		
9	2	10	42	10	420	32	.1	3.2	23.8	mv	A		
10		10	42	10	420	33	.1	3.3	23.8	"	B		
11													
12		10	51	10uA	500	39	.01	.39	7.8		D		
13		10	48	10uA	480	23	.01	.23	4.8		J		
14	3	10	41	10uA	410	47	.01	.47	11.5		K		
15		10	48	10uA	480	74	.002	.148	3.2		L		
16		10	43	10uA	430	34	.1	3.4	22.3	mv	A		
17		10	42	10uA	420	29	.1	29	23.8	"	B		
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													

+31, +5
+15, +19
+16, +19
+15, +9
+21
+35, +3.5
+36, +34

+53, +13
+32, +32
+32, +33
+33 +33

+34, +42
+24, +22
+46, +48
+67, +81
+34 +34
+30, +28

14 6

REMARKS

KEY TO INSULATION RATING

BUSHINGS-INSULATORS-ETC.	WOOD MEMBERS-OIL-ETC.	WINDINGS
G=GOOD	XG=GOOD	WG=GOOD
D=DETERIORATED	XD=DETERIORATED	WD=DETERIORATED
I=INVESTIGATE	XI=INVESTIGATE	WI=INVESTIGATE
B=BAD (REMOVE OR RECONDITION)	XB=BAD (REMOVE OR RECONDITION)	WB=BAD (REMOVE OR RECONDITION)

TEST SET NO. M2H-129 TEST BY R.R. D.S. CHECKED BY _____ SHEET NO. 2 of 3

DOBLE INSULATION TESTS

DOBLE ENGINEERING COMPANY

MISCELLANEOUS EQUIPMENT

FORM MH-ME178

(SPARE BUSHINGS, INSTRUMENT TRANSFORMERS, ETC.)

COMPANY HYDRO — DATE 80-10-15

LOCATION OF TESTS SSD — AIR TEMP. 10°C — OIL TEMP.

EQUIPMENT TESTED BIL03 — WEATHER Sunny — % HUM. 70

DATE LAST TEST

LAST TEST SHEET NO.

S.N. 3843

COPIES TO C phase.

LINE NO.	stack SERIAL NO.	TEST KV	EQUIVALENT 10 KV READINGS: MICROAMPERES METER READING	MULTIPLIER	MICROAMPERES	WATTS METER READING	MULTIPLIER	WATTS	% POWER FACTOR MEASURED	COR. 20°C	ENER. GND. measure	INSULATION RATING
1		10	52	10UA	520	21	.01	.21	4.0		D	Same as
2		10	50	10uA	500	20	.01	.20	4.0		J	A phase
3	1	10	57	10uA	570	18	.01	.18	2.3		K	
4		10	49	10uA	490	22	.01	.22	4.6		L	
5		10	52	10uA	520	42	.1	4.2	19.2	mΩ.	A	
6		10	46	10uA	460	37	.1	3.7	21.7	"	B	
7												
8		10	18	10uA	180	28	.002	.056	3.1		D	
9	2	10	41	10uA	410	32	.1	3.2	24.4	mΩ.	~~D~~	
10		10	44	10uA	440	35	.1	3.5	22.7	"	B	
11												
12		10	58	10uA	580	25	.01	.25	4.4		D	
13		10	49	10uA	490	19	.01	.19	3.9		J	
14	3	10	49	10uA	490	21	.01	.21	4.3		K	
15		10	39	10uA	390	18	.01	.18	4.6		L	
16		10	46	10uA	460	33	.1	3.3	21.7	mΩ.	A	
17		10	39	10uA	390	28	.1	2.8	25.6	"	B	
18												
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												

+22, +20
+19, +21
+17, +19
+21, +23
+43 +41
+37
+3
+28, +28
+29, +33
+36, +34

+20, +30
+27, +11
+22, +28
+18, +18
34, 32
+28, +28

REMARKS

KEY TO INSULATION RATING

BUSHINGS-INSULATORS-ETC.	WOOD MEMBERS-OIL-ETC.	WINDINGS
G=GOOD	XG=GOOD	WG=GOOD
D=DETERIORATED	XD=DETERIORATED	WD=DETERIORATED
I=INVESTIGATE	XI=INVESTIGATE	WI=INVESTIGATE
B=BAD (REMOVE OR RECONDITION)	XB=BAD (REMOVE OR RECONDITION)	WB=BAD (REMOVE OR RECONDITION)

TEST SET NO. M2H-129 TEST BY R.R. D.S. CHECKED BY _____ SHEET NO. 3 of 3

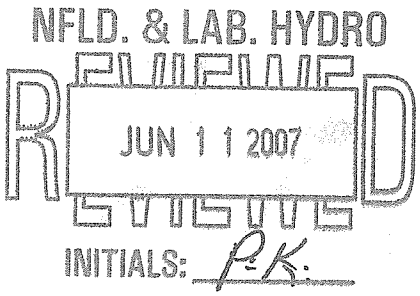
W O P K O R D E R : 3 8 5 2 3 4 SUBSIDIARY: 1 PAGE 1
The Hydro Group Of Companies Date .. 7/05/25

WO TYPE : 1 Corre SSDTS,B1L03,PLC controls,INST PARENT #: 00385234
STATUS : 45 PRIORITY: 4 Requi
ITEM # : 00005814 UNIT #: SSDB1L03 BREAKER,B1L03,SSD TS
PLT COND: B.U. #: 1325 SUPV: WHB Protect & Control Dept
LOCN: SSDTS SSD Term Stn, Sunnyside ORIG: Warren, A Craig
W/H : 1829 Bishop Falls Warehouse PLNR: Lyver, Gerard J.
EMPL: W.O.#: 385234 W.O. SUBCODE: PJC

--- Full Description of Request ----------

Install PLC controls on B1L03
A programmable logic controller to be installed to replace
reclosing control on B1L03
2003 W/O held over til Jan 31/04

---OP#---	----CRAFT----	---DESCRIPTION----------	--SIZE--	-----MHRS----
1.00]	WHBCRTEC]	WHB Tech Services Tech]	2.0]	



-- COMMENTS & WORK DONE ----------

New PLC package wired & tested. old "Cansa" case package removed from Panel 15 & the new PLC installed - wiring changes made & the new recloser was function tested into service Results with Bob Stoyles including any changes needed in logic.

-- ASSET TRACKING INFORMATION ----------

1. List all assets installed (Description and Serial Number):

1.a Provide Nameplate Data for all new assets installed:

2.If an asset was removed, note the Description, Serial# and JDE# if known and where it was transferred. ie. St. Anthony Line Depot, Bishops Falls etc.

3. List all assets disposed or to be disposed (Description, Serial #, and JDE #, if known):

COMPLETED BY: June 2/25 COMPLETED ON: LH / JMcd

-- WORK REMAINING ----------

SUPERVISOR: Bob Stoyles

Work Order # 385234
SSD B1L03

Relay test results for coil resistance and contact resistance. All readings taken with Fluke 76 Meter lead resistance .2 ohms.

Relay	*Coil Ohms*	*Contacts & Resistance*	*Relay Type*
R1	**9.77 Kohms** Coil A & B	**6&4 N/O** .3 ohms energized O.L. de-energized	**KUEP-3D15-110**
R2	**9.71 Kohms** Coil A & B	**6&4 N/O** .3 ohms energized O.L. de-energized	**KUEP-3D15-110**
R3	**9.97 Kohms** Coil A & B	**6&4 N/O** .3 ohms energized O.L. de-energized	**KUEP-3D15-110**
R4	**9.69 Kohms** Coil A & B	**6&4 N/O** .3 ohms energized O.L. de-energized	**KUEP-3D15-110**
R5	**6.32 Kohms** Coil A & B	**Form C**(2 sets) **9&6 open** (.3 ohms relay energized) **9&6 open** (O.L. relay de-energized) **9&3 closed** (.3 ohms relay de-energized) **9&3 closed** (O.L. relay energized) **7&4 open** (.3 ohms relay energized) **7&4 open** (O.L. relay de-energized) **7&1 closed** (.3 ohms relay de-energized) **7&1 closed** (O.L. relay energized)	**KUEP-11D15-110**
R6	**6.27 Kohms** Coil A & B	**Form C**(2 sets) **9&6 open** (.3 ohms relay energized) **9&6 open** (O.L. relay de-energized) **9&3 closed** (.3 ohms relay de-energized) **9&3 closed** (O.L. relay energized) **7&4 open** (.3 ohms relay energized) **7&4 open** (O.L. relay de-energized) **7&1 closed** (.3 ohms relay de-energized) **7&1 closed** (O.L. relay energized)	**KUEP-11D15-110**

R7	**9.92 Kohms** Coil A & B	**6&4 N/O** .3 ohms energized O.L. de-energized	**KUEP-3D15-110**
R8	**9.83 Kohms** Coil 2 & 7	**Form C**(2 sets) **1&3 open** (.3 ohms relay energized) **1&3 open** (O.L. relay de-energized **1&4 closed** (.3 ohms relay de-energized) **1&4 closed** (O.L. relay energized) **8&6 open** (.3 ohms relay energized) **8&6 open** (O.L. relay de-energized) **8&5 closed** (.3 ohms relay de-energized) **8&5 closed** (O.L. relay energized)	**KRP-11DG-110**

Relay	***Coil Ohms***	***Contacts & Resistance***	***Relay Type***
T	**2.62 Kohms** Coil 11& 21	**12&13 N/O** **14&15 N/O** **16&17 N/O** **22&23 N/O** **24&25 N/O** **26&27 N/O**	**RXMS-1** **RK 216 263-AP** **125 VDC**
	All contacts .2 ohms when relay energized and O.L. when de-energized		
BT	**9.67 Kohms** Coil 11& 21	**12&13 N/O** **14&15 N/O** **18&28 N/O** **22&23 N/O** **24&25 N/O** **16&17 N/C** **26&27 N/C**	**RXMA-1** **RK 211 274-AN** **110-125 VDC**
	All open contacts .2 ohms when relay energized and O.L. when de-energized. All closed contacts .2 ohms when relay de-energized and O.L. when relay energized.		

All relays checked against drawings (for contact usage) powered up and operated before installation.

PLC components

RC1	*PC-A984-145*	*Modicon PLC (984-E265)*
RC2	*AS-P120-125*	*Power Supply (P120-125)* *Checked OK*
RC3	*AS-BDAP-253*	*Combined I/O Card (DAP 253)* *All inputs and used outputs checked OK*
RC4	*AS-BDAP-253*	*Combined I/O Card (DAP 253)* *All inputs and used outputs checked OK*
RC5	*AS-BDAP-208*	*Relay Output Card (DAP 208)* *All used outputs checked OK*

The following was done when checking the new PLC recloser into service.

1. *Breaker local close*
2. *Breaker local open*
3. *Breaker remote close*
4. *Breaker remote open*
5. *Reclosing was tried with the following trips*
   a. *21P1 Aph., Bph., and Cph., all reclosed successfully.*
   b. *21P2 Aph., Bph., and Cph., all reclosed successfully.*
   c. *Single ph. trip with reclosing turned off turned into a three ph. Trip*
   d. *BR, BT & F logic was checked.*
   e. *"B" contact to Optimho and other Breaker L03L06 was checked for proper operation.*

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
5126	6/2/2005	SSDTS,B1L03,TERMINAL BOARD	REPLACE DAMAGED PORCELAIN TERMINALS IN CABINET CONTROL CABINET TYPE BD/25 REF DWG TS-10-00 USE SPARE TERMINALS TO REPLACE DAMAGED TERMINALS REPLACED FOUR BROKEN TERMINAL BLOCKS JUNCTION TESTED THE BREAKER. COMPLETED BY: P.O'GRADY ON 2005-06-02 REMOVED SPARE TERMINAL BLOCKS FROM B3B4 AT LHR TO BE INSTALLED IN BREAKER IN SSD. COMPLETED BY: G. HILLER ON 2005-06-02 WORK REMAINING: INSTALL TERMINAL BLOCKS IN B1L03 AT SSD.	47825	90
263859	1/29/2003	SSDTS,B1L03,BREAKER OVERHAUL	SUNNYSIDE TERMINAL STATION - B1L03 COMPLETE THE FOLLOWING ON AIR BLAST CIRCUIT BREAKER 1. REPLACE 9 INTERRUPTORS. 2. REPLACE 3 CONTROL BLOCKS. 3. REPLACE 3 SERVO VALVES. 4. REPLACE 1 SIGNAL DEVICE. 5. OVERHAUL 6 MAIN VALVES. 6. OVERHAUL 1 RETARDING VALVE. REPLACED - 3 SERVO VALVES - 3 CONTROL BLOCKS - 6 MAIN VALVES(FIELD SERVICE) - 1 SIGNALLING DEVICE - 9 INTERRUPTERS BREAKER ALSO MEGGERED DUCTORED AND TIMED. TESTED FOR AIR LEAKS. COMPLETED BY: W. DOWNING, G. HILLIER, P. O'GRADY & G. COMPLETED ON: 2002-12-02 RETARDING VALVE NOT REBUILT. 1 RESISTER CHIPPED ON A 1 STACK CHIPPED ON B PHASE.	47825	90
281652	1/14/2003	SSDTS,B1L03,OVERHAUL(SHOP)	SUNNYSIDE TERMINAL STATION - B1LO3 COMPLETE THE FOLLOWING ON AIR BLAST CIRCUIT BREAKER B1L03 PARTS WHEN RETURNED TO THE SHOP. 1. OVERHAUL 9 INTERRUPTORS.	47804	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
281652	1/14/2003	SSDTS,B1L03,OVERHAUL(SHOP)	2. OVERHAUL 3 CONTROL BLOCKS. 3. OVERHAUL 3 SERVO VALVES. 4. OVERHAUL 1 SIGNAL DEVICE. ALL INTERRUPTERS; SERVO VALVES; CONTROL BLOCKS AND DEVICES OVERHAULED. (TERMINALS CREW)	47804	90
315408	1/29/2003	SSDTS,B1L03,CAPACITOR,REFURB	SSDTS,B1L03,CAPACITOR,REFURBISH CAPACITOR MEGGERED, CLEANED, PRIMED AND PAINTED. COMPLETED BY: P. O'GRADY ON 2003-01-27	47825	90
321854	2/10/2003	SSDTS,VALVE,REPLACE,B1L03	SUNNYSIDE TERMINAL STATION: B1L03 REPLACE VALVE & SEALING DISC. IN SERVO VALVES FOR BREAKER B1L03 AT SSD. (TOTAL 3 PER BREAKER). OUTAGE REQUIRED. DRAIN RECEIVERS. STAMP OUTER CASTING OF EACH VALVE FRONT FACE LEFT CORNER WITH MARKING (P.W.) OUTAGE REQUIRED, DRAIN RECEIVERS. B1L03 SERVO VALVES REMOVED, REFURBISHED, INSTALLED, FOR LEAKS AND RESTORED BACK TO SERVICE. COMPLETED BY: D. BLAKE, G. BRODERICK, P. O'GRADY & S. TUCKER COMPLETED ON: 2003-02-03	47825	90
371613	1/30/2004	SSDTS,B1L03,PLC controls,INST	Install PLC controls on B1L03 A programmable logic controller to be installed to replace reclosing control on B1L03 2003 W/O held over til Jan 31/04 NEW WORK ORDER #371613 COMPLETED BY: J.S. FOLEY ON 2004-01-30	47826	90
371616	1/6/2004	SSDTS,B1L03,INST PLC controls	Install PLC controls on B1L03 Planning Engineer: Craig Warren	47826	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
372957	3/1/2005	SSDTS,B1L03,INDICATION	ECC - Indication for B1L03 at ECC open & close several times, when breaker was opened. CONTACT BOUNCE UNABLE TO DO ANYTHING ABOUT THIS. COMPLETED BY: J.S. FOLEY ON 2005-03-01	47826	90
385234	6/2/2007	SSDTS,B1L03,PLC controls,INST	Install PLC controls on B1L03 A programmable logic controller to be installed to replace reclosing control on B1L03 2003 W/O held over til Jan 31/04 NEW PLC PACKAGE WIRED AND TESTED. OLD "CANSA" CASE PACKAGE REMOVED FROM PANEL 15 AND THE NEW PLC INSTALLED. WIRING CHANGES MADE AND THE NEW RECLOSER WAS FUNTION TESTED INTO SERVICE. RESULTS WITH B. STOYLES INCLUDING ANY CHANGES NEEDED IN LOGIC. COMPLETED BY: L. HOPKINS/J. MCDONALD ON 2007-06-02	47826	80
389723	6/1/2007	SSDTS,BKR B1L03 RE-LUBRICATE	SSDTS,BKR B1L03 RE-LUBRICATE 1. CLEAN COMPONENTS NOW LUBRICATED WITH DOW AND WITH GRAPHITE OIL, RENOLIT & DOW-3451 AS REQUIRED. 2. COMPONENTS TO BE RE-LUBRICATED: 3 CONTROL VALVES 1 SIGNALLING DEVICE 3 SERVO VALVES 9 INTERRUPTERS 3 MAIN VALVES 3. REMOVE STACKS AND INSPECT INTERRIOR GLAZING. 4. INSPECT STACK FLANGE GROUTING. 5. REPLACE ANY DETERIORIATED STACKS AND RECORD. 6. CLEAN STACKS WITH ACETONE PRIOR TO INSTALLATION. 7. USE NEW O-RINGS WHEN REPLACING STACKS. 8. REPLACE VENTILATION CARTRIDGES COMPLETE WITH SEALS ON ALL STACKS. 9. IDENTIFY THE BREAKER FROM WHICH THEY WERE REMOVED RETURN THE USED VENTILATION CARTRIDGES TO A.H.R. NOTE: PART # 68000106 QUANITY MAY HAVE TO BE BY 18 IF THE BREAKER HAS 3 INSULATOR COLUMNS IN THE	47825	80

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
389723	6/1/2007	SSDTS,BKR B1L03 RE-LUBRICATE	STACK. B1L03 RELUBRIACATED AND PM COMPLETED ON BREAKER. FOUND CHIPPED STACK INSULATORS. REPLACEMENT LENGTH. GLYPTOL EXPOSED SURFACE AND RETURNED TO SERVICE. CHIPPED RESISTOR. GLYPOLLED AND RESTORED TO SERVICE. TIMING TEST DONE TO HAVE BASE LINE TECH CHANGED OUT RESTORE AIR TO BREAKER FOUND LEAK IN ONE HEAD. AND REPAIRED LEAK. COMPLETED PM AND FINAL TIMING TESTS. RESTORED TO SERVICE. COMPLETED BY: W. DOWNING ON 2007-06-01	47825	80
393534	4/8/2004	SSD,B1L03,AUX.CONTACTS,CHECK	SSDTS,B1L03,AUX.CONTACTS,CHECK, ALSO SINGLE POLE 1.PHYSICALLY CHECK AUX.CONTACTS FOR TIGHTNESS,NEED RIGHT SIDE PANEL IN ORDER TO CHECK ALL CONTACTS. 2.CHECK SINGLE POLE RECLOSING-INITIATE FROM OUTAGE 1 HR CONTACTS AND RECLOSING CHECKED DURING OUTAGE - OKAY COMPLETED BY: W. DOWNING/J. MCDONALD/L. HOPKINS COMPLETED ON: 2004-04-08	47825	90
417738	7/1/2005	SSDTS,B1L03,CT,SAND & PAINT	SSDTS,B1L03,CT's,SAND & PAINT	47825	90
438274	4/8/2005	SSDTS.B1L03 BT RELAY,REPLACE	Replace SSD B1L03 BT relay Some RXMB1 (BT) relays have faulted. RXMA1 relay on materials work order 439962.	47826	90
439962	4/8/2005	SSDTS.B1L03 BT RELAY,REPLACE	Replace SSD B1L03 BT relay See WO 438274 for labour. This is the work order to purchase the relay. Order stores number 68600952 Qty: 1	47826	90
440828	12/28/2004	SSDTS,B1L03,NOT CLOSING,INVEST	SSDTS,B1L03,NOT CLOSING,INVEST CHECKED FUSES IN BREAKER FRO CONTROL POWER. CHECKED PROTECTION FUSES BEHIND CONTROL PANEL. ECC HAD TROUBLE RECLOSING B1L03	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
440828	12/28/2004	SSDTS,B1L03,NOT CLOSING,INVEST	NO TROUBLE FOUND WEATHER CONDITIONS - SLEET AND ICY. COMPLETED BY: W. WALSH ON 2004-12-28	47825	90
576789	3/6/2007	SSDTS,B1L03,WOULD NOT OPERATE	SSDTS,B1L03,WOULD NOT OPERATE OPERATED BREAKER SEVERAL TIMES LOCALLY WITH OPEN THEN ECC TRIED FROM ST. JOHN'S, STAYED IN SERVICE. LEFT AS IS. BREAKER SEEMS TO OPEN ON DISAGREEMENT. COMPLETED BY: W. DOWNING ON 07-03-06 ---------- WORK REMAINING: COMPLETE TIMING TEST ON BREAKER TO SEE IF OPERATES. REPAIR AS REQUIRED.	47825	90
583884	6/1/2007	SSDTS,B1L03,CONDUIT,REPAIR	SSDTS,B1L03,CONDUIT,REPAIR REPAIR PVC CONDUIT B1L03 P.T. TL203 NEEDS TO BE REGLUED CONDUIT REPAIRED ON P.T. COMPLETED BY: W. DOWNING ON 2007-06-01	47825	90
584868	6/1/2007	SSDTS,B1L03,PVC CONDUIT,REP	SSDTS,B1L03,PVC CONDUIT,REPAIR MAY BE THE SAME AS W/O 584868 COMPLETED.	47825	90
587205	5/10/2007	SSDTS,B1L03,RECLOSER,REPLACE	SSDTS,B1L03,RECLOSER,REPLACE BT RELAY INVESTIGATED ALARM AND FOUND "BT" RELAY P8 IN B1L03 "BURNT OUT" IE THE COIL ISOLATED BREAKER WITH TRADES PERMIT. REPLACED COIL WITH ONE SCAVENGED FROM OLD CHECKED RECLOSING AND DISAFREEMENT VIA SEL RELAY ALL PUT BREAKER BACK IN SERVICE. COMPLETED BY: J. MCDONALD, G. PARSON & P. O'GRADY ON 2007-05-11	47826	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
589257	6/1/2007	SSDTS,B1L03 REPLACE CAPACITORS	SSDTS,B1L03 REPLACE CAPACITORS/VENTILATION PAINT OLD CAPACITORS RETURN OLD VENT. CARTRIDGES TO G.LYVER B.FALLS TO BE ED CAPACITORS REPLACED ON BREAKER COMPLETED BY: W. DOWNING ON 2007-06-01 WORK REMAINING: -CAPACITORS TO BE PAINTED	47825	90
590490	6/1/2007	SSDTS,B1L03 BREAKER PM MTNCE	1.PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK 2.RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A DATE. 3.CONSIDER & REPORT ANY SIGNIFICANT ENVIROMENTAL	47825	90
590921	9/22/2007	SSDTS,B1L03,CAP STRAPS,PAINT	SSDTS,B1L03,CAP STRAPS,PAINT (OUTAGE REQUIRED) PAINT CAPACITOR STRAPS, PAINT IN WAREHOUSE. PAINTING NOT REQUIRED STRAPS ARE STAINLESS STEAL	47825	90
623205	1/9/2008	SSDTS,B1L03,FUNCTION TEST TRIP	SSDTS,B1L03,FUNCTION TEST TRIP AND RECLOSING. FUNCTION TEST BREAKER OPERATION AS PER ART BURSEY'S PERFORMED TESTING ON BREAKER (TRIPPING) RECLOSING SINGLE POLE) AS WELL AS THREE PHASE TRIPPING. ALSO CHECKED PNUMATIC DISAGREEMENT ON BREAKER. ALL TESTS WERE OK AND BREAKER OERATED SMOOTHLY. FOUND CONTACT BOUNCE (OPEN AND CLOSE) ON SOE. ELECTRICIANS CLEANED CONTACTS ON BREAKER CAM THAT GIVE BREAKER INDICATION AND SOE TO ECC. OPERATED BREAKER AND NOW INDICATION IS OK. COMPLETED BY: G. PARSONS/L. HOPKINS/J. MCDONALD COMPLETED ON: 2008-01-09	47826	90
790849	7/9/2010	SSDTS,B1L03,ALARM,INVESTIGATE	SSDTS,B1L03,ALARM,INVESTIGATE ANNUNCIATOR ALARM PLC B1L03 FAILURE ECC ALARM AIR ANOMALLY CHECKED AND FOUND CONTROL FUSE NEGATIVE GONE	47826	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
790849	7/9/2010	SSDTS,B1L03,ALARM,INVESTIGATE	REPLACED ALL OK COMPLETED BY: J. MCDONALD ON 2010-07-09	47826	90
838346	4/8/2011	SSDTS,B1LO3,FUNCTION TEST	SSDTS,B1LO3,FUNCTION TEST QUESTIONABLE OPERATIONS OF L01L03 BREAKER DURING TL201 FAULT . CHECK RECLOSING ON ALL THREE PHASES PROTECTION & CLEAN CAMS IN CONTROL CABINET. OPENED BREAKER B1LO3 AND BOTH DISCONNECT. BLOCKED ON P2 TL203 AND USED SEL RELAY TO CHECK RECLOSING ON PHASE. RECORDED TIMES OF BREAKER TRIP AND RECLOSING. ATTACHED READINGS AND TIMES, EVERYTHING OK. ---------- SSD B1LO3 TRIP RECLOSE RECLOSE SETTING ---------- ---------- A2 .119 .692 30 CYCLE B2 .145 .605 C2 .166 .769 L2 .110 ..... DISAGREEEMENT 2.062 COMPLETED BY: G. PARSONS, J. MCDONALD & L. HOPKINS COMPLETED ON: 2011-04-06 BREAKERS B1L03 SSD AND L01L03 WAV FUNCTION TESTED. TEST #1 TRIP RECLOSE ON A, B, C PHASE VIVA THE SEL. TEST #2 3 PHASE TRIP VIVA SEL. TEST #3 DISAGREEMENT WITH RECLOSER OFF VIVA THE SEL. COMPLETED BY: P. O'GRADY & P&C CREW ON 2011-04-08	47826	80

Verbal Safety Talk _____

Appendix 3, Page 58 of 102

THINK SAFETY FIRST

WO TYPE : 2 PM Wo WAVTS,T5,XFMR PM MTNCE PARENT #: 00922301
STATUS : 45 PRIORITY: 3 Plann
ITEM # : 00006412 UNIT #: WAVT5 TRANSFORMER T5,WAV TS
PLT COND: SD BU #: 1325 SUPV: WHB Station Mtce Dept
LOCN: WAVTS WAV Term Stn, Westerm Avalon ORIG: Lyver, Gerard J.
W/H : 1829 Bishop Falls Warehouse PLNR: Lyver, Gerard J.
EMPL: W.O.#: 922301 W.O. SUBCODE: PMN

--- Full Description of Request ----------
1.PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK SHEET.
2.RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK ORDER REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A LATER DATE.
3.CONSIDER & REPORT ANY ENVIROMENTAL IMPACTS.

OP#	CRAFT	DESCRIPTION	SIZE	MHRS
1.00	WHBCRSEM	WHB ELEC Term. Stn Mtce. Crew	2.0	
2.00	WHBCRTM	WHB Term. Stn Mtce	1.0	

--- Safety Provisions ----------
1.ENSURE NECESSARY WORK PROTECTION IS IN PLACE BEFORE STARTING WORK.
2.COMPLETE TAILBOARD SAFETY TALK BEFORE BEGINNING WORK.

--- Maintenance Loops ----------
00006412 TRANSFORMER T5,WAV TS Y06A

Keyed.

SCANNED & E-FILED

-- COMMENTS & WORK DONE ----------

PM complete

-- ASSET TRACKING INFORMATION ----------

1. List all assets installed (Description and Serial Number):

1.a Provide Nameplate Data for all new assets installed:

2.If an asset was removed, note the Description, Serial# and JDE# if known and where it was transferred. ie. St. Anthony Line Depot, Bishops Falls etc.

3. List all assets disposed or to be disposed (Description, Serial #, and JDE #, if known):

COMPLETED BY: WD/DH/GT/BW/JH COMPLETED ON: 2012/07/27

-- WORK REMAINING ----------

SUPERVISOR: _____

6 YEAR PM – OLTC TRANSFORMER C/W DIVERTER SWITCHES

System ID: T5 Station: WAVTS Serial No.: 61-00-69167
Manufacturer: Federal Pioneer Type: ONAN ONAF M.V.A: 75/100/125
Test Date: July 16, 2012 Test Completed By: W.D/J.H J.D.E. W/O #: 922301

NOTE: All TESTS MUST BE COMPLETED OR MARKED N/A (unless otherwise Instructed).

WEATHER CONDITIONS: dry: [X] rain: [ ] humidity [ ] ambient temperature: 20 °C

DIELECTRIC OIL TEST ASTM D-1816 (kV): Conservator Main Tank: 44 Conservator Diverter Switches: 25
Diverter Switch #1 COMMON Diverter Switch #2 35 Diverter switch #3 _____

WINDING TEMP RELAY: (Check if Applicable)					
First Stage Fans: Setting: 80 °C	Found	°C	Left	80	°C
Second Stage Fans: Setting: 85 °C	Found	°C	Left	85	°C
Alarm: Setting: 115 °C	Found	°C	Left	115	°C
Trip: Setting: 125 °C	Found	°C	Left	125	°C

LIQUID TEMP RELAY: (Check if Applicable)					
Alarm: Setting: 90 °C	Found	°C	Left	90°	°C
Trip: Setting: 110 °C	Found	°C	Left	110	°C

FAULT PRESSURE RELAY: (GAS DETECTOR) Main Tank					
Alarm:	Found	200 (cc)	Left	200	(cc)
Trip;	Found	< 3psi (kpa)	Left	< 3psi	(kpa)

FAULT PRESSURE RELAY: (IN LINE GAS DETECTOR) diverter Switches (Check if Applicable)
(Function test Control Circuits) Tested OK ✓ N/A ____

FAULT PRESSURE RELEASE RELAYS: (Function test Control Circuit if Applicable)
Main Tank: Tested Ok ✓ N/A ____

Diverter Sw: A ph: Tested OK ____ N/A ____	Diverter Sw: B ph: Tested OK ____ N/A ____	Diverter Sw: C ph: Tested OK ____ N/A ____

CONSERVATOR MAIN TANK: (Function Test Low level Alarm) OK ✓
CONSERVATOR DIVERTER SWITCHES: (Function Test Low level Alarm) OK ✓

RESISTANCE CHECKS: (including Wiring to Terminal Boards) **500 Volt Test**
Test & record in Mega Ohms or N/A (Acceptable readings > 500 Mega Ohms)

	Line 1 – Line 2	Line 1 / 2 - GND		Line 1 – Line 2	Line 1 / 2 GND
Winding Temp Relay: **Alarm**	∞	∞	**Trip**	∞	∞
Liquid Temp Relay: **Alarm**	∞	∞	**Trip**	∞	∞
Fault Pressure Relay: **Alarm** (Main Tank)	∞ |	∞ |	**Trip**	∞ |	∞ |
Fault Pressure Relay: **Alarm** (In Line Diverter Switches)	∞	∞	**Trip**	∞	∞

6 YEAR PM – OLTC TRANSFORMER C/W DIVERTER SWITCHES

System ID: _____ Station: _____ Serial No.: _____
Manufacturer: _____ Type: _____ M.V.A: _____
Test Date: _____ Test Completed By: _____ J.D.E. W/O #: 922301

RUST/PAINT CONDITION (A - Minor , B – Moderate , C – Severe)

MAIN TANK:	B	RADIATORS:	B
CONTROL CABINET:	B	OTHER:	

CHECKS COMPLETED:

- ✓ Check Explosion Vent
- ✓ Check HV & LV Connections
- ___ Ladder Guards
- ✓ Check porcelain insulators for chips or cracks
- ✓ Manually Operate Fans
- ✓ Silica Gel Checked replace if 50% or more Contaminated
- ✓ Visual Check For Dirty Insulators & Clean if required
- ✓ Check Conservator Tanks For Water, Drain if Necessary
- ___ Check Oil Filtering Unit (type 51) { check Oil Pressure gauge } Replace Filter if Required (Pumps Located on BBKTS T3, HRDTS T8 & WAVTS T5 ONLY)

CHECKS COMPLETED ONLY IF INSTRUCTED:

- _____ Obtain Gas Analysis Sample
- _____ Transformer Ratio Readings
- _____ Capacitive Bridge Testing
- _____ Doble Test

COMMENTS:

NEW SILICA BREATHER
NEW WINDING TEMP GAUGE
1 NEW Pressure SWITCH.
NEW CORDS TO LIQUID & 1 WINDING Temp GAUGE
OIL LEAK REPAIRED ON Xfmer Level GAUGE.
TAP CHANGER OVERHAULED
TAP CHANGER OIL FILTER DIFFERENTIAL ALARM (OK)
OIL FILTER motor AMPS.

6 YEAR PM – OLTC TRANSFORMER C/W DIVERTER SWITCHES

System ID: T5 Station: WAV Serial No.: _____
Manufacturer: T.R. Type: ONAN/ONAF M.V.A: _____
Test Date: 2012/07/16 Test Completed By: _____ J.D.E. W/O #: 922301

RESISTANCE CHECKS: (including Wiring to Terminal Boards) 500 Volt Test

Test & record in Mega Ohms or N/A (Acceptable readings > 500 Mega Ohms)

	Line 1 – Line 2	Line 1 / 2 - GND
Conservator (Main tank) Oil level Gauge: **Alarm**	inf	inf
Conservator (Diverter Sw's) Oil level Gauge: **Alarm**	inf	inf
Fault Pressure Release Relay (Diverter Sw A ph): **Trip**		
Fault Pressure Release Relay (Diverter Sw B ph): **Trip**	inf	inf
Fault Pressure Release Relay (Diverter Sw C ph): **Trip**		

** Caution: Confirm all Primary Protection Circuits are open before Closing Links.

CHECK OIL LEVELS (High , Normal , low)

CONSERVATOR (MAIN TANK)	OK		CONSERVATOR (DIVERTER SWITCHES)	OK	
HV BUSHINGS:	H1 ✓		H2 ✓	H3 ✓	
LV BUSHINGS:	X1 ✓		X2 ✓	X3 ✓	

OPERATING AMPERAGE: (If Applicable)

1 st STAGE FANS 6.9	2 nd STAGE FANS 6.5	MAIN TANK CABINET HEATER 3.5

GROUND CONTINUITY (RESISTANCE): (Micro-Ohms)

NEUTRAL BUSHING:					
HV. ARRESTORS:	H1 877 mΩ		H2 903 μΩ	H3 787 mΩ	
LV. ARRESTORS:	X1 631 μΩ		X2 831 μΩ	X3 1.020 μΩ	

ON LOAD TAP CHANGER

TAP CHANGER COUNTER:	FOUND 54037	LEFT	54112
CHECK LIMITS:	HIGH ✓	LOW	✓
AMPERAGE:	MOTOR 3.2A	CONTROL CABINET HEATER	OK
CHECK GEARS,CHAINS or BELTS:	Checked OK: ✓		
TRANFORMER WINDING RESISTANCE:	Completed Yes: ✓ No: _____		

TAP changer filter motor ~ 3.4A

DIELECTRIC ABSORBTION (5 KV): 10 MIN. ÷ 1 MIN. = INDEX

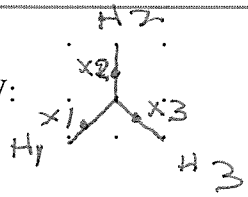
H-LG	1 Min.	Mega Ω	10 Min.	Mega Ω	Index.	%
L-HG	1 Min.	Mega Ω	10 Min.	Mega Ω	Index.	%
HL-G	1 Min. 1.42	Mega Ω	10 Min. 2.54	Mega Ω	Index. 1.62	%

CORE GROUND: (500 Volt test)

Externally Connected Yes ✓ No _____	
RESISTOR: (Ohms) 253.6	CORE GROUND: (Mega Ohms) 500

TRANSFORMER WINDING RESISTANCE TEST FORM

System ID: T 5 Station: WAVES Serial No: 6J-00-69167 Manufacturer: [illegible]
Type: OLTC ✓ TC ____ High voltage 230 Low Voltage 69 Tester Serial No: WDN 0504
Test Date: 2012/07/23 Test Completed By: WD/GT J.D.E. W/O #: 422301

VECTORS: HV: 

LV: . . . TERT: . . .

NOTE: 1. Complete Winding Resistance Test on Tap Position **Found**.
2. Complete Winding Resistance Test on Maximum Tap Position **Raise**.
3. Complete Winding Resistance Test on Maximum Tap Position **Lower**.
4. Confirm Mechanical Center (Off Load Tap Changers).
5. Complete Winding Resistance Test on Tap Position **Left**.

TAP CHANGER LOCATION: HV ✓ LV _____

TAP POSITION	WINDING TESTED	CURRENT RANGE	RESISTANCE RANGE	% CURRENT	RESISTANCE	RESISTANCE DELTA x 1.5
Found 9	H1-X1	500ma	2m	107.1	.277	
Found 9	H2-X2				.277	
Found 9	H3-X3				.276	
Max. Raise ___	H1-X1				.277	
Max. Raise ___	H2-X2				.277	
Max. Raise ___	H3-X3				.276	
Max. Lower 1	H1-X1				.325	
Max. Lower 1	H2-X2				.325	
Max. Lower 1	H3-X3				.325	
Left 1					.325	
Left 1					.325	
Left 1		500ma	2m	107.1	.325	
Non Tap Winding						
Non Tap Winding						
Non Tap Winding						
Tertiary Winding						
Tertiary Winding						
Tertiary Winding						

Note: Observe Indicator Light & Record OHMS or MILLI-OHMS

REMARKS:

	H'-X'	H2 X2	H3-X3	Current. RANGE-500mA % current 107.1	Resistance RANGE 2m
1	.325	.325	.324		
2	.318	.318	.318		
3	.313	.313	.312		
4	.307	.307	.306		
5	.302	.302	.302		
6	.295	.295	.295		
7	.290	.290	.289		
8	.284	.284	.284		
9	.277	.277	.277		
10	.284	.284	.284		
11	.290	.290	.290		
12	.295	.295	.295		
13	.302	.302	.302		
14	.307	.307	.307		
15	.313	.313	.313		
16	.318	.318	.318		
17	.325	.325	.325		

TEMPORARY DE-ENERGIZING DEVICE RECORD	Serial Number	Page Appendix 3, Page 65 of 102

Instructions:

1. This form **must** be kept with the Work Protection and in case of Red Tag or PC17B, a copy will also be kept by the Controlling Authority.
2. Each Holder of Record relying on these grounds **must** apply their own Temporary De-energizing Device tag.
3. Each Work Group relying on the grounds is listed once by the 1st Holder of Record requiring the grounds.
4. Each ground locations requires its own Temporary de-energizing Device Record sheet.
5. Do not remove until all **Work Groups** Listed no longer require use of the Temporary De-energizing Device.

Temporary De-energizing Device	Location: WAVIS 3 GROUNDS ON T5 HIGH SIDE 3 GROUNDS ON T5 LOW SIDE.	PC2/PC17B/PC10A Serial Number 44790

Temporary De-energizing Device Installed by: (print & initial) WD	Work Group	Date:	Time:
Wayne Downing	EM-1	20/2007/04	1130

Holder of Record/Holder Requiring Grounds			Holder of Record/Holder - Grounds no longer Required		
Name (print & initial)	Work Group	Time & Date	Name (print & initial)	Work Group	Time & Date
WAYNE DOWNING WD	EM 1	1230 25/12/07/04	WAYNE DOWNING WD	EM 1	1100 20:2 07 27

Temporary De-Energizing Device Removal for Tests				
PC14/PC17B Test Serial Number	Test - Ground(s) Removed		Return to Pre-test - Grounds Replaced	
	Work Group - Time/Date	HoR Initial	Work Group - Time/Date	HoR Initial

Temporary De-energizing Device Removed by: (print & initial) WD	Work Group	Date:	Time:
Wayne Downing	EM 1	2007/07/27	1105

H-2009-12-1001
MORGAN PRINTING, 709-258-6320

nalcor energy

Holder of Record Check List

Protection Acceptance	PC1 Number	PC2 Number	PC17B Number	PC10A Number	Holder of Record - Time / Date
			44790		2012/07/04
Equipment isolated or isolated & de-energized	T5 AT WAUTS				
Safety Precautions and Instructions					

Holder of Record Worker's List	Worker's Name	Date	Work Group	Time On	Time Off
	G THORNE	2012/07/04	EMI	0907	1535
	D HOSKINS	2012/07/04	EMI	0907	1535
	M AMTHORP.	2012/07/05	EMI	0909	1535
	B WALSH	2012/07/16	EMI	0905	1595
	T HILLIER	2012/07/16	EMI	0920	1530
	G THORNE	2012/07/24	EMI	0830	1530
	R HORLEY	2012/07/25	EMI	0945	1555
	R MORRISEY	2012/07/25	EMI	0945	1555
	G THORNE	2012/07/25	EMI	0945	1555

Holder of Record Test Permission For Workers	Worker's Name	PC14/PC17B PC10A Number	Date	Work Group	Test Permission	Restore to Pretest

Protection Surrendered	Controlling Authority Informed of De-energizing Devise Status?	Work Protection Surrendered Time / Date
✓	☑ Yes	11:11 2012/07/27

H-2009-12-1009-F/B
MORGAN PRINTING, 709-258-6320

Verbal Safety Talk _____
THINK SAFETY FIRST

WO TYPE : 2 PM Wo WAVTS,T5,XFMR PM MTNCE PARENT #: 00678723
STATUS : 48 PRIORITY: 3 Plann
ITEM # : 00006412 UNIT #: WAVT5 TRANSFORMER T5,WAV TS
PLT COND: SD B.U. #: 1325 SUPV: WHB Station Mtce Dept
LOCN: WAVTS WAV Term Stn, Westerm Avalon ORIG: Lyver, Gerard J.
W/H : 1829 Bishop Falls Warehouse PLNR: Lyver, Gerard J.
EMPL: W.O.#: 678723 W.O. SUBCODE: PMN

--- Full Description of Request ----------
1.PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK SHEET.
2.RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK ORDER REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A LATER DATE.
3.CONSIDER & REPORT ANY ENVIROMENTAL IMPACTS.

OP#	CRAFT	DESCRIPTION	SIZE	MHRS
1.00	WHBCRSEM	WHB ELEC Term. Stn Mtce. Crew	2.0	
2.00	WHBCRTM	WHB Term. Stn Mtce	1.0	

--- Safety Provisions ----------
1.ENSURE NECESSARY WORK PROTECTION IS IN PLACE BEFORE STARTING WORK.
2.COMPLETE TAILBOARD SAFETY TALK BEFORE BEGINNING WORK.

--- Maintenance Loops ----------
00006412 TRANSFORMER T5,WAV TS Y06A

Glen
Bill
Jeremy
Dan

NFLD. & LAB. HYDRO
RECEIVED
OCT 31 2008
INITIALS:

T A I L B O A R D S A F E T Y T A L K
RISK ASSESSMENT

FORM # 30-0266

REV. DATE 06/05/01

TASK To Isolate TS Tower @ WW.TS for PM

PEOPLE: (Have I/We Considered)

- Crew members know who is in charge?
- How missing crew members will be briefed?
- Workers capabilities adequate?
- Other work groups/general public that may affect this work?
- Personal Protective Equipment?
- Hazards within the work area?

HARDWARE/EQUIP: (Have I/We Considered)

- Safe working loads/rigging?
- Tool conditions/adequacy?
- Climbing hazards?
- Temporary support of structure?
- Equipment pre-use checks?
- Communications?

PROCEDURES: (Have I/We Considered)

- Scope of work?
- The work method?
- Work Protections/Hold-Off/Special Permits?
- Limits of approach? (_____)
- Back feeds?
- Temporary grounding?
- Test for isolation?
- Fall Arrest?
- Controlled products/data sheets?
- Transportation of Dangerous Goods?
- Confined space entry?
- Rescue methods?
- Cover up required?
- Applicable engineering standards?

ENVIRO/OTHER: (Have I/We Considered)

- Overhead power line hazards?
- Underground uitlities?
- Trenching/excavation hazards?
- Traffic control/barricades/signs?
- Weather conditions?
- Hazardous products spills?
- Terrain?
- Deteriorated Plant?
- ENV SOP's?
- Other? _____

PARTICIPANTS:

D Harkins C. Fisher
W Dean
H Moores

HAZARDS IDENTIFIED	CONTROLS
Boom Truck Misuse	beware use Hazard
Bucket Truck	beware use Hazard
working on heights over 10 ft	use fall arrest.
underlying with oil.	Spill Kit on Site.

(use back if necessary)

Supervisor/Lead Hand/Worker

2008 10 17
Date

6 YEAR PM – OLTC TRANSFORMER C/W DIVERTER SWITCHES 6412

System ID: T5-WMR Station: WHV TS Serial No.: 61-00-69167
Manufacturer: F.P.E Type: OLTC M.V.A: 75/100/125
Test Date: 2008 10 14 Test Completed By: BW CH J.D.E. W/O #: C78723

NOTE: All TESTS MUST BE COMPLETED OR MARKED N/A (unless otherwise Instructed).

WEATHER CONDITIONS: dry: ☑ rain: ☐ humidity ☐ ambient temperature: 12 °C

DIELECTRIC OIL TEST ASTM D-1816 (kV): Conservator Main Tank: 43KV Conservator Diverter Switches: ____
Diverter Switch # 1 ____ Diverter Switch # 2 ____ Diverter switch # 3 ____ TAP CHANGER 41KV
Main Tank 50KV TAP CHANGER Conservator 43

WINDING TEMP RELAY: (Check if Applicable)							
First Stage Fans: Setting: 82 °C	Found	82	°C	Left	82	°C
Second Stage Fans: Setting: 87 °C	Found	87	°C	Left	87	°C
Alarm: Setting: 117 °C	Found	117	°C	Left	117	°C
Trip: Setting: 125 °C	Found	125	°C	Left	125	°C

LIQUID TEMP RELAY: (Check if Applicable)							
Alarm: Setting: 88 °C	Found	~~TAP C~~ 88	°C	Left	88°	°C
Trip: Setting: 105 °C	Found	105°	°C	Left	105°	°C

FAULT PRESSURE RELAY: (GAS DETECTOR) Main Tank							
Alarm:	Found	200	(cc)	Left	200	(cc)
Trip;	Found	400	(kpa)	Left	400	(kpa)

FAULT PRESSURE RELAY: (IN LINE GAS DETECTOR) diverter Switches (Check if Applicable)
(Function test Control Circuits) Tested OK ✓ N/A ____

FAULT PRESSURE RELEASE RELAYS: (Function test Control Circuit if Applicable)
Main Tank: Tested Ok ✓ N/A ____

Diverter Sw: A ph:Tested OK ___ N/A ___	**Diverter Sw: B ph:Tested OK ___ N/A ___**	**Diverter Sw: C ph:Tested OK ___ N/A ___**

CONSERVATOR MAIN TANK: (Function Test Low level Alarm) OK ✓
CONSERVATOR DIVERTER SWITCHES: (Function Test Low level Alarm) OK ✓

RESISTANCE CHECKS: (including Wiring to Terminal Boards) **500 Volt Test**
Test & record in Mega Ohms or N/A (Acceptable readings > 500 Mega Ohms)

	Line 1 – Line 2	Line 1 / 2 - GND		Line 1 – Line 2	Line 1 / 2 GND
Winding Temp Relay: **Alarm**	∞	GR	**Trip**	∞	GR
Liquid Temp Relay: **Alarm**	∞	GR	**Trip**	∞	GR
Fault Pressure Relay: **Alarm** (Main Tank)	∞	GR	**Trip**	∞	GR
Fault Pressure Relay: **Alarm** (In Line Diverter Switches)	∞	GR	**Trip**	∞	GR

6 YEAR PM – OLTC TRANSFORMER C/W DIVERTER SWITCHES

System ID: T5 Station: W.A.V Serial No.: 61-00 69167
Manufacturer: Federal Pioneer Type: _____ M.V.A: 75/100/125
Test Date: 2008/10/14 Test Completed By: GH BW HM DH J.D.E. W/O #: _____

RESISTANCE CHECKS: (including Wiring to Terminal Boards) **500 Volt Test** Test & record in Mega Ohms or N/A (Acceptable readings > 500 Mega Ohms)		
	Line 1 – Line 2	Line 1 / 2 - GND
Conservator (Main tank) Oil level Gauge: **Alarm**	584 mΩ	181mΩ GΩ
Conservator (Diverter Sw's) Oil level Gauge: **Alarm**	∞	156mΩ 1300 mΩ
Fault Pressure Release Relay (Diverter Sw A ph): **Trip**	∞	∞ GΩ
Fault Pressure Release Relay (Diverter Sw B ph): **Trip**	∞	∞ GΩ
Fault Pressure Release Relay (Diverter Sw C ph): **Trip**	∞	∞ GΩ

** Caution: Confirm all Primary Protection Circuits are open before Closing Links.

CHECK OIL LEVELS (High , Normal , low)						
CONSERVATOR (MAIN TANK)			CONSERVATOR (DIVERTER SWITCHES)			
HV BUSHINGS:	H1	Normal	H2	Normal	H3	Normal
LV BUSHINGS:	X1	Normal	X2	Normal	X3	Normal

OPERATING AMPERAGE: (If Applicable)		
1 st STAGE FANS 6.7A.	2 nd STAGE FANS 6.6A.	MAIN TANK CABINET HEATER 3.6

GROUND CONTINUITY (RESISTANCE): (Micro-Ohms)						
NEUTRAL BUSHING:						
HV. ARRESTORS:	H1	647 μΩ	H2	200 μΩ	H3	254 μΩ
LV. ARRESTORS:	X1	611 μΩ	X2	635 μΩ	X3	784 μΩ

ON LOAD TAP CHANGER			
TAP CHANGER COUNTER:	FOUND 38962	LEFT 38983	
CHECK LIMITS: ✓	HIGH OK	LOW OK.	
AMPERAGE: 4.1 A.	MOTOR ✓	CONTROL CABINET HEATER 3.6 A	
CHECK GEARS,CHAINS or BELTS:	Checked OK: ✓		
TRANFORMER WINDING RESISTANCE:	Completed Yes: ✓ No: _____		

DIELECTRIC ABSORBTION (5 KV): 10 MIN. ÷ 1 MIN. = INDEX						
H-LG	1 Min. 1.5 GΩ	Mega Ω	10 Min. 2.14 GΩ	Mega Ω	Index. 1.36	%
L-HG	1 Min. 1.7 GΩ	Mega Ω	10 Min. 2.288 Ω	Mega Ω	Index. 1.38	%
HL-G	1 Min. 1.6 GΩ	Mega Ω	10 Min. 2.36	Mega Ω	Index. 1.45	%

CORE GROUND: (500 Volt test)	
Externally Connected Yes ____ No ____	
RESISTOR: (Ohms)	CORE GROUND: (Mega Ohms)

6 YEAR PM – OLTC TRANSFORMER C/W DIVERTER SWITCHES

System ID: T5 Station: WAV. Serial No.: 61-0069167
Manufacturer: Federal Pioneer Type: _____ M.V.A: 75/100/125
Test Date: 2018 17 Test Completed By: Rudolf/SH/H.M.D4. J.D.E. W/O #: _____

RUST/PAINT CONDITION (A - Minor , B – Moderate , C – Severe)	
MAIN TANK: A	RADIATORS: A
CONTROL CABINET: B	OTHER:

CHECKS COMPLETED:

- ___ Check Explosion Vent
- ___ Check HV & LV Connections
- ___ Ladder Guards
- ___ Check porcelain insulators for chips or cracks
- ___ Manually Operate Fans
- ___ Check Oil Filtering Unit (type 51) { check Oil Pressure gauge } Replace Filter if Required (Pumps Located on BBKTS T3, HRDTS T8 & WAVTS T5 ONLY)
- ___ Silica Gel Checked replace if 50% or more Contaminated
- ___ Visual Check For Dirty Insulators & Clean if required
- ___ Check Conservator Tanks For Water, Drain if Necessary

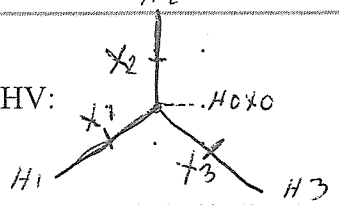
CHECKS COMPLETED ONLY IF INSTRUCTED:

- _____ Obtain Gas Analysis Sample
- _____ Transformer Ratio Readings
- _____ Capacitive Bridge Testing
- _____ Doble Test

COMMENTS: Tank. Conservator Diverter oil Level Gauge Replace. new one ordered & Replaced

TRANSFORMER WINDING RESISTANCE TEST FORM

System ID: T-5 Station: W.A.V. Serial No: 61-00-69167 Manufacture: Federal Pioneer.
Type: OLTC ~ TC ___ High voltage 230 Low Voltage 138 Tester Serial No: ___
Test Date: 2008/10/14 Test Completed By: B.W. MH H.M. D.H. J.D.E. W/O #: 678723

VECTORS: HV: 

LV: . . . TERT: N/A

NOTE: 1. Complete Winding Resistance Test on Tap Position **Found**.
2. Complete Winding Resistance Test on Maximum Tap Position **Raise**.
3. Complete Winding Resistance Test on Maximum Tap Position **Lower**.
4. Confirm Mechanical Center (Off Load Tap Changers).
5. Complete Winding Resistance Test on Tap Position **Left**.

TAP CHANGER LOCATION: HV ✓ LV ___

TAP POSITION	WINDING TESTED	CURRENT RANGE	RESISTANCE RANGE	% CURRENT	RESISTANCE	RESISTANCE DELTA x 1.5
Found 10	H1	500 MA	20	105.3	0.80Ω	
Found 6	" 2	500 MA	20	105.7	.79Ω	
Found 6	" 3	500MA	20	105.6	0.80Ω	
Max. Raise ___	H1	500 mA	20	105.2	.83Ω	
Max. Raise ___	H2	500mA	20	104.3	.82Ω	
Max. Raise ___	H3	500 mA	20	104.1	.83Ω	
Max. Lower ___	H3	500 mA	20	104	.83Ω	
Max. Lower ___	H2	500 mA	20	103	.83Ω	
Max. Lower ___	H1	500 mA	20	105.6	.83	
Left 6	H1	500 mA	20	105.6	.80Ω	
Left 6	H2	500 mA	20	104.9	.80Ω	
Left 6	H3	500 mA	20	103.2	.80Ω	
Non Tap Winding	N/A					
Non Tap Winding	N/A					
Non Tap Winding	N/A					
Tertiary Winding	N/A					
Tertiary Winding	"					
Tertiary Winding	"					

Note: Observe Indicator Light & Record OHMS or MILLI-OHMS

REMARKS:

Nameplate - Autotransformer with Tertiary

Company	Newfoundland & Labrador Hydro	**Serial Number**	61-00-69167
Location	WAV	**Special ID**	
Division	P&C EAST	**Circuit Designation**	T5
Manufacturer	FP	**Configuration**	
Year Manufactured	1989	**Tank Type**	FREE-BREATH
Mfr Location		**Oil Volume**	L
Phases	3	**BIL**	950 kV
Class	ONAN/ONAF/ONAF	**Coolant**	OIL
Weight			
kV	230, 138,	**VA Rating**	75, 100, 125, MVA
Note			

Test Date	8/20/1996	**Test Time**	10:40:55 AM	**Weather**	CLOUDY
Air Temperature	16 °C	**Tank Temperature**	15 °C	**Rel. Humidity**	71 %
Tested by	JM/CQ	**Work Order #**	5552	**Last Test Date**	
Checked by		**Test Set Type**	M4K	**Retest Date**	
Checked Date		**Set Top S/N**	0736	**Reason**	ROUTINE
Last Sheet #		**Set Bottom S/N**	0695	**Travel Time**	
P.O. #		**Ins. Book #**		**Duration**	
Copies		**Sheet #**	1	**Crew Size**	

Arrester Nameplate

Location	Serial #	Mfr	Overall Catalog	Unit Catalog	Type	Rated kV	Order
H1-T	D6418	COB	219652	215920-3008	VN	70	
H1-B	D6419	COB	219652	215920-3013	VN	82	
H2-T	D6420	COB	219652	215920-3008	VN	70	
H2-B	D6417	COB	219652	215920-3013	VN	82	
H3-T	D6424	COB	219652	215920-3008	VN	70	
H3-B	D6425	COB	219652	215920-3013	VN	82	
X1-T	D4666	COB	219598	215920-3001	VN	42	
X1-B	D4667	COB	219598	215920-3005	VN	56	
X2-T	D4668	COB	219598	215920-3001	VN	42	
X2-B	D4669	COB	219598	215920-3005	VN	56	
X3-T	D4670	COB	219598	215920-3001	VN	42	
X3-B	D4671	COB	219598	215920-3005	VN	56	

Bushing Nameplate

Desig.	Serial #	Mfr	Type	C1 % PF	C1 Cap	C2 % PF	C2 Cap	kV	Amps	Year
H1	273414	TTI	U	.33	383		697	300	600	1989

H2	273415	TTI	U	.26	382		712	300	600	1989
H3	273416	TTI	U	.26	379		616	300	600	1989
X1	272494			.26	350		623	145	600	1989
X2	272516			.33	350		609	145	600	1989
X3	272495			.30	356		576	145	600	1989
N	272556			.23	532			15	400	1989

Overall Tests

Meas.	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
CH + CHT	10	38.910	1.890		1.19	10321		
CH	10	22.270	1.421	0.76	1.19	5907	G	
CHT(UST)	10	16.620	0.507	0.37	1.19	4410	G	
CHT		16.640	0.469	0.33	1.19	4414		
CT + CHT	2	54.940	1.837		1.19	14573		
CT	2	38.300	1.317	0.40	1.19	10161	G	
CHT(UST)	2	16.630	0.508	0.37	1.19	4411	G	
CHT		16.640	0.520	0.37	1.19	4412		

Bushing C1

ID	Serial #	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap (pF)	IR_{auto}	IR_{man}
H1	273414	.33	383	10	1.424	0.036	0.25	1.00	377.60	G	
H2	273415	.26	382	10	1.430	0.028	0.20	1.00	379.30	G	
H3	273416	.26	379	10	1.482	0.033	0.22	1.00	393.10	G	
X1	272494	.26	350	10	1.305	0.033	0.25	1.00	346.10	G	
X2	272516	.33	350	10	1.300	0.042	0.32	1.00	344.90	G	
X3	272495	.30	356	10	1.325	0.038	0.29	1.00	351.50	G	
N	272556	.23	532	10	1.986	0.048	0.24	1.00	526.80	G	

Bushing C2

ID	Serial #	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap (pF)	IR_{auto}	IR_{man}
H1	273414		697	2	2.929	0.237	0.81	1.00	776.90	I	
H2	273415		712	2	2.947	0.164	0.56	1.00	781.60	I	
H3	273416		616	2	2.615	0.255	0.98	1.00	693.50	I	
X1	272494		623	2	2.499	0.117	0.47	1.00	662.80	I	
X2	272516		609	2	2.441	0.080	0.33	1.00	647.30	I	
X3	272495		576	2	2.344	0.133	0.57	1.00	621.80	I	

Surge Arrester Tests

Location	Test Mode	Test kV	mA	Watts	IR_{auto}	IR_{man}
H1-T	UST RB	10	0.163	0.056	G	

H1-B	GAR RB	10	0.371	0.109	G	
H2-T	UST RB	10	0.160	0.057	G	
H2-B	GAR RB	10	0.375	0.110	G	
H3-T	UST RB	10	0.161	0.058	G	
H3-B	GAR RB	10	0.375	0.114	G	
X1-T	UST RB	10	0.260	0.117	G	
X1-B	GAR RB	10	0.530	0.214	I	
X2-T	UST RB	10	0.258	0.110	G	
X2-B	GAR RB	10	0.531	0.208	I	
X3-T	UST RB	10	0.259	0.114	G	
X3-B	GAR RB	10	0.533	0.206	I	

Exciting Current Tests

	Mfr	Type	Steps	Boost %	Buck %	Position Found	Position Left	Oil Volume
De-Energized Tap Changer								
On-Load Tap Changer	Rein		17			1	1	

			H1 - H0			H2 - H0			H3 - H0				
DETC	LTC	Test kV	mA	Watts	X	mA	Watts	X	mA	Watts	X	IR_{auto}	IR_{man}
	1	10	14.760	144.30		8.807	85.720		14.100	141		G	
	9	10	17.430	166.90		10.350	103.20		16.240	160.60		G	
	17	10	21.230	200		12.800	127		19.800	192.70		G	

Company : NFLD HYDRO
Division: P & C EAST
Location: WAV Special ID: T5

Test Date: Jul 23 2001 Test Time: 15:14:54

Identification

Mfr: FP Yr Mfr: 1988 Serial #: 61-00-69167
Ph : 3 Cfg: Y-Y CCT Desig: T5

kV : 230 /138 /6.9 MVA:75 / 100 / 125 // Tanktype: OPEN-CONSER
Coolant: OIL

Air temp: 30 deg C App temp: deg C RH: 37% Weather: PTCLDY

Overall Tests

#	Insul.	kV	mA	Watts	%Pwr Factor meas	%Pwr Factor corr	Corr	Cap(pF)
1	CH + CHT	10	38.690	1.244			1.00	10264
2	CH	10	22.040	0.756	0.34	0.34	1.00	5848
3	CHT(UST)	10	16.630	0.505	0.30	0.30	1.00	4413
4	CHT		16.650	0.488	0.29	0.29	1.00	4416
	CT + CHT	2	54.900	1.943			1.00	14564
	CT	2	38.260	1.401	0.37	0.37	1.00	10150
7	CHT(UST)	2	16.640	0.499	0.30	0.30	1.00	4414
8	CHT		16.640	0.542	0.33	0.33	1.00	4414

Bushing Tests

C1

Bush	Nameplate Data Mfr	Type	S/N	Cap(pF)	%PF	Test Results kV	%PF	Cap(pF)
H1	TTI	U	273414	383	.33	10	0.25	378.50
H2	TTI	U	273415	382	.26	10	0.20	378.40
H3	TTI	U	273416	379	.26	10	0.24	392.70
X1	TTI	U	272494	350	.26	10	0.25	345.80
X2	TTI	U	272516	350	.33	10	0.32	347
X3	TTI	U	272495	356	.30	10	0.27	351.50
Y1	TTI	U						
Y2	TTI	U						
Y3	TTI	U						
N	TTI	U	272556	532	.23	10	0.25	527.80

C2

Bush	Nameplate Data Mfr	Type	S/N	Cap(pF)	%PF	Test Results kV	%PF	Cap(pF)
H1	TTI	U	273414	697		2	1.10	752.40
H2	TTI	U	273415	712		2	0.82	755.60
3	TTI	U	273416	616		2	0.70	665.80
X1	TTI	U	272494	623		2	0.99	661.60
X2	TTI	U	272516	609		2	0.77	645.10
X3	TTI	U	272495	576		2	1.17	617.80
Y1	TTI	U						

Company : NFLD HYDRO
Division: P & C EAST
Location: WAV Special ID: T5

Test Date: Jul 23 2001 Test Time: 15:14:54

Y2	TTI	U					
Y3	TTI	U					
N	TTI	U	272556	70	.5	36.44	153.40

Oil Sample Tests

	Sample Location	mA	Watts	%PF
1	MAIN TANK	0.883	0.023	0.26

Surge Arrester Tests

	Location	Mfr	S/N	R-kV	T-kV	mA	Watts
1	H1 TOP	OB	D6418	82.0	10	0.158	0.077
2	H1 BOT	OB	D6419	70.0	10	0.209	0.093
3	H2 TOP	OB	D6420	82.0	10	0.158	0.077
4	H2 BOT	OB	D6417	70.0	10	0.208	0.084
5	H3 TOP	OB	D6424	82.0	10	0.157	0.077
6	H3 BOT	OB	D6425	70.0	10	0.211	0.086
8	X1 TOP	OB	D4666	56.0	10	0.253	0.151
9	X1 BOT	OB	D4667	42.0	10	0.270	0.120
10	X2 TOP	OB	D4668	56.0	10	0.252	0.147
11	X2 BOT	OB	D4669	42.0	10	0.271	0.126
12	X3 TOP	OB	D4670	56.0	10	0.252	0.150
13	X3 BOT	OB	D4671	42.0	10	0.270	0.136

<End of Report>

Verbal Safety Talk _____

THINK SAFETY FIRST

WO TYPE : 5 Capit WAVTS,T5,TAPCHANGER OVERHAUL PARENT #: 00915689
STATUS : 45 PRIORITY: 4 Requi
ITEM # : 00283756 UNIT #: WAVT5-LTC TAP CHANGER,T5 WAV TS
PLT COND: BU #: 13251204 SUPV: WHB Station Mtce Dept
LOCN: WAVTS WAV Term Stn, Westerm Avalon ORIG: Eddy, Brad
W/H : 1829 Bishop Falls Warehouse PLNR: Wellman, Barry F.
EMPL: W.O.#: 915689 W.O. SUBCODE:

--- Full Description of Request ----------
WAVTS,T5,TAPCHANGER OVERHAUL
(PARTS ORDERED BY B EDDY ON PO# 113683, DUE JUNE 27)
(REINHAUSEN TECH SCHEDULED FOR JULY 5)

OP#	CRAFT	DESCRIPTION	SIZE	MHRS
1.00	WHBCRSEM	WHB Stns Elect Maintenanc	1.0	

STOCK NUMBER	DESCRIPTION	UOM	QTY	COST
89400002	OIL,TRANSFORMER (205 L DRUM)	DR	3.00	760.51
88900031	ABSORBENT,OIL PAD	BN	1.00	32.83
58400074	FILTER,CARTRIDGE 12" (ALSOP)	EA	2.00	171.16

Keyed 12-07-06
R.B

-- COMMENTS & WORK DONE ----------

Tap Changer overhauled by Contractor

Tap Changer in good Shape.

-- ASSET TRACKING INFORMATION ----------

1. List all assets installed (Description and Serial Number):

1.a Provide Nameplate Data for all new assets installed:

2. If an asset was removed, note the Description, Serial# and JDE# if known and where it was transferred. ie. St. Anthony Line Depot, Bishops Falls etc.

3. List all assets disposed or to be disposed (Description, Serial #, and JDE #, if known):

COMPLETED BY: W.D. Ball COMPLETED ON: July 7/2012

-- WORK REMAINING ----------

SUPERVISOR: [signature]

EXTRA MATERIAL USED

INVENTORY PART #	DESCRIPTION	UOM	QTY

EXTRA MATERIAL RETURNED

INVENTORY PART #	DESCRIPTION	UOM	QTY

VEHICLE USAGE

VEHICLE #	HOURS USED

TAILBOARD SAFETY TALK FORM (Cont)

Hazards

/ - Risk
X - No Risk

People

_ Adequate PPE Worn
_ Allergies
_ Arc Flash
_ Awkward Positions
_ Chemical Burn
_ Cuts/Abrasions
_ Electrical Shock
_ Falling from Heights
_ Falling Objects
_ Infectious Agents
_ Inhale Hazardous Substances
_ Overexertion
_ Overhead Work
_ Particles in Eye
_ Pinch Points
_ Poisonous Substances
_ Prolonged Positions
_ Respiratory Distress
_ Slips/Trips
_ Sprains/Strains
_ Thermal Burn

Equipment

_ Crane/Lifting Equipment in Operation
_ Damaged/Defective
_ High Voltage
_ Inadequate Guards/ Barriers
_ Moving Equipment Mobile
_ Moving Machinery
_ Poor Ergonomic Design
_ Pressurized Equipment
_ Pressurized Lines
_ Proper Tools not available for Job

Materials

_ Chemical/Other Substance Spills
_ Explosive/Flammable
_ Fibre Optic Cables
_ Hazardous Chemicals
_ Hazardous Waste Present
_ Radioactive Material Present
_ Steam Present

Environment

_ Back Feeds
_ Blind Spots
_ Dangerous Animals
_ Dangerous Flora/Fauna
_ Inadequate Parking Lots
_ Noise
_ Overhead Lines
_ Poor Air Quality
_ Poor Lighting
_ Poor Storage of Materials
_ Poor Weather
_ Poor Workspace Design
_ Public Can Access Area
_ Rough Roads/Terrain
_ Slippery Surfaces
_ Trenches Present
_ Underground Line
_ Vehicle/Machine Traffic
_ Vibration

No.	Hazards	Controls/Barriers
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Ensure all crew members complete necessary Step Back 5X5(s).

Person in Control of Work (Print): _____ Date: _____

(Sign): _____

Western Avalon Terminal Station

Service report

MR Order number: _____ Name 1: Michael Arnthor

Service notification: _____ Name 2: _____

Responsible person for order: _____ Work from _____ until 05-07 2012

☒ Maintenance ☐ Repair ☐ Modification ☐ Examination

End customer: Newfoundland & Labrador Hydro Contact person: Reginald Day

Transf. manufacturer: _____ Transformer no.: 61 80 09167

Location-adress: Chapel Arm NL N 47.51568° W53.68537 Year of manuf.: 1989 Transformer load.: _____ %

$P_{nom.}$: 125 MVA $U_{nom.}$: 230 / 138 kV

☐ Indoor ☒ Outdoor Photo: ☐ Yes ☒ No

Tapchanger type: HIETD 400 145 10193W No.: 066205 No. of ops: 56724

Type of motordrive: MA7 No.: 066205 Counter reading: 56724

Transition resistor: R 1: 3,3 Ω ; R 2: _____ Ω Varistors: ☐ yes ☒ no Spark gaps resp.: ☐ U ☐ V ☐ W

Div.-switch no.: 066205 ☒ removed ☒ installed ☒ maintained No. of ops.: 56724

Spare div.-switch no.: _____ ☐ removed ☐ installed ☐ maintained No. of ops.: _____

Oil change: ☒ yes ☐ no Sort: _____ Quantity: ~ 400 liter ☐ TM100 ☐ Tapguard

Contact wear: ☐ single contact wear (mm) ☐ sum contact wear Typ: T,R,G (mm) traces of arcing: ≤ 0,1 mm

SC (fixed)		SC (mov.)		SC (sum)		Contact roller SC Ø	21,8
TC I (fixed)		TC I (mov.)		TC I (sum)		Contact roller TC Ø	21,5
TC II (fixed)		TC II (mov.)		TC II (sum)			

Tap-changer

Function Test: ☒ mech. ☒ Idle ☐ load Switching supervisory device.: ☒ without ☐ checked

Suction pipe: ☐ without bled. ☒ yes ☐ no Insulation parts checked: ☒ Mechanical state checked: ☒

Press. tight: ☒ Yes ☐ no ____ cm / h Identical operating positions MDU/OLTC: ☒ Carbon deposits: ☐ none / _____ mm

Motor drive unit

Mech. state checked: ☒ Electr. devices checked: ☒ Position transmitter checked: ☒ Drive limits test: ☒ mech. ☐ electr.

Drive shafts

☐ Round ____ mm / ☒ square Clearance axial checked: ☒ Mech. state checked: ☒ Cardan joints: ☐ yes ☒ no

Protective relay

Type: ☐ RS1000 ☒ RS2001 ☐ XK ☐ others Cleaning: ☒ Function - Test: ☐ with CB ☒ without CB ☐ no

Oilfilter plant

Type: ☐ OF100 ☒ 51 ☒ others ☐ without Filter cartridge change: ☒ ☐ Carbon filter ☒ Combined filter

Remarks: The OLTC components inspected are in good condition and the results of the test switchings were satisfactory.

The OLTC is ready for service.

City, Date Chapel Arm NL 05 July 2012 20 ____ Signature (MR staff member)

New Foundland & Labrador Hydro
Western Avalon Station

Customer report

MR Order number: _____ Name 1: Michael Amthor

Service notification no.: _____ Name 2: _____

Serialno.: MR 066205 Responsible person for order: _____

Single distance km _____ Total distance km _____ ☐ Car ☐ Van ☐ Lorry

Accessory: ☐ Oil pump: ___day(s) ☐ Lifting device ___day(s) ☐ Tent ___day(s) ☐ Crane ___day(s)

Partnumber:	Description:	Quantity:	Code:	Partnumber:	Description:	Quantity:	Code:
10495700	coupling bracket	2		07134400	locking	5	
05196003	coupling bolt	4		451323	washer 5,3	3	
10018200	o-ring	2		709407 01	small parts DS	2	
12759600	oil filter insert comb.	1		59002102	gasket RS 2001	1	
59057001	gasket	1		59008702	gasket bevel gear	1	
10185200	screw M6×16	6		860258	o-ring cover M.	1	
10180900	screw M6×30	9		16017002	gasket door MA7	4m	
05901105	small parts H	1					
09918501	lead	3					
10104400	screw M5×10	3					
02408498	locking	2					
10155900	screw M6×60	3					
860122	gasket	4					
01528400	washer M5	9					
10104500	screw M5×16	9					

Code: 1 = Technical service canban stock; 2 = already booked items; 3 = from customer (without charging)

Working / travelling hours:

Date	Operation	Start (travel regular)	Finish (travel overtime)	Break from (work regular)	Break to (work overtime)	Duration in hrs	Trip / work	Staff member
04-07-2012	8[00]	2[30]	8,0	6,5			☐ / ☐	Michael Amthor
05-07-2012	7[30]	18[30]			8	2,5	☐ / ☐	Michael Amthor
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	
							☐ / ☐	

Remarks: flight from Moncton to Halifax was delayed. AC changed Moncton – Toronto – St. John's

The signatory confirms the correctness of total hours, materials and accessory data listed in the service report as well as the receipt of a copy of the report.

City, date Chapel Arm 20 12 Signature (Customer) _____

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
400421	5/11/2004	WAV,T5 LTC SCREEN FOR PCB	WESTERN AVALON TERMINAL STATION TEST T5 TAP CHANGER OIL FOR PCB'S NO PCB'S PRESENT. COMPLETED BY: P. O'GRADY & S. TUCKER ON 2004-05-11	47825	90
584743	7/27/2007	WAVTS, T5 TAPCHANGER OIL SAM	WAVTS, T5 TAP CHANGER OIL SAMPLE OBTAIN OIL SAMPLE FOR AS PER T.SHAVE'S INSTRUCTIONS QUOTE WORK ORDER ON INVOICE 1) If oil volume in the equipment is less than 250 gallons (1200 L) flush 1 quart of oil, otherwise flush a gallon into waste oil container. 2) Bottle Samples: rinse bottle by partially filling and gently swirling and emptying the oil into the waste container. Fill bottle to within an inch of the top, to allow for expansion. Visually examine fluid for water droplets or foreign particles. If present, re-sample. If not, attach the cap securely, identify the sampled unit on the bottle's label. Do not tape the cap. 3) Syringe Samples: the plastic stopcock, which comes with the syringe must remain firmly affixed to the syringe to prevent leaks. Flushing the syringe: a) Move the handle toward the sampling valve. b) Open sampling valve and move the handle toward the syringe allowing oil to flush the tube and stopcock. c) Move the handle towards the side port, allowing oil pressure to enter the syringe barrel, forcing the plunger out. Until the inside of the syringe has been wetted with oil, it may be necessary to pull the plunger. d) When oil reaches the 50 cc mark, move the handle towards the sampling valve and eject oil from ssyringe by pushing in the plunger. Catch this ejected oil in waste container Draw the Sample: a) Move the handle towards the side port and allow oil pressure to fill the syringe. DO NOT PULL ON THE PLUNGER When oil reaches the 40-45cc mark, move the handle towards	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
584743	7/27/2007	WAVTS, T5 TAPCHANGER OIL SAM	the syringe. Do not over fill the syringe to avoid gas escape from the plunger side. b) Examine sample to ensure it is free of bubbles and foreign particles. If sample is good, move handle towards the syringe, close drain valve and remove the syringe with stopcock still firmly attached to the syringe. If sample is not clear, repeat sample procedure. c) Record info: on sample bottle check sheet as per enclosed instructions. OIL SAMPLE TAKEN COMPLETED BY: G. HILLIER ON 2007-07-24 --- SYRINGE SAMPLE TAKEN FROM BOTTOM OF TANK. COMPLETED BY: G. HILLIER ON 2007-08-08	47825	90
588492	5/18/2007	WAVTS,T5,SILICA GEL,CHANGE	WAVTS,T5,SILICA GEL,CHANGE SMALL BREATHER INSTALLED T5 BREATHER NOW IN DRYER. COMPLETED BY: W. DOWNING & S. TUCKER ON 2007-05-18 REINSTALL T5 BREATHER WHEN SILICA GEL DRY.	47825	90
589066	9/7/2007	WAVTS,T5,REPLACE TEMP. BREATHE	WAVTS,T5,REPLACE TEMP. BREATHER REPLACE TEMPORARY SILICA GEL BREATHER WHEN DRY. SILICA GEL DRIED AND REPLACED COMPLETED BY: G. HILLIER ON 2007-09-17	47825	90
642725	5/7/2008	WAVTS,T5 OIL SAMPLE TAP CHANGE	WAVTS,T5 OIL SAMPLE TAP CHANGER ONE SAMPLE REQUIRED NO OUTAGE REQUIRED	47825	90
646548	5/22/2008	WAVTS T5 OIL LEAK	WAVTS T5 OIL LEAK	47825	90
658366	9/23/2008	WAVTS,T5,STAIN,OIL,CLEAN UP	SWOP#2008003195 Eastern Terminal Station Equipment WAVTS, T5, Oil stain on Tap changer access door and main TRF. Clean oil stain and repair leak if any	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
658366	9/23/2008	WAVTS,T5,STAIN,OIL,CLEAN UP	CHECKED FOR OIL LEAKS AROUND COVER AND CLEANED UP OIL STAINS. COMPLETED BY: S. TUCKER ON 2008-09-23	47825	90
675991	1/26/2012	WAVTS,T5,WINDING TEMP. GAUGES	WAVTS,T5,WINDING TEMP. GAUGES MOISTURE IN TWO WINDING TEMP. GAUGES, REPLACE	47825	80
678081	10/16/2008	WAVT5 REPLACE RAD VALVES	WAVT5 REPLACE RAD VALVES REPLACE RUSTED RAD DRAIN VALVES WITH STAINLESS. REPLACED TWO VALVES ON T5 RADS COMPLETED BY; W. WALSH/H. MOORES/W. DEAN COMPLETED ON: 2008-10-17	47825	90
678723	10/17/2008	WAVTS,T5,XFMR PM MTNCE	1.PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK 2.RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A DATE. 3.CONSIDER & REPORT ANY ENVIROMENTAL IMPACTS. -PM DONE AS PER WORK ORDER -DIVERTER OIL LEVEL GAUGE REPLACED -MAIN TANK OIL LEVEL GAUGE 1 LINE 156 M COMPLETED BY: W. WALSH ON 2008-10-17	47825	90
702663	7/19/2012	WAVTS,T5,MOISTURE IN WD RELAY	WAVTS,T5,MOISTURE IN WD RELAY WINDING TEMPERATURE RELAY REPLACED COMPLETED BY: W. WALSH/G. THORNE ON 2012-07-19	47825	80
702679	5/13/2009	WAVTS,T5,CONSERVATOR TANK,REP	WAVTS,T5,CONSERVATOR TANK,REPLACE LEVEL GAUGE OUTAGE REQUIRED GAUGE REPLACED COMPLETED BY: W. DOWNING ON 2009-05-14	47825	90
710350	5/12/2009	WAVTS,T5,FALL ARREST PLATES	WAVTS,T5,FALL ARREST PLATES,INSTALL THREE FALL ARREST PLATES WELDED ON TRANSFORMER COMPLETED BY: W. DOWNING ON 2009-05-11	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
750012	11/28/2009	WAVTS,T5 TAP CHANGER,FAILURE	WAVTS,T5 TAP CHANGER,FAILURE TIMER REPLACED WITH NEW TEMP ONE. NEW TIMER TO BE (B. STOYLES). COMPLETED BY: W. DOWNING ON 2009-11-28	47825	90
821557	7/20/2012	WAVTS,T5 SELICA GEL CONTAINER	T5 SELICA GEL CONTAINER REPLACE TEMPORARY UNIT NEW SILICA GEL CONTAINER INSTALLED COMPLETED BY: W. WALSH/W. DOWNING ON 12-07-20	47825	80
844084	3/6/2012	WAVTS,T5 TAPCHANGER OIL SAM	WAVTS, T5 TAP CHANGER OIL SAMPLE OBTAIN OIL SAMPLE FOR AS PER T.SHAVE'S INSTRUCTIONS QUOTE WORK ORDER ON INVOICE 1) If oil volume in the equipment is less than 250 gallons (1200 L) flush 1 quart of oil, otherwise flush a gallon into waste oil container. 2) Bottle Samples: rinse bottle by partially filling and gently swirling and emptying the oil into the waste container. Fill bottle to within an inch of the top, to allow for expansion. Visually examine fluid for water droplets or foreign particles. If present, re-sample. If not, attach the cap securely, identify the sampled unit on the bottle's label. Do not tape the cap. 3) Syringe Samples: the plastic stopcock, which comes with the syringe must remain firmly affixed to the syringe to prevent leaks. Flushing the syringe: a) Move the handle toward the sampling valve. b) Open sampling valve and move the handle toward the syringe allowing oil to flush the tube and stopcock. c) Move the handle towards the side port, allowing oil pressure to enter the syringe barrel, forcing the plunger out. Until the inside of the syringe has been wetted with oil, it may be necessary to pull the plunger. d) When oil reaches the 50 cc mark, move the handle towards the sampling valve and eject oil from ssyringe by pushing in the plunger. Catch this ejected oil in waste container	47825	80

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
844084	3/6/2012	WAVTS,T5 TAPCHANGER OIL SAM	Draw the Sample: a) Move the handle towards the side port and allow oil pressure to fill the syringe. DO NOT PULL ON THE PLUNGER When oil reaches the 40-45cc mark, move the handle towards the syringe. Do not over fill the syringe to avoid gas escape from the plunger side. b) Examine sample to ensure it is free of bubbles and foreign particles. If sample is good, move handle towards the syringe, close drain valve and remove the syringe with stopcock still firmly attached to the syringe. If sample is not clear, repeat sample procedure. c) Record info: on sample bottle check sheet as per enclosed instructions. OIL SAMPLE TAKEN COMPLETED BY: G. HILLIER/W. WALSH ON 2012-03-06	47825	80
914315	5/10/2012	WAVTS,T5,TAP CHRANGER OIL SAMP	WAVTS,T5,TAP CHRANGER OIL SAMPLE FOR TASA TESTING OIL SAMPLE FROM PM INDICATED POSSIBLE PROBLEMS SAMPLE TAKEN SENT TO TJH2b IN CALGARY COMPLETED BY: B. TOBIN/W. DOWNING ON 2012-05-10	47825	80
922300	7/25/2012	WAVTS,T5,TRF DOBLE PM	DOBLE TRANSFORMER EVERY 6 YEARS. note sent. 1. CHECK LATEST DOBLE TEST RESULTS TO SEE WHEN LAST TRANSFORMER WAS TESTED. 2. DOBLE TRANSFORMER AS PER CHECK SHEET AND RECORD 3. ANY VARIATIONS FROM INITIAL DOBLE RESULTS SHOULD BE BROUGHT TO THE ATTENTION OF THE P AND C SUPERVISOR. Performed Doble test on T5 at WAVTS on Jy.25th,2012.OK Results sent to all P&C at Whtb. on JY 26...RH. ---- PERFORMED DOBLE TEST - JULY 25 2012 RESULTS SENT TO WHITBOURNE P&C - JULY 26, 2012. (R. HURLEY) ----	47826	80
922301	7/27/2012	WAVTS,T5,XFMR PM MTNCE	1.PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK	47825	80

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
922301	7/27/2012	WAVTS,T5,XFMR PM MTNCE	2.RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A DATE. 3.CONSIDER & REPORT ANY ENVIROMENTAL IMPACTS. PM COMPLETED. COMPLETED BY: W. DOWNING, D. HOSKINS, G. THORNE, B. J. HILLIER ON 2012-07-27	47825	80
923911	10/16/2012	WAVTS,T5 REPLACE GAS RELAY	WAVTS,T5 REPLACE GAS RELAY NEW GAS RELAY ORDERED TO REPLACE ONE USED ON T5 PM. MAINTENANCE WO 922301 GAS RELAY ARRIVED AT WBN ON 2012-10-16 COMPLETED BY? R. DAY ON 2012-10-16	47825	80
925139	7/11/2012	WAVTS,T5,RELAY CABLES,REPLACE	WAVTS,T5,RELAY CABLES,REPLACE REPLACE WINDING TEMP, LIQUID LEVEL AND GAS RELAY FOUND TO BE DETERIORATED ON TRANSFORMER PM CABLES SUPPLING TWO TEMP GAUGES AND ONE LIQUID GAUGE WERE REMOVED AND REPLACED ONE WINDING TEMP GAUGE WAS REPLACED CCOMPLETED BY: W. WALSH/J. HILLIER ON 12-07-11	47825	80

Verbal Safety Talk _____

THINK SAFETY FIRST

WO TYPE : 2 PM Wo HRDTS,B1L17 BREAKER PM MTNCE PARENT #: 00963994
STATUS : 45 PRIORITY: 3 Plann
ITEM # : 00005994 UNIT #: HRDB1L17 BREAKER,B1L17,HRD TS
PLT COND: SD BU #: 1325 SUPV: WHB Station Mtce Dept
LOCN: HRDTS HRD Term Stn, Holyrood ORIG: Lyver, Gerard J.
W/H : 1829 Bishop Falls Warehouse PLNR: Lyver, Gerard J.
EMPL: W.O.#: 963994 W.O. SUBCODE: PMN

--- Full Description of Request ----------

1.PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK SHEET.
2.RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK ORDER REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A LATER DATE.
3.CONSIDER & REPORT ANY SIGNIFICANT ENVIROMENTAL IMPACTS.

OP#	CRAFT	DESCRIPTION	SIZE	MHRS
1.00	WHBCRSEM	WHB ELEC Term. Stn Mtce. Crew	2.0	
2.00	WHBCRTM	WHB Term. Stn Mtce	1.0	

--- Tools/Materials & Equip Status ----------

1. CHERRY PICKER OR BUCKET TRUCK
2. DOBLE TEST ELECTRONIC TIMING EQUIPMENT
3. DUCTOR TESTER

--- Safety Provisions ----------

1.ENSURE NECESSARY WORK PROTECTION IS IN PLACE BEFORE STARTING WORK.
2.COMPLETE TAILBOARD SAFETY TALK BEFORE BEGINNING WORK.

--- Plan and Drawing Reference ----------

--- Maintenance Loops ----------

00005994	BREAKER,B1L17,HRD TS	Y06A

Keyed 13-04-15
RB

-- COMMENTS & WORK DONE ----------

work done as Per Pm sheets

-- ASSET TRACKING INFORMATION ----------

1. List all assets installed (Description and Serial Number):

1.a Provide Nameplate Data for all new assets installed:

2.If an asset was removed, note the Description, Serial# and JDE# if known and where it was transferred. ie. St. Anthony Line Depot, Bishops Falls etc.

3. List all assets disposed or to be disposed (Description, Serial #, and JDE #, if known):

COMPLETED BY: BW WJ COMPLETED ON: 13 04 07

-- WORK REMAINING ----------

SUPERVISOR: _____

6 Year PM – 230 KV DLF AIR BLAST CIRCUIT BREAKER INSPECTION

System ID: BL17 Station: HRDTS Serial No.: 170 B 3/1873
Manufacturer: Brown Boveri Type: DLF 245 ND 2 Voltage: 245 KV
Test Date: 8/3 04 04 Test Completed By: GW WD. J.D.E.W/O #: 963994

WEATHER CONDITIONS: [ ] dry [ ] rain [ ] humidity [ ] temperature

NOTE: All TESTS MUST BE COMPLETED OR MARKED N/A (unless otherwise Instructed).

BEFORE OPERATING: Pressure 425 PSI kPa Counter: 01859

ACCEPTABLE DUCTOR READINGS < 120 µOhm		
	% CURRENT	µOhm
A ph	100 100	~~252 µΩ~~ 114 µΩ
B ph	100 100	~~233 µΩ~~ 77.8 µΩ
C ph	100	107.8 µΩ

MEGGER TEST 5 KV (PHASE TO GROUND)					
A PH	32 GΩ	Mega Ω	B PH 50 GΩ	Mega Ω	C PH 65 GΩ Mega Ω

TIMING TEST (milliseconds)			
	A	B	C
3-PH Close	54/55	~~53~~ 53	51 51
3-PH Trip	24 24	23 23	24 23
Trip Free (dwell)	54/55	53/53	51/57
Disagreement On Trip	33 32	32 32	1499
Resistor Contacts			

Command Current Close 2.98 amps Trip 4.31 amps

NOTE: THE BREAKER (TIMING TEST) PERFORMANCE REPORT INCLUDING ALL MAIN CONTACTS SHOULD BE ATTACHED TO THE COMPLETED INSPECTION FORM.

CONTROL CIRCUIT RESISTANCE (Ohms): (test to be completed from the Control Cabinet Terminal Board)						
Trip Coil # 1:	A ph 63.7	Ω	B ph 62.2	Ω	C ph 62.2	Ω
Trip Coil # 2:	A ph 87.4 Ω	Ω	B ph	Ω	C ph	Ω
Close:	A ph 42.4	Ω	B ph 42.2	Ω	C ph 42.2	Ω

HEATER AMPERAGE			
CABINET HEATER :	~~5.0 A.~~ 5.1 A.		
CONTROL BLOCKS:	A: R .6 A	B: S .6 A	C: T .3 A.

Phase C indicator linkage is broken control box

Close Tc 3,4 3,6 3,8
R1 R2 R3
1.2 1.2 1.2

6 Year PM – 230 KV DLF AIR BLAST CIRCUIT BREAKER INSPECTION

System ID: BIL17 Station: HRISTS Serial No.: 170-73-3/1973
Manufacturer: Brown Boveri Type: DLF 245 no2 Voltage: 245KV
Test Date: 2013 04 04 Test Completed By: BWJ WD J.D.E.W/O #: _____

PRESSURE SETTINGS (kPa)		
	Found	Left
400 Block Reclose	410	410
373 Block Trip	376	376
Aux Block Trip		
388 Block Close	390	390
Low Pressure Alarm 303	315	315

CHECKS COMPLETED:
- ✓ Air Leaks
- ✓ Lubricate Control Blocks
- ✓ Check Primary Connections
- ✓ 20 Minute Pressure Drop
- ✓ A ph Control Block Aux Contacts
- ✓ B ph Control Block Aux Contacts
- ✓ C ph Control Block Aux Contacts
- ✓ Control Cabinet Aux Contacts

AFTER OPERATING: Pressure 405 psi kPa Counter: 01868

ONLY IF INSTRUCTED
- NA Doble Test
- NA Clean Air Intake Filters
- NA Inspect 1 Arcing Chamber
  Chamber Lubrication Required _____ yes _____ no

COMMENTS:
Phase B & C indicater linkage broken in Control block box

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
925329	8/1/2012	HRDTS,B1L17,CAPACITORS,LEAKING	HRDTS,B1L17,CAPACITORS,LEAKING REPLACE LEAKING CAPACITORS CLEAN UP OIL, REMOVE SOIL ENSURE PAPER WORK COMPLETED BEFOR TRANSPORTING TO SEE ENV-SOP-11 B1L17 AT HRDTS. TWO NEW CAPACITORS INSTALLED. SERIAL # 8402655 TESTED @ 2569 PT SERIAL # 8402646 TESTED @ 2773 PT. COMPLETED BY: P. O'GRADY & CREW ON 2012-08-01	47825	80
946137	11/2/2012	HRDTS,B1L17,CAPACITORS,TEST	HRDTS,B1L17,CAPACITORS,TEST,DISPOSE OF AS PER POLICY AND REGULATIONS. CAPACITORS ARE DISPOSED TWO TESTED LESS THAN 2 PPM AND TWO TESTED AT 29 PPM'S AND 4.5 PPM'S OF PCB. TWO THAT TESTED HIGH ARE IN THEIR DESIGNATED AREA FOR PICK-UP AND OTHER TWO ARE DRAINED. (R. EDISON)	47806	80
497354	12/6/2005	Check Operation of HRD B1L17	Check Operation of HRD B1L17 Reclose on TL217 on Nov 18. Breaker B1L17 at Holyrood was slow in operating. Check operation of breaker. Call Ern Buglar or Art Bursey for further information HRD BREAKER TIMINGS FROM DOBLE TR 3100 --- PHASE A PHASE B PHASE C TRIPS CONTACT 1 25.3 MS 25.2 MS 25.5 MS CONTACT 2 25.1 MS 25.0 MS 25.2 MS --- CLOSES CONTACT 1 53.6 MS 54.1 MS 61.4 MS 53.3 MS 53.8 MS 61.4 MS --- CHECK TRIP/RECLOSING ON B1L17 ********** THE TRIP/RECLOSING WAS INITIATED VIA P2 PROTECTION FOR A B PH, AND C PH. THE FOLLOWING TIMES WERE NOTED FROM (DEC. 6, 2005) ON EMS. THIS WAS DONE TWICE FOR	47826	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
497354	12/6/2005	Check Operation of HRD B1L17	----------	47826	90

A PHASE

TIME
---
94 A TRIP 11.06.40.894
BREAKER OPEN 11.06.40.999
BREAKER CLOSED 11.06.42.634
****

B PHASE

TIME

94B TRIP 11.07.59.658
BREAKER OPEN 11.07.59.728
BREAKER CLOSED 11.08.01.181
****

C PHASE

TIME

94C TRIP 11.08.35.644
BREAKER OPEN 11.08.35.741
BREAKER CLOSED 11.08.37.358

A PHASE

TIME

94A TRIP 11.47.13.748
BREAKER OPEN 11.47.13.853
BREAKER CLOSED 11.47.15.500
****

B PHASE

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
497354	12/6/2005	Check Operation of HRD B1L17	TIME ------ 94B TRIP 11.47.37.117 BREAKER OPEN 11.47.37.186 BREAKER CLOSED 11.47.38.635 ********** C PHASE --------- TIME ------ 94C TRIP 11.47.53.489 BREAKER OPEN 11.47.53.587 BREAKER CLOSED 11.47.55.204 ********** 3 PH OPEN VIA BREAKER OPEN SWITCH VIA T RELAY. ---------- TIME ------ TRIP 13.21.25.499 BREAKER OPEN 13.21.25.573 COMPLETED BY: L. HOPKINS ON 2005-12-06	47826	90
497889	12/6/2005	HRDTS,B1L17,CHECK PROTECTION/T	HRDTS,B1L17,CHECK PROTECTION AND TIME BREAKER IF TESTS REQUIRED AS A RESULT OF SLOW OPERATION ON A Breaker and protection tested ; results in WO # 497354 under actual work done	47826	90
497890	12/7/2005	HRDTS,B1L17,CHECK PROTECTION/T	HRDTS,B1L17,CHECK PROTECTION AND TIME BREAKER IF TESTS REQUIRED AS A RESULT OF SLOW OPERATION ON A P.C. INITATED SINGLE PHASE PROTECTION TRIPS, TIME MEASURED BY SOE TIMING TEST TRIP, CLOSE TRIP FREE. COMPLETED BY: P. O'GRADY ON 2005-12-07	47825	90
547236	9/15/2006	HRDTS,BIL17,TRIPPED ON DISA	HRDTS,BIL17,TRIPPED ON DISAGREEMENT OUTAGE REQUIRED. WORK PROTECTION WAS REQUIRED. OPERATED BREAKER	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
547236	9/15/2006	HRDTS,BIL17,TRIPPED ON DISA	AT BK. CABINET. ALSO OPERATED BK. FROM CONTROL ALSO FROM HRD CONTROL ROOM ELECTRICTY. CHECKED ALL AND "T" RELAY. BREAKER WORKING OK. COMPLETED BY: G. HILLIER, J. MCDONALD & P. O'GRADY COMPLETED ON: 2006-09-14	47825	90
880287	11/3/2011	HRDTS,B1L17,TC INDICATION	HRDTS,B1L17,TC INDICATION TRIP COIL HEALTH LIGHT NOT WORKING FOUND A LOOSE CONNECTION IN THE NEON LIGHT SOCKET COMPLETED BY: P. O'GRADY/W.WALSH ON 2011-11-03	47825	80
880288	11/3/2011	HRDTS,B1L17,TC INDICATION	HRDTS,B1L17,TC INDICATION TRIP COIL HEALTH LIGHT NOT WORKING CHECKED BREAKER PRESSURE SWITCH A CONTACTS AND COIL RESISTANCES PANEL NEON LIGHT SOCKET TIGHTENED, CHECKED APERATION - COMPLETED BY: R. STOYLES/P.O'GRADY/W.WALSH COMPLETRED ON: 11-11-03	47826	80
962976	2/14/2013	HRDTS,B1L17,C-PH ARCING CHAMBE	HRDTS,B1L17,C-PH ARCING CHAMBER OVERHAUL. REMOVE C-PH ARCING CHAMBER, SHIP TO BIF HAVE OVERHAULED AND REINSTALLED WITH NEW HOLLOW CENTRE PHASE HEAD OF B1L17 REMOVED AND SENT TO COMPLETED BY: W. DOWNING ON 2013-02-14	47825	90
523886	2/20/2008	HRD TS B1L17 RTV COATING	HRD TS B1L17 RTV COATING APPLY RTV COATING TO BREAKER GLASS. CONTACT ERNEST BUGLAR (ENGINEERING) FOR DETAILS RTV COATING IS IN WHITBOURNE TWO PHASE DONE OTHER ONE NOT REQUIRED THIS PRODUCT HAS NOT PROVEN TO BE ANY GOOD NOT REQUIRED AS PER H.IRELAND	47825	90
547504	10/11/2006	HRDTS,B1L17,TEST,TIMING	HRDTS,B1L17,TEST,TIMING. ONE PHASE SLOW OPENING SOMETIMES DISAGREEMENT ALARM ANNUNICATES. OUTAGE REQUIRED.	47825	90

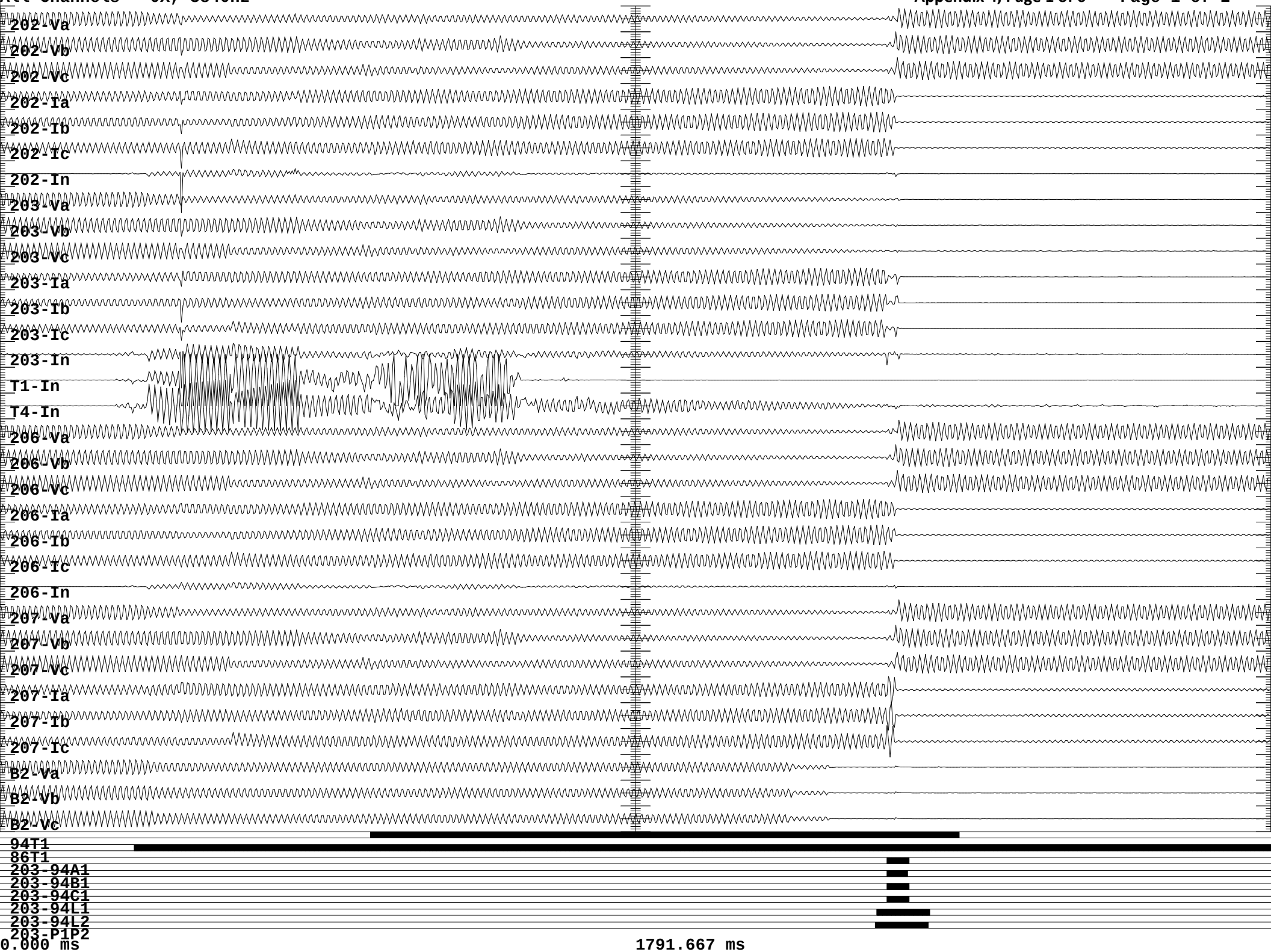
WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
547504	10/11/2006	HRDTS,B1L17,TEST,TIMING	CHECKED ALL 3 PHASES WITH TIMING SET. DISAGREEMENT ON BREAKER WORKING OK. ALARM RESET OK FOR ALL 3 OPERATIONS. COMPLETED BY: G. HILLIER & B. WALSH ON 2006-10-11	47825	90
728010	9/17/2009	HRDTS,B1L17,CHECK AUX.CONTACTS	HRDTS,B1L17,CHECK AUX.CONTACTS BREAKER TRIPPED UNDER DISAGREEMENT. CHECK WO 733227 PERMISSIVE CONTACTS CLEANED AND BREAKER FUNCTION FOUND OK	47825	90
965961	2/28/2013	HRDTS,B1L17,RTV COATING APPLY	RTV COATING APPLY. DISMANTLE COLUMNS AND HEADS, APPLY COATING AND BREAKER. BREAKER HEADS SUPPORT COLUMNS AND CAPICITORS ALL WITH A RTV COATING BY CONTRACTOR. COMPLETED BY: P. O'GRADY ON 2013-02-28 INTERRUPTER HEAD INSTALLED. COMPLETED BY: W. WALSH, I. ORGAN, P. O'GRADY,W. DEAN COMPLETED ON: 2013-03-23	47825	80
676502	7/10/2009	HRDTS,B1L17,RELIEF VALVE,REPLA	HWDTS,B1L17,RELIEF VALVE,REPLACE."B-PH ONLY" valve replaced	47825	90
733227	8/23/2009	HRDTS,B1L17,TRIP/BKR FAIL,INV	HRDTS,B1L17,TRIP/BKR FAIL,INVESTIGATE LIGHTNING STORM CAUSED TL217 PROTECTION TO OPERATE BUT B1L17 WENT INTO LOCKOUT ON THURSDAY, AUG 20, 2009 AT AROUND 7:16 A.M., THERE A LIGHTNING STRIKE ON A PHASE, TL217. THIS CAUSED AN A PHASE TO NEUTRAL FAULT ON OUR PROTECTION. THE FAULT CAUSED OUR PROTECTION TO OPERATE A1 AND A2 RELAYS B1L17 BREAKER DID NOT TRIP. THE PROTECTION ALSO CAUSED TO OPERATE AND BRING IN A BREAKER FAIL 86 TRIP. THE L2 RELAY GOING TO TRIP COIL TWO ACTUALLY CAUSED THE TO TRIP AND WAS THEN LOCKED OUT BECAUSE OF THE 86 TRIP. THE ELECTRICIANS CHECKED BREAKER B1L17 UNDER PERMIT	47826	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
733227	8/23/2009	HRDTS,B1L17,TRIP/BKR FAIL,INV	FOUND THE FOLLOWING: TRIP COIL 1 TRIP COIL 2 3-4 R = 18.2 K OHMS 89 OHMS 3-4 S = 47.1 K OHMS 3-4 T = 29.1 K OHMS THEY DID CLEAN AND BURNISH THE CONTACTS IN THE AND ALSO DID THE SAME ON THE SIGNALING DEVICE AFTER THEY FOUND THE FOLLOWING: TRIP COIL #1 TRIP COIL #2 3-4 R = 61.2 OHMS 90 OHMS 3-4 S = 62.1 OHMS 3-4 T = 64 OHMS WE ALSO CHANGED THE P8 RELAY IN THE BREAKER P8 RESISTANCE 1-2 = .2 OHMS 3-4 = .6 OHMS 5-6 = 1.2 OHMS 7-8 = 1.6 OHMS IT APPEARS THAT THE BREAKER CONTACTS IN OUR TRIP COIL HAD A HIGH RESISTANCE DUE TO THE CONTACTS BEING DIRTY CORRODED. THIS CAUSED THE TRIP COIL ONE NOT TO OPERATE PROPERLY. AFTER THE BREAKER WAS PUT BACK TOGETHER IT TIMING TESTED BY THE ELECTRICIANS. THE BREAKER WAS ALSO FUNCTION TESTED USING THE P1 AND PROTECTION TO TRIP THE BREAKER USING A1, B1, C1 AND A2, B2, C2 RELAYS. THE BREAKER TRIPPED AND RECLOSED PROPERLY ON EACH PHASE. IT ALSO TRIPPED THREE PHASE PROPERLY. COMPLETED BY: G. PARSONS/J. MCDONALD/L. HOPKINS COMPLETED ON: 2009-08-21	47826	90
881761	1/24/2012	HRDTS,AIR SYSTEM ANOMOLY	HRDTS,AIR SYSTEM ANOMOLY B1L17 RESET AIR ON BRAKER B12L18	47825	80

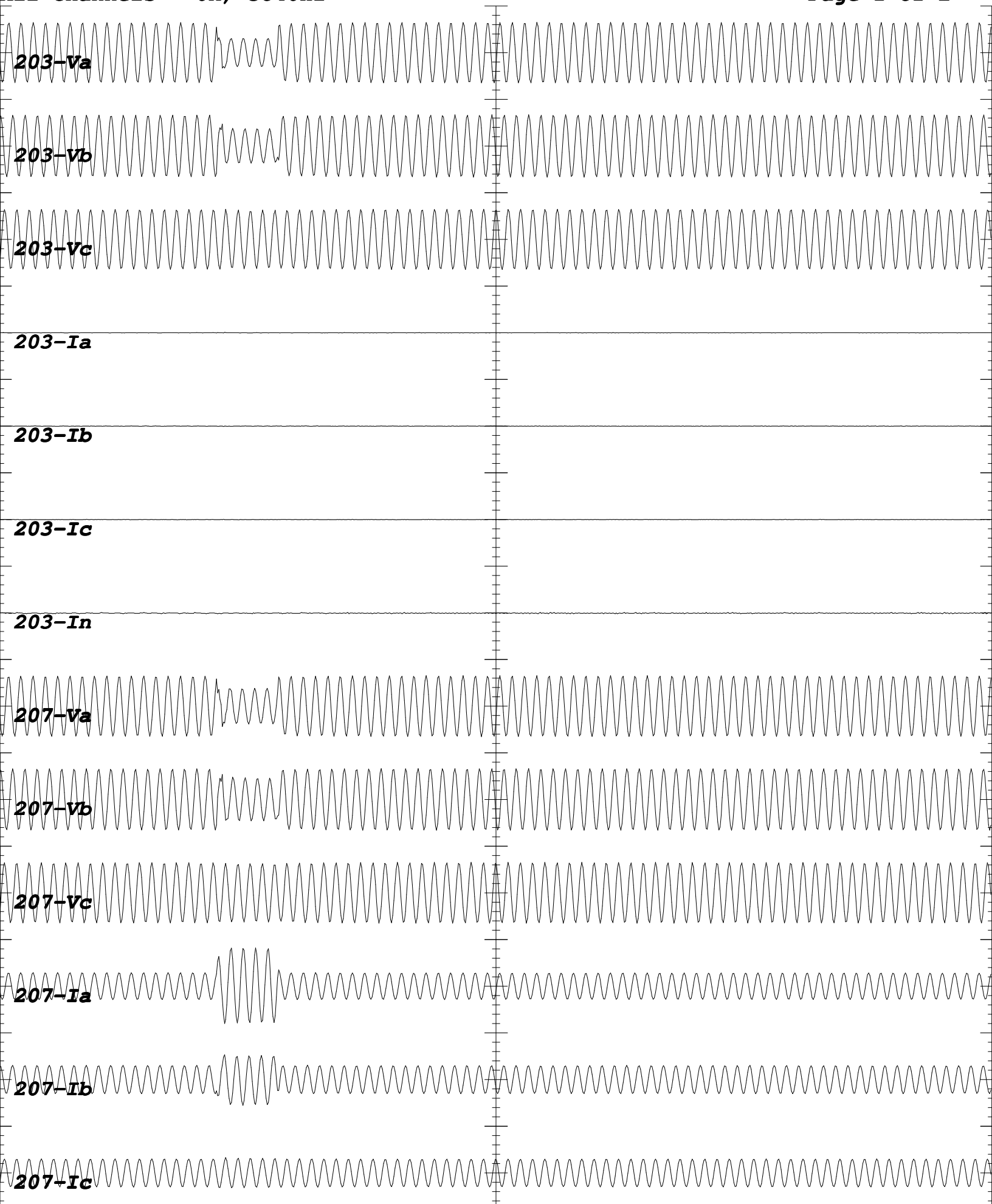
WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
881761	1/24/2012	HRDTS,AIR SYSTEM ANOMOLY	COMPLETED BY: M. PENNEY ON 2011-10-26 COMPLETED	47825	80
976955	4/9/2013	HRDTS,B1L17,AIR PRESS ALARM	HRDTS,B1L17,AIR PRESS ALARM INVESTIGATE ALARM CAUSED BY AIR PRESSURE LOWER THAN 400 PSI RECLOSING SET POINT AIR VALVE ADJUSTED SEVERAL TIMES TO CLEAR ALARM COMPLETED BY: W. DOWNING ON 13-04-09	47825	80
978023	4/7/2013	HRDTS,INVEST.AIR ALARM B1L17	HRDTS,INVEST.AIR ALARM B1L17 AIR ANOMALY BREAKERB1L17 BREAKER INVESTIGATE CHECKED AIR PRESSURE ALARM ON B1L17. ALARM RESET PRESSURE RECOVERED TO 400 PSI. COMPLETED BY: W. DOWNING ON 2013-04-07 AIR ALARM ON B1L17, VALVE STICKING, VALVE ADJUSTED CLEARED. COMPLETED BY: W. DOWNING & B. TOBIN ON 2013-04-10	47825	80
393852	4/8/2004	HRD B1L17 INSULATORS WASH	HRD B1L17 INSULATORS WASH WASH INSULATORS USING KARCHER POWER WASHER (1500 USING WATER ONLY.BREAKER DEENERGIZED FOR WASHING. INSPECT EXISTING RTV COATING AND ADD COMMENTS ON B1L17 PRESSURED WASHED NO VISIBLE SIGN OF ARCING TOP VENT SHROUD RUSTED ON A AND C PHASE COMPLETED BY: P. O'GRADY/W. WALSH/S. TUCKER COMPLETED ON: 2004-04-07	47825	90
326986	6/12/2003	HRDTS,B1L17,AIR LEAK,INVEST*	HRDTS,B1L17,AIR LEAK,REPAIR B PHASE CONTROL BLOCK. SCHEDULE WITH UNIT 1 OUTAGE-AROUND MAY 12TH INVESTIGATED AIR LEAK & FOUND LEAK IN THE CONTROL BLOCK ON B PHASE. NEEDS CONTROL BLOCK TO BE OVERHAULED. COMPLETED BY: G. HILLIER ON 2003-06-12	47825	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
326986	6/12/2003	HRDTS,B1L17,AIR LEAK,INVEST*	TAKE OUTAGE AND DRAIN AIR OF BREAKER AND REPAIR CONTROL BLOCK (DLF 230KV AIR BLAST BK.)	47825	90
333692	6/27/2003	HRDTS,B1L17,PAINT REC. TANKS*	HOLYROOD TERMINAL STATION: BREAKER #B1L17 PAINT RECEIVER TANKS WHITE. PAINT TO BE USED IS AN INDUSTRIAL TYPE WHITE COLOR. BRUCE COLLIER HAS IDENTIFIED THE PAINT AND REQUIRED AMOUNT. THIS WORK CAN BE PERFORMED FROM SCAFFOLD AND OUTAGES WILL NOT BE REQUIRED. NAME PLATES ARE TO BE COVERED DURING THE PAINTING RUST AREAS TO BE SCRAPED AND PRIMED. THE APPLICATION METHOD TO BE WITH BRUSH, ROLLER OR PAD OR A THESE. SPRAY PAINTING METHOD IS NOT TO BE USED. PAINTED AIR RECEIVERS COMPLETED BY: H. MOORES ON 2003-06-27	47825	90
344962	10/9/2003	HRDTS,B1L17,LEAK,REPAIR	HRDTS,B1L17,LEAK,REPAIR DLF 245 NC2 PARTS REQUIRED REPLACED PART #A1-B110 WHICH IS THE PRIMARY CONTROL VALVE SEALING. COMPLETED BY: P.O'GRADY/W.DOWNING ON 2003-10-09	47825	90
398074	12/4/2004	HRDTS.B1L17 INSTALL PLC	HRD 230kV Bkr B1L17 Controls Install Programmable Logic Controller for breaker controls on HRD Bkr B1L17. Remove old relays and case for recloser. Refer to WO #398085 for parts. CHECKED BREAKER FOR PROPER OPERATION BEFORE PROCEEDING WITH JOB. HAD PROBLEM WITH AIR PRESSURE. NEEDED MECHANIC, RESOLVED PROBLEMS CONTINUED WITH REMOVED OLD RECLOSER AND INSTALLED NEW PLC BASED RECLOSER, ASSOCIATED RELAYS AND WIRING. BUZZED OUT CIRCUITS, FUNCTION TESTED AND CHECKED INTO SERVICE. THE BT RELAY SLATED FOR THIS JOB WAS USED AT WAV. C. WARREN REPLACED WITH A DIFFERENT TYPE ABB RXMA1. COMPLETED BY: J. HOPKINS/J.MCDONALD ON 2004-12-04	47826	90

WO#	Comp. Date	Work Description	Detailed Description/Actual Work	Supervisor	St
398085	1/5/2005	HRD 230kV Bkr B1L17 Controls	HRD 230kV Bkr B1L17 Controls Install Programmable Logic Controller for breaker controls on HRD Bkr B1L17. Remove old relays and case for recloser. Refer to WO #398074 for labour. COMPLETED COMPLETED BY: J.S. FOLEY ON 2005-01-05	47826	90
551787	10/20/2006	HRDTS,B1L17 BREAKER PM MTNCE	1.PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK 2.RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A DATE. 3.CONSIDER & REPORT ANY SIGNIFICANT ENVIROMENTAL	47825	90
963994	4/7/2013	HRDTS,B1L17 BREAKER PM MTNCE	1.PERFORM PM IN ACCORDANCE WITH APPROPRIATE CHECK 2.RECORD ANY UNCOMPLETED DEFICIENCIES ON A WORK REQUEST IN ORDER TO HAVE THE WORK COMPLETED AT A DATE. 3.CONSIDER & REPORT ANY SIGNIFICANT ENVIROMENTAL WORK DONE AS PER PM SHEETS. COMPLETED BY: B. WALSH & W. DOWNING ON 2013-04-07	47825	80


202-Va
202-Vb
202-Vc
202-Ia
202-Ib
202-Ic
202-In
203-Va
203-Vb
203-Vc
203-Ia
203-Ib
203-Ic
203-In
T1-In
T4-In
206-Va
206-Vb
206-Vc
206-Ia
206-Ib
206-Ic
206-In
207-Va
207-Vb
207-Vc
207-Ia
207-Ib
207-Ic
B2-Va
B2-Vb
B2-Vc
94T1
86T1
203-94A1
203-94B1
203-94C1
203-94L1
203-94L2
203-P1P2
0.000 ms
1791.667 ms

Trace	Label	Name	Scale	Units/Division
1	202-Va	230 KV TL202 A Phase Voltage	1.00	72177.652 V
2	202-Vb	230 KV TL202 B Phase Voltage	1.00	72458.470 V
3	202-Vc	230 KV TL202 C Phase Voltage	1.00	72601.507 V
4	202-Ia	TL202 A Phase Current	5.00	338.114 A
5	202-Ib	TL202 B Phase Current	5.00	338.290 A
6	202-Ic	TL202 C Phase Current	5.00	339.371 A
7	202-In	TL202 Neutral Current	15.00	113.019 A
8	203-Va	230 KV TL203 A Phase Voltage	1.00	72423.934 V
9	203-Vb	230 KV TL203 B Phase Voltage	1.00	72506.562 V
10	203-Vc	230 KV TL203 C Phase Voltage	1.00	72394.188 V
11	203-Ia	TL203 A Phase Current	5.00	337.960 A
12	203-Ib	TL203 B Phase Current	5.00	338.712 A
13	203-Ic	TL203 C Phase Current	5.00	338.641 A
14	203-In	TL203 Neutral Current	15.00	112.692 A
15	T1-In	T1 Neutral Current	2.00	1059.220 A
16	T4-In	T4 Neutral Current	2.00	1059.457 A
17	206-Va	230KV TL206 A Phase Voltage	1.00	72296.314 V
18	206-Vb	230KV TL206 B Phase Voltage	1.00	72600.926 V
19	206-Vc	230KV TL206 C Phase Voltage	1.00	72753.172 V
20	206-Ia	TL206 A Phase Current	5.00	339.398 A
21	206-Ib	TL206 B Phase Current	5.00	338.909 A
22	206-Ic	TL206 C Phase Current	5.00	338.978 A
23	206-In	TL206 Neutral Current	15.00	113.283 A
24	207-Va	230KV TL207 A Phase Voltage	1.00	72562.495 V
25	207-Vb	230KV TL207 B Phase Voltage	1.00	72516.289 V
26	207-Vc	230KV TL207 C Phase Voltage	1.00	72466.927 V
27	207-Ia	TL207 A Phase Current	5.00	339.563 A
28	207-Ib	TL207 B Phase Current	5.00	338.912 A
29	207-Ic	TL207 C Phase Current	5.00	340.012 A
30	B2-Va	138 KV B2 A Phase Voltage	1.00	43573.561 V
31	B2-Vb	138 KV B2 B Phase Voltage	1.00	43518.666 V
32	B2-Vc	138 KV B2 C Phase Voltage	1.00	43444.008 V
33	94T1	94T1	N/A	N/A
34	86T1	86T1(NC)	N/A	N/A
35	203-94A1	TL203 94A1X	N/A	N/A
36	203-94B1	TL203 94B1X	N/A	N/A
37	203-94C1	TL203 94C1X	N/A	N/A
38	203-94L1	TL203 94L1	N/A	N/A
39	203-94L2	TL203 94L2	N/A	N/A
40	203-P1P2	TL203 21P1/P2	N/A	N/A



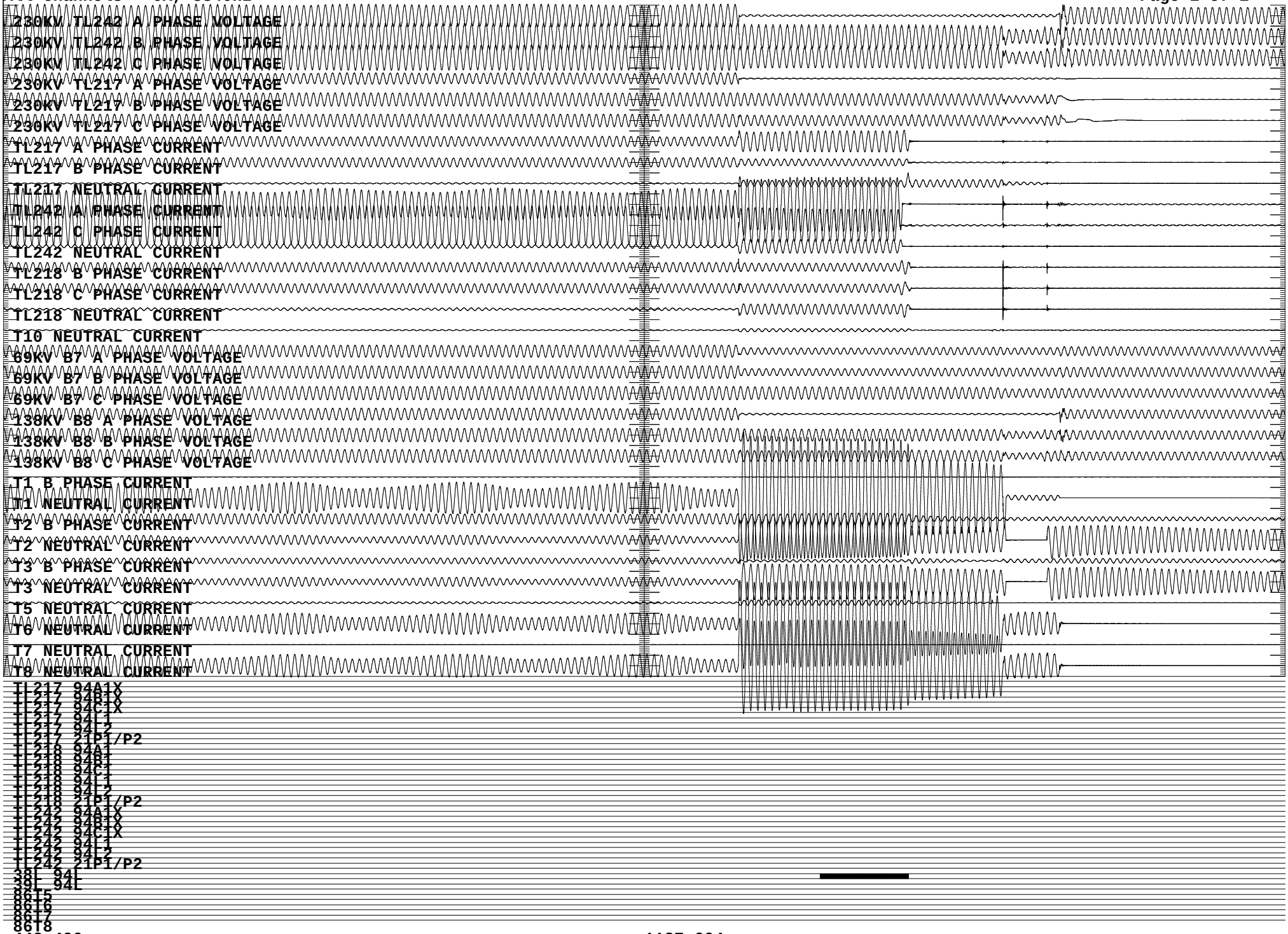
0.000 ms

671.875 ms

Trace	Label	Name	Scale	Units/Division
1	203-Va	230 KV TL203 A Phase Voltage	1.00	72423.934 V
2	203-Vb	230 KV TL203 B Phase Voltage	1.00	72506.562 V
3	203-Vc	230 KV TL203 C Phase Voltage	1.00	72394.188 V
4	203-Ia	TL203 A Phase Current	5.00	337.960 A
5	203-Ib	TL203 B Phase Current	5.00	338.712 A
6	203-Ic	TL203 C Phase Current	5.00	338.641 A
7	203-In	TL203 Neutral Current	15.00	112.692 A
8	207-Va	230KV TL207 A Phase Voltage	1.00	72562.495 V
9	207-Vb	230KV TL207 B Phase Voltage	1.00	72516.289 V
10	207-Vc	230KV TL207 C Phase Voltage	1.00	72466.927 V
11	207-Ia	TL207 A Phase Current	5.00	339.563 A
12	207-Ib	TL207 B Phase Current	5.00	338.912 A
13	207-Ic	TL207 C Phase Current	5.00	340.012 A

Transcan DFR : Holyrood Terminal Station HOLY0FF1.X01 2014/Jan/05 21:27:40 (IRIG-B)

All Channels - 0X, 3840Hz



-443.490 ms 1127.604 ms

Transcan DFR : Holyrood Terminal Station HOLY0FF1.X01 2014/Jan/05 21:27:40 (IRIG-B)
All Channels - 0X, 3840Hz

Trace	Label	Name	Scale	Units/Division
1	242 Va	230KV TL242 A PHASE VOLTAGE	2.00	36484.911 V
2	242 Vb	230KV TL242 B PHASE VOLTAGE	2.00	36668.145 V
3	242 Vc	230KV TL242 C PHASE VOLTAGE	2.00	36558.966 V
4	217 Va	230KV TL217 A PHASE VOLTAGE	1.00	73037.310 V
5	217 Vb	230KV TL217 B PHASE VOLTAGE	1.00	73091.451 V
6	217 Vc	230KV TL217 C PHASE VOLTAGE	1.00	73084.955 V
7	217 Ia	TL217 A PHASE CURRENT	10.00	190.731 A
8	217 Ib	TL217 B PHASE CURRENT	10.00	190.602 A
9	217 In	TL217 NEUTRAL CURRENT	10.00	191.105 A
10	242 Ia	TL242 A PHASE CURRENT	40.00	47.666 A
11	242 Ic	TL242 C PHASE CURRENT	40.00	47.655 A
12	242 In	TL242 NEUTRAL CURRENT	10.00	190.959 A
13	218 Ib	TL218 B PHASE CURRENT	10.00	190.594 A
14	218 Ic	TL218 C PHASE CURRENT	10.00	190.584 A
15	218 In	TL218 NEUTRAL CURRENT	10.00	190.902 A
16	T10 In	T10 NEUTRAL CURRENT	10.00	63.553 A
17	69B7 Va	69KV B7 A PHASE VOLTAGE	1.00	21949.857 V
18	69B7 Vb	69KV B7 B PHASE VOLTAGE	1.00	21892.398 V
19	69B7 Vc	69KV B7 C PHASE VOLTAGE	1.00	21941.347 V
20	138B8 Va	138KV B8 A PHASE VOLTAGE	1.00	43771.399 V
21	138B8 Vb	138KV B8 B PHASE VOLTAGE	1.00	43808.592 V
22	138B8 Vc	138KV B8 C PHASE VOLTAGE	1.00	43804.811 V
23	T1 Ib	T1 B PHASE CURRENT	10.00	190.832 A
24	T1 In	T1 NEUTRAL CURRENT	10.00	190.743 A
25	T2 Ib	T2 B PHASE CURRENT	10.00	190.428 A
26	T2 In	T2 NEUTRAL CURRENT	10.00	190.595 A
27	T3 Ib	T3 B PHASE CURRENT	10.00	189.763 A
28	T3 In	T3 NEUTRAL CURRENT	10.00	190.734 A
29	T5 In	T5 NEUTRAL CURRENT	10.00	47.620 A
30	T6 In	T6 NEUTRAL CURRENT	10.00	63.600 A
31	T7 In	T7 NEUTRAL CURRENT	10.00	63.546 A
32	T8 In	T8 NEUTRAL CURRENT	10.00	158.810 A
33	217 94A1	TL217 94A1X	N/A	N/A
34	217 94B1	TL217 94B1X	N/A	N/A
35	217 94C1	TL217 94C1X	N/A	N/A
36	217 94L1	TL217 94L1	N/A	N/A
37	217 94L2	TL217 94L2	N/A	N/A
38	217 21P	TL217 21P1/P2	N/A	N/A
39	218 94A1	TL218 94A1	N/A	N/A
40	218 94B1	TL218 94B1	N/A	N/A
41	218 94C1	TL218 94C1	N/A	N/A
42	218 94L1	TL218 94L1	N/A	N/A
43	218 94L2	TL218 94L2	N/A	N/A
44	218 21P	TL218 21P1/P2	N/A	N/A
45	242 94A1	TL242 94A1X	N/A	N/A
46	242 94B1	TL242 94B1X	N/A	N/A
47	242 94C1	TL242 94C1X	N/A	N/A
48	242 94L1	TL242 94L1	N/A	N/A
49	242 94L2	TL242 94L2	N/A	N/A
50	242 21P	TL242 21P1/P2	N/A	N/A
51	38L 94L	38L 94L	N/A	N/A

NEWFOUNDLAND AND LABRADOR HYDRO

Sequence of Events
Leading up to Sunnyside Transformer Fault on January 4, 2014

February 2014

newfoundland labrador hydro
a nalcor energy company

Table 1: Events leading up to Sunnyside Transformer Fault - January 4, 2014

Date	Time	Event
Jun. 1, 2013	**12:00**	The Stephenville Gas Turbine de-rated by 25 MW due to excessive heat build-up in the B turbine module during operation, resulting from the poor condition of the insulating blankets around the turbine and exhaust stack.
Oct. 3, 2013	**08:00**	Hardwoods Gas Turbine removed from service for alternator overhaul. Scheduled completion date was December 19, 2013.
Dec. 11, 2013		During testing at Hardwoods Gas Turbine on December 10, a jacking oil pump failed. The pump on the unit at Stephenville Gas Turbine was temporarily removed and installed at Hardwoods, causing the Stephenville unit to become unavailable while a replacement pump was obtained and installed.
Dec. 14, 2013		A new record system demand of 1,501 MW was supplied.
Dec. 15, 2013	**01:20**	Significant frazil ice accumulation affected the Exploits generation at Grand Falls. Plant production reduced from 63 MW to 38 MW (by 25 MW).
Dec. 16, 2013		Granite Canal Generating Station reduced to 32 MW due to axial vibration.
Dec. 21, 2013	**14:00**	Hardwoods Gas Turbine unavailable, suspected due to the failure of a three-way fuel valve associated with Engine A. The failure occurred during commissioning of the new alternator, following a refurbishment undertaken during the fall.
Dec. 23, 2013	**20:21**	Stephenville Gas Turbine restored to 25 MW with the installation of a new jacking pump to replace the old pump, which was removed on December 11 and sent to Hardwoods. The remaining 25 MW of capacity was pending the delivery of new insulating blankets, scheduled for early January 2014.
Dec. 25, 2013		Holyrood Unit 2 de-rated (by 25 MW) to 142 MW due to a broken control valve.
Dec. 26, 2013	**06:00**	Holyrood Unit 3 de-rated (by 100 MW) to 50 MW due to a failure of a forced draft (FD) fan motor.

Date	Time	Event
		Total unavailable generation at this time is approximately 233 MW. Implemented generation loading sequence generation shortages protocol up to step eight (with the exception of step seven). A copy of this protocol is at the end of this Sequence of Events. Communication continued with Newfoundland Power (NP) as to the status of generation assets, load forecasts, and protocols. Communications occurred internally to ensure awareness of the situation. Supply and demand at peak. Demand: 1385 MW Supply: 1426 MW
Dec. 27, 2013		Generation loading sequence generation shortages protocol was not required. Communication continued with NP as to the status of generation assets, load forecasts and protocols. Supply and Demand at Peak. Demand: 1331 MW Supply: 1456 MW
Dec. 28, 2013	**06:34**	Bay d'Espoir Unit 2 was removed from service due to air supply issue with circuit breaker B1T2. The unit was restored at 1138 hours.
Dec. 28, 2013		Generation loading sequence generation shortages protocol was not required. Forecast peak for December 29 of 1410 MW. This was communicated to NP. Preparations were made between both utilities to prepare, as per shortage protocol. A customer conservation message was discussed as a potential requirement for December 29. The decision was to be made early on December 29. Supply and demand at peak. Demand: 1354 MW Supply: 1456 MW
Dec. 29, 2013		The Stephenville Gas Turbine failed to start initially. The unit was successfully started at 2224 hours. Implemented generation loading sequence generation shortages protocol up to step 13; including asking Corner Brook Pulp and Paper (CBPP) to shed processing load. Continued to discuss the potential of issuing a public conservation message but determined it was not required. Forecast peak for December 30 of 1420 MW. Continued communication with NP regarding the continuing need to implement the Generation

Date	Time	Event
		Loading Sequence Generation Shortages protocol.
	16:35	Implemented the Generation Loading Sequence Generation Shortage Protocol steps to start NP standby generation, implement NP voltage reductions and call on curtailable customer.
	17:08	Received first assistance from CBPP (28 MW)
		Supply and Demand at Peak. Demand: 1425 MW Supply: 1470 MW
		Determined that immediate resolution of Holyrood and Hardwoods generation issues were not possible.
Dec. 30, 2013		Implemented Generation Loading Sequence Generation Shortage protocol up to step 13; This included asking CBPP to shed approximately 30 MW of load in the morning and 52 MW in the evening. There was an internal meeting held to discuss progress on generation and preparations going forward. Discussions were initiated with CBPP regarding a more formal capacity assistance agreement. Forecast peak for December 31 of 1400 MW. Continued communication with NP regarding the continuing need to implement the Generation Loading Sequence Generation Shortage protocol. Supply and Demand at Peak. Demand: 1417 MW (morning) Demand: 1417 MW (evening) Supply: 1458 MW A review of the weather forecasts highlighted that January 2-3 demand levels are were expected to be high. Generation Loading Sequence Generation Shortage protocol not required.
Dec. 31, 2013		A short- term capacity assistance agreement was reached with CBPP for 20, 40 or 60 MW blocks of power. Forecast peak for January 1 of 1450 MW. Continued communication with NP regarding the continuing need to implement the Generation Loading Sequence Generation Shortage protocol.

Date	Time	Event
		The Public Utilities Board was notified of extended capacity issues with the Stephenville Gas Turbine, Hardwoods Gas Turbine and Holyrood Unit 3.
Dec. 31, 2013		Supply and Demand at Peak. Demand: 1393 MW Supply: 1453 MW Implemented Generation Loading Sequence Generation Shortage protocol up to step 13. This included capacity assistance from CBPP for 40 MW during peak.
Jan. 1, 2014		Forecast peak for January 2 of 1500 MW. Continued communication with NP regarding the continuing need to implement the Generation Loading Sequence Generation Shortage protocol. Supply and Demand at Peak. Demand: 1440 MW Supply: 1484 MW
Jan. 2, 2014	**08:00**	A conservation request discussion was initiated with NP in the early morning. The short-term forecast indicated that the evening peak would outstrip available supply.
	14:00	Conservation request issued to all island customers.
	16:13	NP started feeder interruptions. See attached slide for details of the feeder interruptions from January 2 to January 8.
	16:34	Granite Canal unit tripped with a loss of 33 MW.
	16:56	Newfoundland and Labrador Hydro (Hydro) started feeder interruptions. See attached slide for details of the feeder interruptions from January 2 to January 8. Peak Demand supplied 1493 MW at 16:15 hours.
Jan 3, 2014	**12:06**	Unit 2 restored to 165 MW, with only a minor de-rating of 5 MW.

NP – Feeder Interruptions

Date	Time	Feeder Rotations	Average Duration (minutes)
Thursday January 2, 2014	4:13 pm to 10:45 pm	77	88
Friday January 3, 2014	6:57 am to 7:36 pm	141	44
Sunday January 5, 2014	7:23 am to 8:29 pm	158	54
Monday January 6, 2014	5:17 am to 10:48 am	39	47
Wednesday January 8, 2014	3:23 pm to 5:42 pm	32	25

NLH – Feeder Interruptions

Date	Time	Feeder Rotations	Average Duration (minutes)
Thursday January 2, 2014	4:56 pm to 10:50 pm	6	30
Friday January 3, 2014	7:00 am to 7:30 pm	25	30
Sunday January 5, 2014	5:04 pm to 7:03 pm	5	60
Wednesday January 8, 2014	3:32 pm to 4:30 pm	3	30

newfoundland labrador hydro
a nalcor energy company

SYSTEM OPERATING INSTRUCTION

STATION:	GENERAL	**Inst. No.**	T-001
TITLE:	GENERATION LOADING SEQUENCE AND GENERATION SHORTAGES*, **	**Rev. No.**	07
		Page 1	**of** 2

INTRODUCTION

In the event of a system generation shortage, the following guidelines shall be followed in the sequence outlined in order to minimize outages to customers:

PROCEDURE

A. Normal Generation Loading Sequence

1. Bring on line all available Hydro hydroelectric generators and load them to near their full capacity.
2. Request Newfoundland Power to maximize their hydro production.
3. Make a Capacity Request of Deer Lake Power to maximize their hydroelectric generation.
4. Request Non-Utility Generators to maximize their hydro production.
5. Increase Holyrood production to near full capacity.
6. Notify customers taking non-firm power and energy that if they continue to take non-firm power, the energy will be charged at higher standby generation rates.
7. Ask Newfoundland Power to curtail any interruptible loads available.
8. Start and load standby generators, both Hydro and Newfoundland Power units, in order of increasing average energy production cost with due consideration for unit start-up time.

PREPARED BY:	**APPROVED/CHECKED BY:**	**ISSUED DATE:** 1992-07-16
Robert Butler		**REV. DATE:** 2009-04-29

newfoundland labrador hydro
a nalcor energy company

SYSTEM OPERATING INSTRUCTION

STATION:	GENERAL	**Inst. No.**	T-001
TITLE:	GENERATION LOADING SEQUENCE AND GENERATION SHORTAGES	**Rev. No.**	07
		Page 2	**of** 2

PROCEDURE (cont'd.)

9. Cancel all non-firm power delivery to customers and ensure all industrial customers are within contract limits.

If load is still increasing and it is apparent that a generation shortage may occur, proceed as follows:

10. Ensure that steps A1 to A9 above have been followed and implemented.

11. Inform Newfoundland Power of Hydro's need to reduce supply voltage at Hardwoods and Oxen Pond and other delivery points to minimum levels to facilitate load reduction. Begin voltage reduction.

12. Request industrial customers to shed non-essential loads and inform them of system conditions.

13. Request industrial customers to shed additional load.

14. Request Newfoundland Power to shed load by rotating feeders. At the same time, shed load by rotating feeders in Hydro's Rural areas where feeder control exists.

Note:

Generation from Wind Farms may shutdown with little notice.

* Part of the Environmental Plan
** Part of the Emergency Response Plan

PREPARED BY:	**APPROVED/CHECKED BY:**	**ISSUED DATE:** 1992-07-16
Robert Butler		**REV. DATE:** 2009-04-29

NEWFOUNDLAND AND LABRADOR HYDRO

Sequence of Events
Following Sunnyside Transformer Fault on January 4, 2014

February 2014

newfoundland labrador hydro
a nalcor energy company

Events Following SSD Transformer Fault - January 4, 2014

Date	Time	Event
Jan. 4, 2014		Weather forecast for blizzard conditions and heavy snowfall; crews prepared for storm response.
	08:00	Crews dispatched to major terminal stations on the Avalon. Remote hydroelectric plants staffed by operators, and the road to the Upper Salmon plant was maintained open.
	09:05:34	Fault detected in transformer T1 at Sunnyside (SSD). The SSD transformer T1 lockout protection operated resulting in following breaker operations: SSD L109T4 open SSD B3T4 open SSD B1L02 open SSD B2T1 open Four of five breakers for T1 operate, breaker B1L03 failed to open, keeping the 230 kV Bus B1 and transformer T1 energized from TL203. Fault evolved and protection circuits at multiple locations sensed the fault.
	09:05:35	SSD disconnect switch B1T1 in-transit alarm, indicated the disconnect switch had started to open.
	09:05:36	The Paradise River generating unit tripped, with a loss of 8 MW. As a result of the failure of SSD B1L03 to open and clear the T1 fault, the primary one, primary two and backup protection operated on transmission line TL203 at the Western Avalon Terminal Station (WAV). The backup protection also operated for transmission line TL203 at SSD. The following breakers opened for this event: SSD L03L06 open WAV L01L03 open WAV L03L17 open

Date	Time	Event
		TL203 was open at the WAV end and SSD Bus B1 and transformer T1 were de-energized. Backup protection also operated on transmission line TL237 at Come by Chance (CBC) and WAV. The following breakers opened for this event: CBC B1B2 open WAV L01L37 open Circuit breaker B1L37 at WAV appeared to have been delayed in opening by two seconds for the protection trip. **Transmission Lines TL203 (SSD – WAV) and TL237 (CBC – WAV) were out of service and the Avalon was isolated from the rest of the power system. Bus B1 and Transformer T1 at the Come By Chance TS were still energized. The Holyrood Generating Plant remained on-line, momentarily.**
	09:05:37	Normal Newfoundland Power supply to Hydro Place was lost; Hydro's EMS switched to battery power.
	09:05:37	Units at Holyrood cannot supply the load. Holyrood Units 2 and 3 are tripped and isolated from the system by unit breakers. Unit 1 trip is initiated and unit breaker B1B11 opened three phases. Unit breaker B1L17 opened only on two phases during the trip. Backup protection operated on transmission line TL242 at Hardwoods Terminal Station (HWD). Breaker B1L42 opened at HWD. Backup protection operated on transmission line TL218 at Oxen Pond Terminal Station (OPD). Breaker B1L18 opened at OPD. Holyrood Unit 3 was isolated from the system. **Transmission Lines TL203 (SSD – WAV) and TL237 (CBC – WAV) were out of service and the Holyrood Generating Plant was shut down and isolated. The 138 kV and 66 kV transmission had also tripped via NP lines 64L, 86L, 39L from WAV to HRD.**

Date	Time	Event
	09:05:38	Breaker B1L37 at WAV opened, closed and then re-opened in a three second period, an indication that the breaker operated only on two phases.
	09:05:38	Star Lake generating plant tripped with the loss of 18 MW and Stephenville Gas Turbine tripped.
	09:05:41	Cat Arm and Hinds Lake generating plants tripped with a loss of 205 MW of generation.
	09:05:41	SSD disconnect switch B1T1 was fully open, providing full isolation of transformer T1.
	09:05:45	Diesel G1 at Hydro Place on-line, re-storing AC supply.
	09:05:45	Hydro's EMS switched to diesel supply.
	09:09:45	EMS indication for breaker B2L42 at Holyrood toggled between open and closed multiple times, likely making its actual state unclear to the ECC operators.
	09:13	Upper Salmon generating plant tripped with the loss of 88 MW.
	09:27	Breaker B1B2 at Come By Chance closed by the ECC, marking the start of restoration phase and energizing transmission line TL237 to Western Avalon.
	09:41	Attempts to energize Bus B1 at WAV from line TL237. Line breaker B1L37 closed, but tripped again 1.2 seconds later. It was later determined that only two phases of the breaker had closed and there was a phase disagreement trip, momentarily energizing Busses B1 and B3, the WAV transformers, and transmission line TL208 to Vale, all on two phases. A Gas/Oil/Temperature alarm was received for transformer T5. ECC opened WAV breaker B1L08 to isolate TL208 and attempted to close B1L37 again, with the same result. Another Gas/Oil/Temperature alarm is received for T5.
	09:51	WAV circuit breaker L01L37 was closed by ECC, energizing a 230 KV ring Bus section at WAV, transmission line TL201 and the HWD terminal station.

Date	Time	Event
	09:57	Stephenville Gas Turbine in service at 25 MW.
	10:08	Upper Salmon generating plant in service at 88 MW.
	10:14	Granite Canal generating plant in service at 40 MW.
		ECC attempted to close breaker B2L42 at HWD to energize TL242 into Holyrood and restore station service. This energized HRD Bus B12 and, since unit breaker B1L17 had failed during the earlier events and remained closed on one phase, this resulted in a single-phase energizing of Unit 1 transformer T1. Protection circuits for TL242 operated at both HWD and Holyrood. Additional breakers were opened by ECC to provide for further isolation of the HRD TS.
	10:24	Holyrood station service is restored via transmission line TL242 (HWD – HRD) and HRD transformer T10.
	10:26	Holyrood unit disconnect switches B1T1 and B2T2 were opened by the HRD operators.
	10:38	Hydro Place diesel unit G1 tripped offline due to high temperature. There is no power at Hydro Place and EMS switched to battery power.
	10:41	Breaker B1L36 is closed at HWD, restoring transmission line TL236 (HWD – OPD) and OPD TS.
	10:41	ECC closed breaker B3L47 at Deer Lake, energizing transmission line TL247 and starting the process of restoring Cat Arm generating units.
	10:57	Breaker B1L03 at SSD, the breaker that failed to open during the T1 fault, opens un-commanded.
	11:03	The beginning of a 43-minute outage to the ECC, EMS. The outage resulted from a short power interruption (13 seconds), upon the loss of primary supply (Newfoundland Power), the standby diesels and the UPS system. The system was recovered and re-established at 11:46.
	12:00	SSD transformer T1 isolated from the system via disconnect switches. Transformer reported to be still on fire.

Date	Time	Event
	12:13	Three additional, but unsuccessful, attempts to close breaker B1L37 at WAV to restore 230 Busses B1 and B3. Similar to previous attempts the breaker closed only momentarily and at least one T5 transformer Gas/Oil/Temperature alarm was received. At 12:15 the ECC closed WAV breaker B1L17.
	12:18	Cat Arm Unit 2 in service at 65 MW.
	12:22	ECC closed breakers L03L17 and L01L03 at WAV, energizing Busses B1 and B3 from TL237. Due to previous actions this also energized transmission lines TL203 to SSD and TL217 to HRD. WAV transformer T5 lockout protection operated after restoration of Busses B1 and B3, isolating the transformer from the system via WAV breaker B1B3 and transformer disconnects B3T5 and B4T5. It was later determined there was an internal failure of the transformer tap changer. WAV busses B1 (230 KV) and B2 (66 KV) were restored.
	12:23	ECC restores TL217 (WAV - HRD).
	12:30	ECC restores TL218 (HRD - OPD).
	12:56	Cat Arm Unit 1 in service at 65 MW.
	12:57	Bus B1 and Transformer T4 are re-energized at SSD, re-establishing station service and restoring the breaker compressed air system.
	12:58	Switching at SSD to restore the load side of transformer T4 (138 KV). Breaker B3T4 closed by ECC, resulting in the operation of the Bus B1 lockout switch at SSD, initiated by the transformer disconnect switch, B1T4, opening under load and resulted in an arcing fault. Breakers B3T4 and B1L02 tripped. Breaker B1L03 had been previously isolated. Attempt to restore T4 failed. Impact was confined to the Sunnyside Station. Investigation determined the Bus B1 differential protection operated upon closure of B3T4, likely caused by the current transformers and

Date	Time	Event
		wiring on transformer T1 having been destroyed by the transformer fire.
	14:10	Stephenville Gas Turbine off line.
	14:28	Stephenville Gas Turbine in service at 25 MW.
	14:36	After a couple of unsuccessful attempts, the SSD transformer T4 disconnect B1T4 is closed.
	14:37	Circuit breaker B4L64 closed at WAV, restoring 64L and the 138 kV supply to Newfoundland Power on the Avalon.
	14:40	ECC closed breaker L03L06 at SSD, restoring both ends of TL203 (SSD – WAV).
	14:41	The SSD 230 KV Bus B1 was re-energized by ECC via breaker B1L02, which also energized transformer T4. SSD Station service is restored.
	15:12	Hinds Lake unit restarted and loaded to 75 MW. There were considerable issues with the unit breaker B1G1.
	15:25	Circuit breaker B8L39 was closed at HRD, restoring the 138 kV loop from WAV to HRD. **All transmission to the Avalon was restored.**
	15:33:26	A second attempt was made to restore the load side of SSD transformer T4 (138 KV). Breaker B3T4 closed by ECC and again resulted in the opening of the transformer disconnect switch B1T4 under load. The protection at Sunnyside did not operate as expected to clear the arcing fault, which resulted in the operation of the protection on the remote ends of transmission lines TL202 and TL206 at Bay d'Espoir (BDE).
	15:33:32	Breakers B11L06 and L06L34 opened at BDE to trip transmission line TL206 as expected.
	15:33:33	Protection at BDE did not operate to trip transmission line TL202 as expected. Breakers B3B4 and B4B5 would ordinarily trip TL202 at the

Date	Time	Event
		BDE end, but were slow in operating. Lockout protection operated and resulted in a trip of breakers B5B6, B3T5, B3T6, and B2B3. This resulted in a loss of TL204 (BDE – Stoney Brook), and BDE Units 5 and 6 (loss of 150 MW of generation). Breakers L02L07 and B1L02 tripped to isolate TL202 at SSD. **There was a loss of supply from BDE to Sunnyside and the Avalon Peninsula, including Come By Chance. The Auto Restoration Scheme (ARS) was in a disabled state following the return of the EMS at 11:46.**
	15:33:43	Cat Arm Units 1 and 2 tripped off-line with a loss of 130 MW of generation.
	15:37	ECC initiates a close of breaker B11L06 to close TL206 at the BDE end. The line was already closed at the SSD end. This action energized the terminal stations east of SSD.
	15:38	Primary one protection operated on the following transmission lines: TL201 – HWD and WAV TL203 – SSD and WAV TL207 – CBC and SSD TL217 – HRD and WAV TL218 – HRD and OPD TL236 – HWD and OPD TL242 – HRD and HWD Associated line breakers opened for these line protection trips.
	15:39	ECC initiated a breaker group open at WAV. Transmission Line TL206 was restored (BDE – SSD). Power was restored to SSD TS, TL207 and North Atlantic Refining at Come by Chance.
	15:40	Circuit breaker B3T4 was opened at SSD by ECC.
	15:53	Transmission Line TL203 (SSD – WAV) and WAV TS was restored.
	15:54	Transmission Line TL201 (WAV – HWD) and HWD TS was restored.

Date	Time	Event
	16:05	BDE Unit 6 restored at 75 MW. Transmission Line TL236 (HWD – OPD) and OPD TS were restored.
	16:06	BDE Unit 5 restored at 75 MW. Cat Arm Unit 1 restored at 65 MW.
	16:09	Transmission Line TL204 (BDE – Stony Brook) restored.
	16:09	Transmission Line TL242 (HWD – HRD) and HRD TS and station service restored.
	16:10	Transmission Line TL202 (BDE – SSD) restored.
	16:14	Transmission Line TL237 (CBC – WAV) in service.
	16:19	Transmission Line TL217 (WAV – HRD) restored.
	16:26	Cat Arm Unit 2 restored at 65 MW. Granite Canal unit restored to 32 MW.
	16:59	Star Lake generating unit restarted and loaded to 18 MW.
	18:00	Transmission Line TL218 (OPD – HRD) restored.
	18:31	SSD Transformer T4 re-energized, restoring station service.
	20:07	Transmission Line TL219 restored, bringing grid power to Burin Peninsula, which was lost during the initial trip at 09:05.
	21:34	Holyrood Unit 2 back on-line at 165 MW (minor de-rating of 5 MW).
	21:45	The 138 kV loop from Stony Brook to SSD restored.
Jan. 5, 2014	**01:40**	Holyrood Unit 3 on-line at 50 MW. (Holyrood Unit 1 remained down due to vibration issues)

Date	Time	Event
	08:10	ECC closes breaker B1L08 at WAV to energize TL208 to Vale.
	10:40	WAV transformer T3 overload protection trip. Transmission Line 64L tripped at WAV. Outages to Newfoundland Power customers in the Bay Roberts area. Newfoundland Power circuit breaker at Bay Roberts on 39L failed with no supply available from HRD.
	10:44	Transmission Line 64L restored at WAV. Newfoundland Power customers restored.
	11:08	WAV transformer T3 overload protection trip. Outages to Newfoundland Power customers in the Bay Roberts area. Newfoundland Power circuit breaker at Bay Roberts on 39L had failed with no supply available from HRD.
	11:18	Transmission Line 64L restored at WAV. Newfoundland Power customers restored.
	21:27:34	Disconnect switch B1T1 closed at HRD, the first step before the generator is synchronized to the system.
	21:27:41	Disconnect switch B1T1 opened at HRD after the operation of the unit lockout switch on HRD Unit 1. The unit lockout switch operated on HRD Unit 2. Primary protection one and backup protection operated on Transmission Line TL217 at WAV end only. Circuit breakers B1L17 and L03L17 opened. Backup protection operated on transmission line TL218 at OPD end only. Circuit breaker B1L18 opened at OPD.
	21:27:41	Primary protection one operated on transmission line TL242 at HWD end only. Breakers B2L42 at HWD and HRD opened. Protection relay 94TS/T1 operated on transformer T1 at HRD.

Date	Time	Event
		Breaker failure lockout protection operated on the following circuit breakers at HRD. HRD B3L18 HRD B3B130 HRD B1L17 Breaker failure lockout protection operated on circuit breaker B1L17 at WAV and Bus B1 at WAV. The unit lockout switch operated on HRD Unit 3. **The St. John's area was being supplied via TL201 from WAV. Holyrood Units 2 and 3 were off-line (Unit 1 had tripped during the previous day). The 138 kV loop from WAV to HRD was not available.**
	22:19	Transmission Line TL242 (HWD – HRD) restored.
Jan. 6, 2014	**02:02**	Circuit breaker B1L17 was isolated at HRD.
	03:34	Transmission Line TL217 was energized from WAV to HRD to test for line or Bus fault. No fault was found and TL217 was restored.
	05:29	Holyrood Unit 2 back on-line at 165 MW, with a minor de-rating of 5 MW.
	05:46	Transmission Line TL218 (OPD – HRD) restored.
	07:17	HRD Unit 3 on-line at 50 MW.
Jan. 8, 2014	**15:27**	Test performed to energize HRD Bus B1. Disconnect switches B1L17-1 and B1B11-2 were opened. HRD disconnect switch B1T1 was closed. No problems detected and disconnect switch B1B11-2 was closed. Approval given to HRD plant to synchronize Unit 1 to the system.
	15:38	Holyrood Unit 1 on-line at 165 MW, with a minor de-rating of 5 MW.

Alarms from T1 Trip.

TL203 prot trip 1-B

T1 Lock out 5-A

T1 OT, OV, TOOS 5-B

T1 GAS, WT, OL 6-A

T1 prot trip 6-B

7-A Relay inoperative

8-A comp trouble

10-A 125VDC Batt charger
GND./FAIL

11-A T4 OT, OV, TOOS

16-A AIL system
LAP, HAP
DRYER FAIL

13-C BILO2
Block/Trip/Rec'l
& DISAUL

15-C 138KV ABCB DISAGR.
B2T4, L109T4
L100L109, L19L100

16-C 138KV ABCB
L.A.P

17-C 230 KV ABCB
LAP

19-A BILO3 BL TRIP Rec'L
& Disagreement

22-A 138KV ABCB
Heat fail

230KV ABCB
Heat fail

SSD T.S. PNL. NO. 14 TL203 PROT.

Time 11:10 Date JAN 4 20 14 Oper. _____

OPTIMHO (21)

1. RECORD READING _____
2. PRESS " AC/READ" _____
3. PRESS " AC/READ" _____
4. PRESS "RESET".

DATE JAN 4/2014

21/P1

TRIP [X]

ALARM [X]

FLASHED

21/P2

O INST O TIME X COMM O SOTF TRIP	1 X 2 3 4 ZONE

EN X	A X B C G 0 FAULT TYPE	51 50 O/C

SEL - 321 (21 P2)

1. PRESS "FAULT" ONCE AND RECORD DATE & TIME

DATE: _____ TIME: _____

2. PRESS "→"ONCE AND RECORD TYPE: MET

3. PRESS "→"AGAIN AND RECORD DIST: _____

4. PRESS "→"AGAIN AND RECORD GROUP: ____

5. PRESS "EXIT"

SSD T.S. PNL. NO. 15 TL203 PROT.

Time 11:13 Date ____ 20 ___ Oper. _____

I	I	I
50 B AØ	50 B BØ	50 B CØ

3VT

30 ~~Z2~~	30C
30 CL	

TL 203

B1L03 RECL.	AØ	BØ	CØ	3Ø
72	36	39	37	28

DATE Jan 4/2014

T	I
50/51N	

SSD T.S. PNL. NO. 26 TL219 PROT.

Time 11:30 Date ____ 20 ___ Oper. _____

50/51N

- ☐ INST
- ☐ TIME
- ☐ START

50/51L

A	B	C	
☐	☐	☐	INST
☐	☐	☐	TIME
☐	☐	☐	START

79

170

PRI.3PH

110

BV 3PH.

149

DATE JAN 4/2014

OPTIMHO (21)

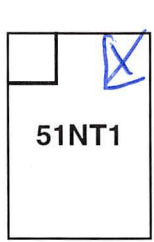
1. RECORD READING _____
2. PRESS "AC/READ" _____
3. PRESS "AC/READ" _____
4. PRESS RESET. _____

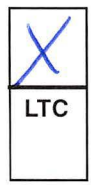
21

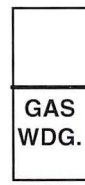
- TRIP ☐
- ALARM ☐

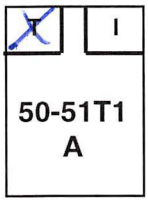
SSD T.S. PNL. 16 TRF.1 PROT.

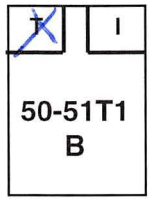
Time 11:32 Date JAN 4 2014 Oper. _____

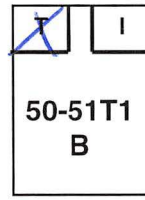


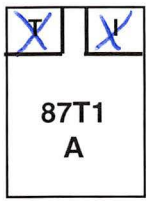


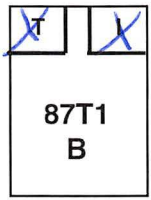


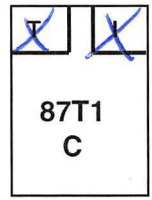








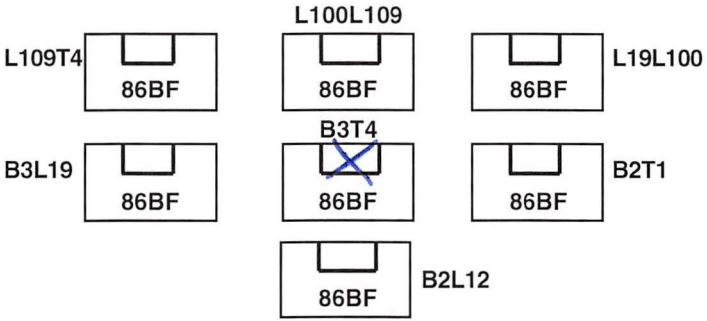




#2

SSD T.S. PNL. NO. 28 138KV BKR. FAIL. PROT.

Time _____ Date _____ 20 ____ Oper. _____



50BF-L09T4&50BF-L100L09

X	Y	INST	A	B	C	Q	N
○	○	○	○	○	○	○	○

RELAY O/C CONDITIONS

DISPLAY

DISPLAY

50BF-L19L100&50BF-B3L19

X	Y	INST	A	B	C	Q	N
○	○	○	○	○	○	○	○

RELAY O/C CONDITIONS

DISPLAY

DISPLAY

50BF-B3T4&50BF-B2T1

X	Y	INST	A	B	C	Q	N
○	○	○	○	○	○	○	○

RELAY O/C CONDITIONS

DISPLAY 86TR-X

DISPLAY

50BF-B2L12

X	Y	INST	A	B	C	Q	N
○	○	○	○	○	○	○	○

RELAY O/C CONDITIONS

DISPLAY

DISPLAY

For operated relay(s) push "Events"
Record Date & Time & Push →
for "Type of Fault"

↓ Scrolls to Next Event

Relay _____

Event _____

_____

_____

Relay _____

Event _____

_____

_____

Relay _____

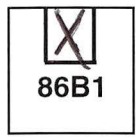
Event _____

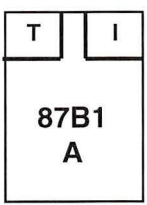
_____

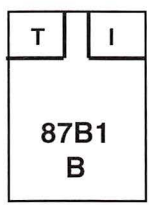
_____

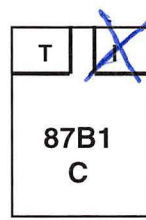
SSD T.S. PNL. 17 230KV BUS. DIFF. & SERV.REST.

Time _____ Date ____ 20 ___ Oper. D.K









Second Ath... TL202 3

SSD T.S. PNL. NO. 13 TL202 PROT.

Time 0959 Date JAN 4 20 14 Oper. DK

I
50 B AØ

I
50 B BØ

I
50 B CØ

30 Z2	~~30C~~
30 CL	

TL 202

B1L02 RECL.	AØ	BØ	CØ	3Ø
52	51	44	39	42
52	52	45	40	43

DATE _____

T	I
50/51N	

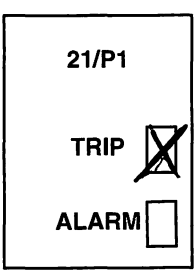
SSD T.S. PNL. NO. 14 TL203 PROT.

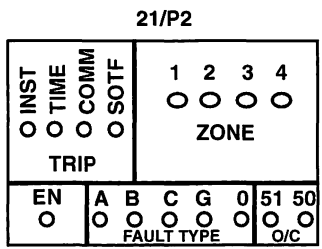
Time 6:59 **Date** JAN 4 **20** 14 **Oper.** DK

OPTIMHO (21)

1. **RECORD READING** SOTF
2. **PRESS " AC/READ"** 2014 JAN 4 15:34:24
3. **PRESS " AC/READ"** SOTF
4. **PRESS "RESET".**

DATE _____





SEL - 321 (21 P2)

1. PRESS "FAULT" ONCE AND RECORD DATE & TIME

DATE: _____ TIME: _____

2. PRESS "→"ONCE AND RECORD TYPE:_____

3. PRESS "→"AGAIN AND RECORD DIST: _____

4. PRESS "→"AGAIN AND RECORD GROUP: ____

5. PRESS "EXIT"

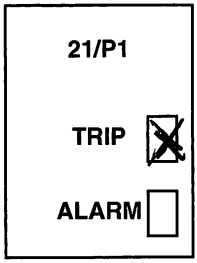
SSD T.S. PNL. NO. 12 TL202 PROT.

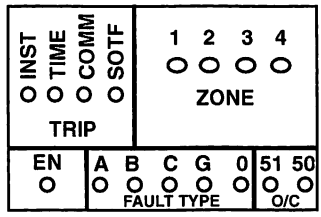
Time 7:01 **Date** JAN 4 **20** 14 **Oper.** D.K

OPTIMHO (21)

1. **RECORD READING** DISTANCE AIDED BC
2. **PRESS " AC/READ"** 2014 JAN 4 16:32:02
3. **PRESS " AC/READ"** LOC -9.4 KM
4. **PRESS "RESET".** 168.8 ms.

DATE _____





SEL - 321 (21 P2)

1. PRESS "FAULT" ONCE AND RECORD DATE & TIME

DATE: _____ TIME: _____

2. PRESS "→"ONCE AND RECORD TYPE:_____

3. PRESS "→"AGAIN AND RECORD DIST: _____

4. PRESS "→"AGAIN AND RECORD GROUP: ____

5. PRESS "EXIT"

7:20

5-B T1 OT, UV, TOUS

6-A T1 GAS, WT, OL

16-A AIR SYSTEM
LAP. HAP
Dryer FAIL

13-C BILOC
BLOCK TRIP/RECL
& DISAGREEMENT

14-C LOC LOT
BLOCK TRIP/RECLOSE
& DISAGREEMENT

16-C 138KV ABCB
LAP

17-C
230KV ABCB LAP

SSD T.S. PNL. NO. 1 L03L06 RECLOSER

Time _____ Date ____ 20 ___ Oper. _____

B1L03 Trip/Reclose & Disallow

20-A L06L07 Block Trip/Reclose & Disallow

B03L06
RECL

DATE _____

(B)

SSD T.S. PNL. NO. 11 TL206 PROT.

Time 708 Date JAN 4 20 14 Oper: D.L

I
50B A

I
50B B

I
50B C

30 Z2	~~30C~~
30 CL	

LO6L17 ← TL206 →

RECL.	A ~~0~~	B ~~0~~	C ~~0~~	3 ~~0~~
177	128	55	48	35
177	127	54	47	34

DATE _____

T
50-51N

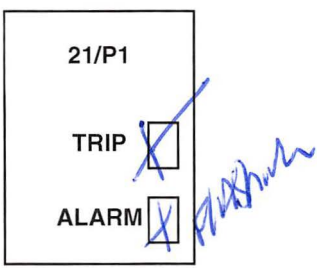
SSD T.S. PNL. NO. 10 TL206 PROT.

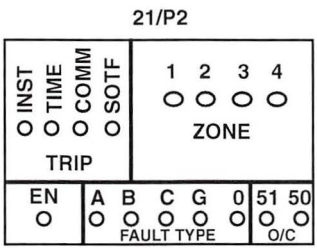
Time 7:10 Date 4 JAN 20 14 Oper: D.K

OPTIMHO (21)

1. RECORD READING SOTF
2. PRESS " AC/READ" 20KM JAN 4 16:35:12
3. PRESS " AC/READ" LOC -95.2 Km
4. PRESS "RESET". 61.67 ms

DATE _____





SEL - 321 (21 P2)

1. PRESS "FAULT" ONCE AND RECORD DATE & TIME

DATE: _____ TIME: _____

2. PRESS "→"ONCE AND RECORD TYPE: _____

3. PRESS "→"AGAIN AND RECORD DIST: _____

4. PRESS "→"AGAIN AND RECORD GROUP: ____

5. PRESS "EXIT"

SSD T.S. PNL. NO. 9 TL207 PROT.

Time ~~JAN 2014~~ 7:20 Date JAN 4 2014 Oper. D.V

LO2L07 3ph. REC.	LO2L07 1ph. REC.
60	75
60	~~73~~ 74

DATE Sept. 22, 2010 → Feb. 10/2013

50/51N

SSD T.S. PNL. NO. 8 TL207 PROT.

Time 4:00 Date ____ 20 ___ Oper. _____

30 C1	30 C2

OPTIMHO (21)

1. RECORD READING SOTF
2. PRESS " AC/READ" 2014 JAN 4 16:39:51
3. PRESS " AC/READ" LOC 215.5Km
4. PRESS "RESET". 60.42mS

DATE 2013/02/10

94L1	94L2
99	20
9F	2D

21/P1

TRIP [X]

ALARM [X]

Flasher

21/P2

O INST O TIME O COMM O SOTF TRIP

1 2 3 4 ZONE

EN | A B C G 0 FAULT TYPE | 51 50 O/C

SEL - 321 (21 P2)

1. PRESS "FAULT" ONCE AND RECORD DATE & TIME

DATE: _____ TIME: _____

2. PRESS "→"ONCE AND RECORD TYPE: _____

3. PRESS "→"AGAIN AND RECORD DIST: _____

4. PRESS "→"AGAIN AND RECORD GROUP: ____

5. PRESS "EXIT"

(3)

SSD T.S. PNL. NO. 28 138KV BKR. FAIL. PROT.

Time 7:00 Date Jan 4 20 2014 Oper. _____

L100L109

L109T4 | 86BF | L19L100

B3T4

B3L19 | B2T1

B2L12

50BF-L09T4&50BF-L100L09

X	Y	INST	A	B	C	Q	N
○	○	○	○	○	○	○	○

RELAY | O/C CONDITIONS

DISPLAY

DISPLAY

50BF-L19L100&50BF-B3L19

X	Y	INST	A	B	C	Q	N
○	○	○	○	○	○	○	○

RELAY | O/C CONDITIONS

DISPLAY

DISPLAY

50BF-B3T4&50BF-B2T1

X	Y	INST	A	B	C	Q	N
○	○	○	○	○	○	○	○

RELAY | O/C CONDITIONS

DISPLAY

DISPLAY

50BF-B2L12

X	Y	INST	A	B	C	Q	N
○	○	○	○	○	○	○	○

RELAY | O/C CONDITIONS

DISPLAY

DISPLAY

For operated relay(s) push "Events"
Record Date & Time & Push →
for "Type of Fault"

↓ Scrolls to Next Event

Relay _____

Event _____

_____

_____

Relay _____

Event _____

_____

_____

Relay _____

Event _____

_____

_____

WAV T.S. **PNL. NO. 5** **TL217 PROT.**

Time 1130 **Date** Jan 5, 2014 **Oper.** SB

OPTIMHO (21)

1. **RECORD READING** Z2 AN Delay
2. **PRESS "AC/READ"** 2014 Jan 5 22:21:33
3. **PRESS "AC/READ"** 208 KM 60 ms
4. **PRESS RESET.**

+91.47

21/P1

TRIP ☑
ALARM ☐

21/ P2

INST ○ TIME ⊘ COMM ○ SOTF ○
TRIP

1 2 3 4
○ ⊘ ○ ○
ZONE

EN ○

A ⊘ B ○ C ○ G ⊘ O ○
FAULT TYPE

51 ○ 50 ○
O/C

SEL - 321 (21 P2)

1. PRESS "FAULT" ONCE AND RECORD DATE & TIME

DATE: _____ TIME: _____

2. PRESS "→" ONCE AND RECORD TYPE: _____

3. PRESS "→" AGAIN AND RECORD DIST: _____

4. PRESS "→" AGAIN AND RECORD GROUP: ____

5. PRESS "EXIT"

WAV T.S. **PNL. NO. 3** **BKR. FAIL PROT.**

Time 1130 **Date** Jan 5, 2016 **Oper.** BA

30 B1L08	30 B1L37

30 L01L03	30 L03L17

✓ 86BF/B1

30 B1L17	30 B1B3

30 B1T1	30 B1T2

30 L01L37

WAV T.S. PNL. NO. 22 TRF. T5 PROT.

Time_____ Date Jan 4 19__ Oper.____

Sat.

30 63	30 49	30 LTC	

86T5

T
51N

T I
50-51 A

T I
50-51 B

T I
50-51 C

A I
87 A

A I
87 B

A I
87 C

WAV T.S. PNL. NO. 11 TL237 PROT.

Time _____ Date Jan 8/ 2021 Oper. _____

30 C1	30 C2

B1L37
RECL.

94LD

94L1

DATE _____

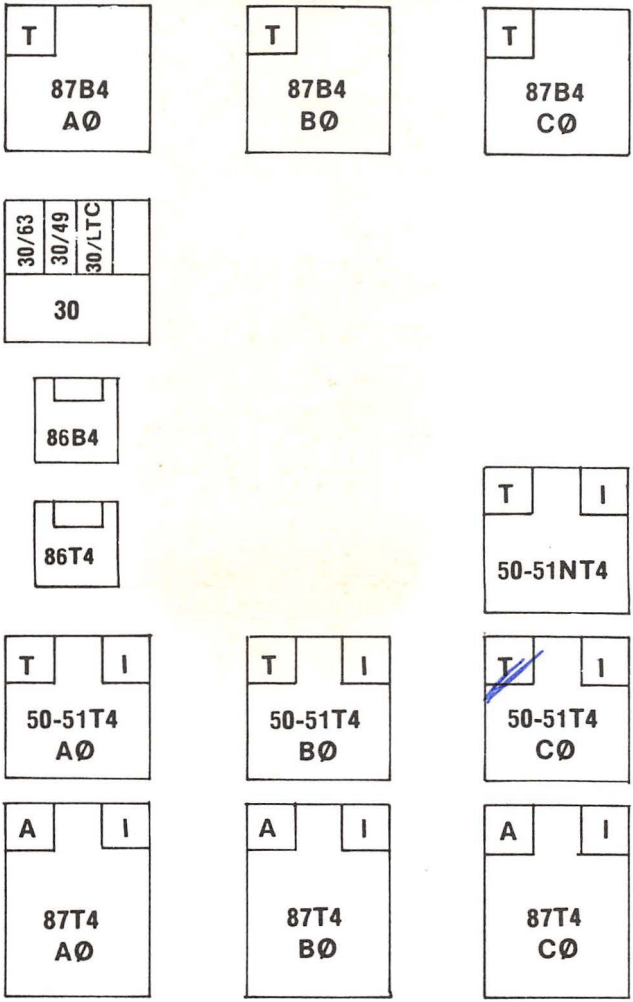
T		I
50-51 N		

50/51 T3B Time.

87 T3 A inst

WAV T.S. _____ HRS. _____ 19____

PNL. No. 20 TRANSFORMER T4 & Bus 4 PROT.

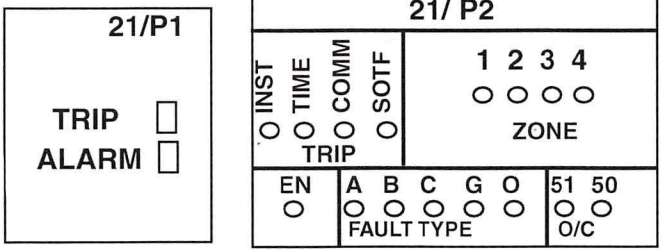


WAV T.S. PNL. NO. 12 TL203 PROT.

Time 1330 Date 2014/01/13 Oper. WD

OPTIMHO (21)

1. RECORD READING Z 1 A N
2. PRESS "AC/READ" 1341- 19
3. PRESS "AC/READ" _____
4. PRESS RESET.



SEL - 321 (21 P2)

1. PRESS "FAULT" ONCE AND RECORD DATE & TIME

DATE: 2014/01/12 TIME: 1243.08 . 076

2. PRESS "→"ONCE AND RECORD TYPE: AG

3. PRESS "→"AGAIN AND RECORD DIST: +3.94

4. PRESS "→"AGAIN AND RECORD GROUP: 1

5. PRESS "EXIT"

WAV T.S. PNL. NO. 14 TL201 PROT.

Time 10:41 Date JAN 15/14 Oper. D. Rich

OPTIMHO (21)

1. RECORD READING _____
2. PRESS "AC/READ" _____
3. PRESS "AC/READ" _____
4. PRESS RESET.

21/P1

TRIP ☐
ALARM ☐

21/P2

INST ○ TIME ⊗ COMM ○ SOTF ○ TRIP

1 2 3 4
○ ○ ○ ○
ZONE

EN ⊗

A B C G O
○ ○ ○ ○ ○
FAULT TYPE

51 50
⊗ ○
O/C

SEL - 321 (21 P2)

1. PRESS "FAULT" ONCE AND RECORD DATE & TIME

DATE: 01/15/14 TIME: 0909:59.770

2. PRESS "→" ONCE AND RECORD TYPE: BG T

3. PRESS "→" AGAIN AND RECORD DIST: +36.02

4. PRESS "→" AGAIN AND RECORD GROUP: 1

5. PRESS "EXIT"

WAV T.S. PNL. NO. 6 TL217 PROT.

Time 10:46 Date Jan 15 2014 19(20) Oper. D.L

A	B	C
50 B		

T	I
50-51N	

30Z2	~~30C~~ 3VT
30CL	

B1L17 RECL.	TL217 AØ	BØ	CØ	3Ø
58	59	34	46	40

DATE _____

3Ø B.U.

WAV T.S. PNL. NO. 11 TL237 PROT.

Time 0:26 Date JAN 15/2014 Oper: D. KING

30 C1	30 C2
	X

B1L37 RECL.

20
19

94LD

93
93

DATE _____

94L1

141
138

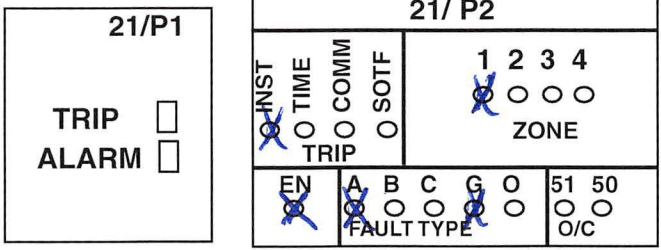
T		I
50-51 N		

WAV T.S. PNL. NO. 12 TL203 PROT.

Time 10:27 Date JAN 15/24 Oper. D. King

OPTIMHO (21)

1. RECORD READING _____
2. PRESS "AC/READ" _____
3. PRESS "AC/READ" _____
4. PRESS RESET.



SEL - 321 (21 P2)

1. PRESS "FAULT" ONCE AND RECORD DATE & TIME

DATE: 2014/01/12 TIME: 1243.08.076

2. PRESS "→"ONCE AND RECORD TYPE: AG

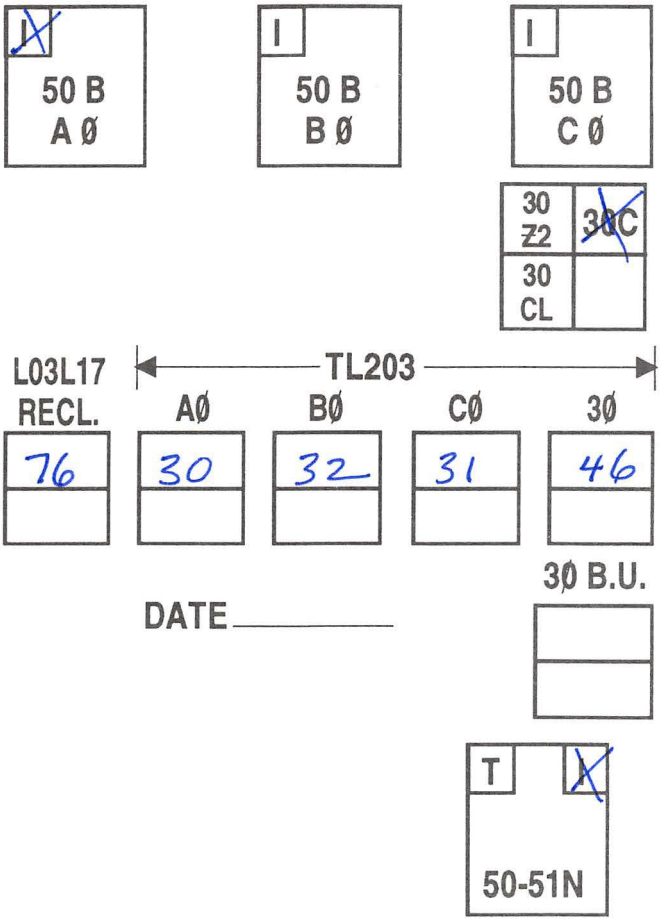
3. PRESS "→"AGAIN AND RECORD DIST: +3.94

4. PRESS "→"AGAIN AND RECORD GROUP: 1

5. PRESS "EXIT"

WAV T.S. PNL. NO. 13 TL203 PROT.

Time 10:30 Date JAN 15 2014 19__ Oper: D.L



SEL. 2411,

→ All Light on

WAV T.S. PNL. NO. 15 TL201 PROT.

Time 10:44 Date JUL 15/2014 Oper. D. KML

30 Z2	30C
30 CL	

LO1L03 ← TL201 →

RECL	A Ø	B Ø	C Ø	3 Ø
88	72	62	60	65
87	70	60	58	63

DATE Jan 11, 2013

X	I
50-51N	

SeL 2411
ALL LIGHTS ON

HRD T.S. Pnl. No. 33 Bkr. Fail. Prot.

Time_____ Date_____19___Oper._____

JAN 4/2014

RELAY CASE - R3

30 13	30 19	30 14	30 15	30 18	30 24	30 17	30 16

RELAY CASE - R4

30 26	30 25

86 BF B3 B13

86 BF B3 L18

30-14 B3 B13

30-15 B2 L42

86 BF B1 L17 FAG 30-3 - 30-4 dida 4 drop

TL 218 P1

SOTF

2014 Jan 4

478.1 KM

70.5 Fault level.

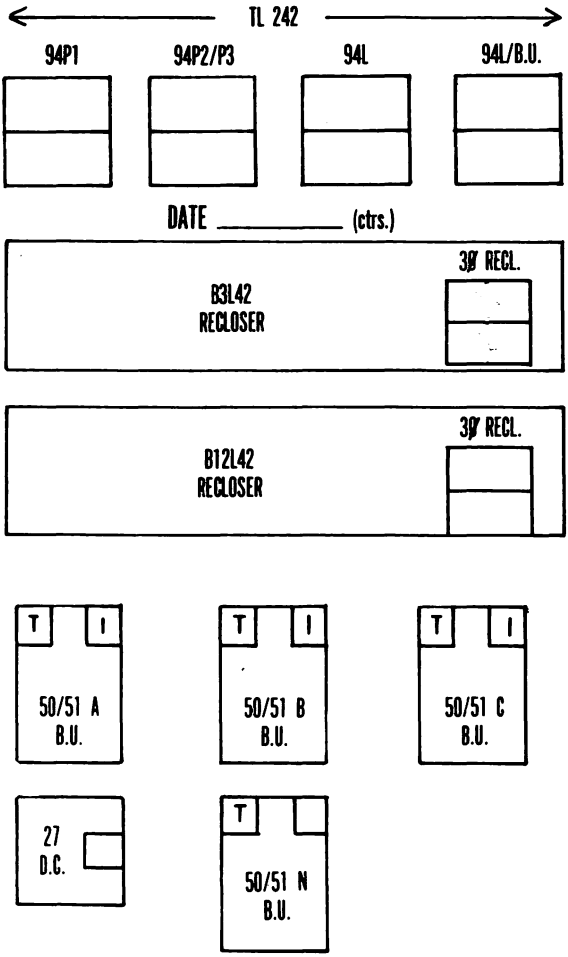
~~Reactor~~

Actual. 12.44 Jan 6

relay shows 2014 Jan 5 23:56:34

HRD T.S. PNL. NO. 27 230KV PROT. - TL 242

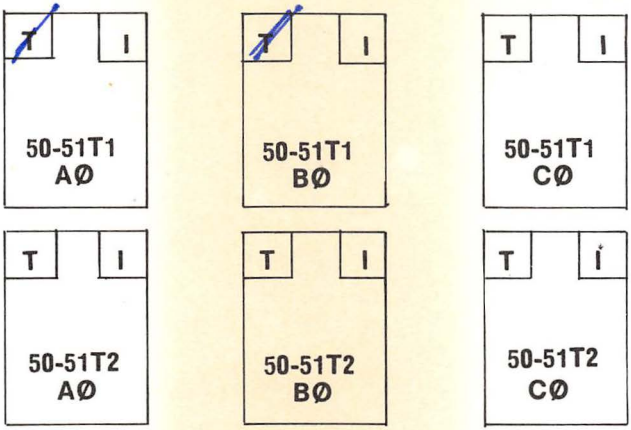
TIME _____ DATE _____ 19 ____ OPERATOR _____



HRD T.S. _____ HRS. _____ 19____

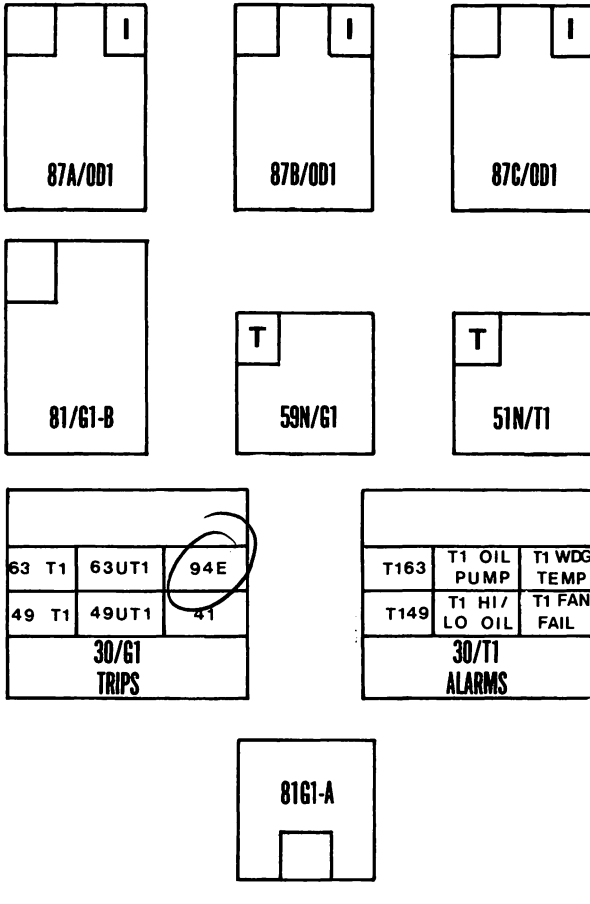
PNL. No. 31 230 KV & TRANSFORMERS

T1 & T2 PROTECTION JAN 4/2014



HRD. G.S. Jan 7, 2014 HRS. 10.30 19 2014

PNL. NO. 2 NO. 1 GEN. & TRF. PROT.



HRD T.S. _____ HRS. _____ 19____

PNL. No 5 ANNUNCIATOR

JAN 4/2014

A

1	2	3	4	5	6	7	8	
9	10	11	12	13	14	15	16	
17	18	19	20	21	22	23	24	
25	26	27	28	29	30	31	32	

B

1	2	3	4	5	6	7	8	
9	10	11	12	13	14	15	16	
17	18	19	20	21	22	23	24	
25	26	27	28	29	30	31	32	

C

1	2	3	4	5	6	7	8	
9	10	11	12	13	14	15	16	
17	18	19	20	21	22	23	24	
25	26	27	28	29	30	31	32	

TL 217

SOTF

Jun 4 16.33.49

Actual time on relay

2014 Jun 6 01.47.49

HRD T.S. Pnl. No. 24 TL217 Prot.

Time_____ Date_____19___Oper._____

30 C	30 CL	30 Z2	

B12L17

A ph.	B ph.	C ph.	Recl.	3 ph.
43	28	40	49	30

~~3 ph. DU~~ B12L17 Reclose

34

Date Jan 16, 2013

Optimho(21)

1. Record reading _____
2. Press "Ac/Read"_____
3. Press Reset

21
trip ☐
alarm ☐

21Z2

TL 242

SO TF

Jan 4 15.58

to

Jan 4.

Relay. time . 2014 Jan 6 00:46:39

HRD T.S. Ph. No. 26 TL218 Prot.

Appendix 16 Page 172 of 187

Time _____ Date _____ 19__ Oper._____

30 C	30 CL	30 Z2	

B2L18

A ph.	B ph.	C ph.	Recl.	3 ph.
22	19	26	28	17

3 ph. BU

Date Sept 11 12

Optimho (21)

1. Record Reading _____
2. Press "Ac/Read" _____
3. Press "Ac/Read" _____
4. Press Reset.

21	21Z2
trip ☐	☐
alarm ☐	

DESIGN STUDY AND FAILURE INVESTIGATION FOR AUTO TRANSFORMER

NALCOR

SERIAL # 289147

CANADIAN GENERAL ELECTRIC

PREPARED BY

ABB Inc.
Transformer Remanufacturing & Engineering Services (TRES)
Brampton, ON Canada

ABB Project Number: xxxxxx

Prepared by: Myra Mikhail, P.Eng
Senior Transformer Design Engineer

James Li, P.Eng
Senior Transformer Design Engineer

Reviewed by: Mustafa Lahloub P.Eng
Engineering Manager, TRES Brampton

Approved by: Ed G. teNyenhuis, M.Eng, P.Eng.
Technical Manager, TRES Canada

February 03, 2014; Draft

Table of Contents

1. INTRODUCTION 4

2. SHORT CIRCUIT STUDY 6

2.1. Procedure 6

2.2. Windings Short Circuit Capability: 6

3. DIELECTRIC STUDY 1

3.1. Procedure 1

3.2. Major Winding insulation 1

4. DISSOLVED GAS IN OIL ANALYSIS (DGA) 1

4.1. SSD T1 - (CGE 289147) 1

4.2. SSD T4 – (CGE 288838) 5

4.3. STB T1 – (CGE 288894) 8

4.4. STB T2 – (CGE 288839) 11

5. GENERAL OIL QUALITY 14

5.1. SSD T1 – (CGE 289147) 14

2.1.1 Main Tank 14

2.1.2 LTC Tank 15

5.2. SSD T4 – (CGE 288838) 16

2.2.1 Main Tank 16

2.2.2 LTC Tank 17

5.3. STB T1 – (CGE 288894) 18

2.3.1 Main Tank 18

2.3.2 LTC Tank 19

5.4. STB T2 – (CGE 288839) 20

2.4.1 Main Tank 20

2.4.2 LTC Tank 21

6. TRANSFORMER POWER FACTOR MEASUREMENT 22

6.1. SSD T1 – (CGE 288147) 22

6.2. SSD T4 – (CGE 288838) 24

6.3. STB T1 – (CGE 288894) 26

6.4. STB T2 – (CGE 288839) 28

7. MAINTENANCE HISTORY 30

7.1. SSD T1 – (CGE 289147) 30

7.2. SSD T4 – (CGE 288838) 32

7.3. STB T1 – (CGE 288894) 33

7.4. STB T2 – (CGE 288839) 34

8. INSPECTION 35

8.1. Findings and Observations 35

9. CONCLUSION 43

10. RECOMMENDATIONS 47

1. Introduction

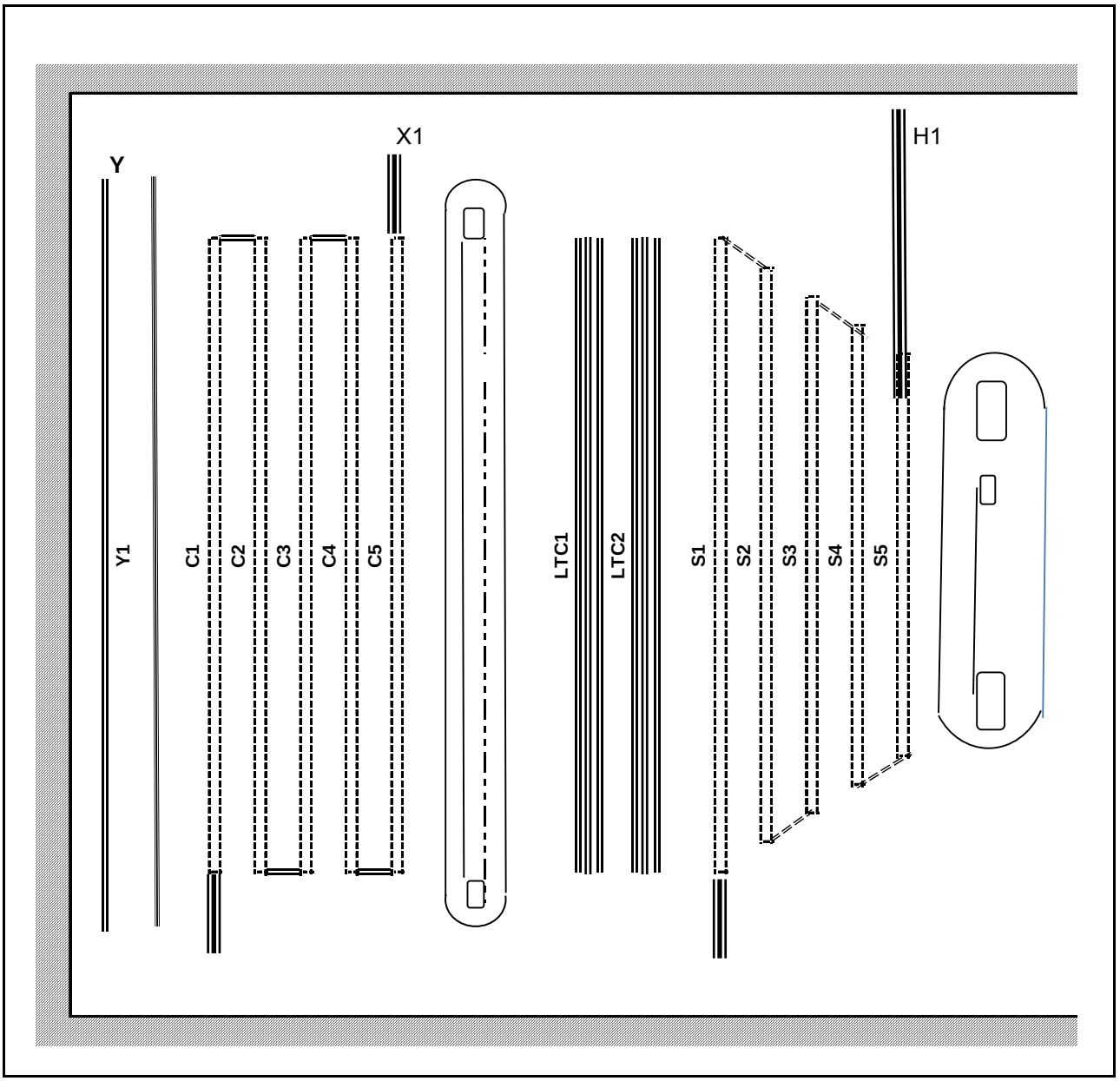
This transformer, sn 289147, failed and caught fire on January 4, 2014. The information available shows that the fault took more cycles than normal to be cleared. The transformer was on fire for about 66 hours. The transformer sustained major damage due to the failure and the fire. The customer requested that ABB inspect the transformer to try and identify the cause of the failure.

Also a comprehensive short circuit and dielectric study of the design is performed. There are four transformers manufactured to the same design. These transformers are built by Canadian General Electric under the Serial Numbers 288838, 288839 & 288894 in 1976 and 289147 in 1978.

Table 1 – Auto Transformer

Identification	Canadian General Electric
Rating	75/100/125 MVA, ONAN/ONAF/ONAF, 65°C Rise, 3Ph, 60Hz
Voltage	HV: 230 kV Grd Y, +5, -15 % ON Load taps LV: 138 KV Grd Y. TV: 6.9 KV Delta.
Lightning Insulation Levels	HV: 900 kV BIL LV: 550 kV BIL HV Neut: 110 kV Bil TV: 95 kV BIL
Core	3 phase unit, 3 legged design.
Windings	On each leg from the core outward: TV: Single layer, copper, MTC conductors. Shield LV : 5 Layers, copper, MTC conductors. Shield RV: 2 layers. Each with 4 multi starts, copper, MTC conductors. HV : 5 Layers, copper, MTC conductors. Shield.
Cooling Equipment	5 Radiators (156 tubes each) 9 Fans 28 In Diam
Manufacturing Date	First 3 units built in 197, the last unit buit in 1978, in Guelph, Ontario.

Figure 1 - Schematic Diagram of the Windings



2. Short Circuit Study

A 3D FEM leakage flux program was used to model this design. This program calculates the flux pattern in the windings as well as the short circuit currents in each winding and the associated forces.

2.1. Procedure

System Impedance:

From the original design, the system available MV is 3000 MVA on 230 KV side and 2000 MVA on the 138 kV side. This will translate in a 4.167% Impedance on the 230 kV side and 6.25% impedance on the 138 kV side on the 125 MVA base. These values are used in the analyses.

Short Circuit Calculation:

The transformer short circuit forces were analyzed with the on load tap changer on Rated, maximum and minimum tap positions.

The transformer core and windings were modeled on a computer program to enable the magnetic field and force calculations to be calculated. Program calculates the winding impedances between pairs of winding and uses the system impedances to calculate the short circuit currents in the transformer windings at the different tap positions. The program then calculates the axial and radial forces on each winding. In this case the forces are calculated on each layer of each winding with more than one layer.

These forces are than used in the design program. From the characteristics of the windings and the type of conductors used, the effect of the forces is derived and the allowable limits are calculated.

2.2. Windings Short Circuit Capability:

From the program results, the forces were calculated and compared with the allowed limits.

Table 2 - Short Circuit Calculations for the TV Winding (single Layer)

TV Winding (Single Layer)		Calculated	Allowed
Average radial inward stress	Psi	19 278	39 347
Dynamic conductor tilting stress	Psi	11249	12000
Axial pressure on end rings	Psi	**10500**	6000

Note:

This winding is failing on axial forces. The winding pressboard end rings are not strong enough to sustain the axial force. The calculated force is higher than the strength of the end ring material.

The other stresses on this winding are within the limits of the design.

Table 3 - Short Circuit Calculations for the Common Winding (Five Layers)

Common Winding (Five Layers)		**Calculated**	**Allowed**
Average radial inward stress	Psi	2899	24183
Dynamic conductor tilting stress	Psi	3779	12000
Axial pressure on end rings	Psi	5750	6000

Note:

This winding is adequately designed for the short forces for all the criteria that needed to be checked.

Table 4 - Short Circuit Calculations for the Tap Winding

Tap Winding (Two Layers)		**Calculated**	**Allowed**
Average radial inward stress	Psi	5805	22489
Dynamic conductor tilting stress	Psi	1432	12000
Axial pressure on end rings	Psi	3000	6000

Note:

This winding is adequately designed for the short forces for all the criteria that needed to be checked.

Table 5 - Short Circuit Calculations for the Series Winding (Five Layers)

Series Winding (Five Layers)		**Calculated**	**Allowed**
Average radial outward stress	Psi	11327	40000
Dynamic conductor tilting stress	Psi	1763	2484
Axial pressure on end rings	Psi	4000	6 000

Note:

This winding is adequately designed for the short forces for all the criteria that needed to be checked.

3. Dielectric Study

The following is an insulation study of the transformer using ABB designs tools and standards.

3.1. Procedure

The design information was obtained from the archives and the transformer insulation clearances were checked against ABB standards.

For the purpose of the study, it was assumed that the quality of the transformer oil and insulation was acceptable for doing full level insulation testing as if the transformer was new.

3.2. Major Winding insulation

Below in

Table to **Error! Reference source not found.**3 are shown actual and allowed calculated electrical clearance values for the major winding insulation. The calculation shows that the insulation arrangement is satisfactory.

Table 6 – Radial Clearances

		Actual	Minimum
Core Leg - TV Winding	mm	9	9
TV Winding - Ground Shield	mm	11	8
Ground Shield - Common Winding	mm	10	10
Common Winding - Tap Winding	mm	11	11
Tap Winding – Series Winding	mm	28	17
Phase – Phase	mm	189	88

Table 7 – Axial Clearances

		Actual	Minimum
TV Winding – Core Yokes	mm	157	33
Common Winding - Core Yokes	mm	152	121
Tap Winding – Core Yokes	mm	152	121
Series Winding – Core Yokes	mm	233	204

All Winding leads, including tap leads, clearances to each other and to ground are within the design allowed rules.

4. Dissolved Gas in Oil Analysis (DGA)

4.1. SSD T1 - (CGE 289147)

Below is the report of the DGA data for the period of 1991 to 2013. The gas signatures for this transformer are shown in **Figure** to **Figure**

The following is noted for the transformer DGA:

- The concentration of Hydrogen (H2) has been well below IEEE C57.104-2008 guide condition level 1 since 1991, the highest level was 49 ppm.
- The concentration of Methane (CH4) and Ethane (C2H6) have been steadily low for the period of the data provided. The Ethylene (C2H4) level is slightly above condition level one of the IEEE C57.104-2008 guide since 1991.
- The concentration of Acetylene (C2H2) has been above IEEE C57.104-2008 guide condition level 2 since 1991. The level went up and down since then but was almost stable around the 10ppm. This could be oil leaking from LTC diverter compartment.
- The carbon dioxide level has been below the IEEE C57.104-2008 guide condition level 2 for the time period provided. The carbon monoxide level is slightly above the IEEE C57.104-2008 guide condition level 1 since 1991. However the ratio of CO2/CO is between 4 and 9. The normal CO2/CO ratios are typically in the range of 5-9. The ratio of the carbon oxides suggests that the concentrations are due to the normal aging process of the transformer.
- Shown below in **Figure 5** is a distribution plot of carbon oxide gas levels taken from a survey by the IEEE Transformer Committee using > 520,000 data records of units in service. This very large quantity of data is being used to revise the gas level limits in C57.104 (the famous Table 1 with condition 1 – 4 levels) – note that the levels will be increased. As can be seen, the 90th percentile levels are 700 ppm and 7500 for CO and CO2 respectively. **Figure 6** shows the CO distribution by age categories and for 30 – 40 years category, the 90th percentile is about 700 ppm. The history gassing on this transformer was around 500 ppm and 3600 ppm for CO and CO2 respectively. Thus these levels are well below the 90th percentile of the IEEE data for the age of this unit.
- The presence of large concentrations of oxygen in the oil can promote the formation of acids in the oil and cellulose and accelerate the aging rate of the cellulose insulation. It is recommended that the concentration of oxygen in the transformer be less than 2000 ppm (Refer to CIGRE report 323 – Aging of Cellulose in Mineral-Oil Insulated Transformers). The transformer maintenance record (09/21/2007) provided by the customer does not mention if the oil had ever been vacuum processed since 1991. The oil samples from this transformer have consistently shown very high oxygen concentrations (>20,000 ppm). The source of this high oxygen is the free-breathing oil conservator. To reduce the oxygen in the transformer oil and eliminate the uncertainty concerning the gas generation.

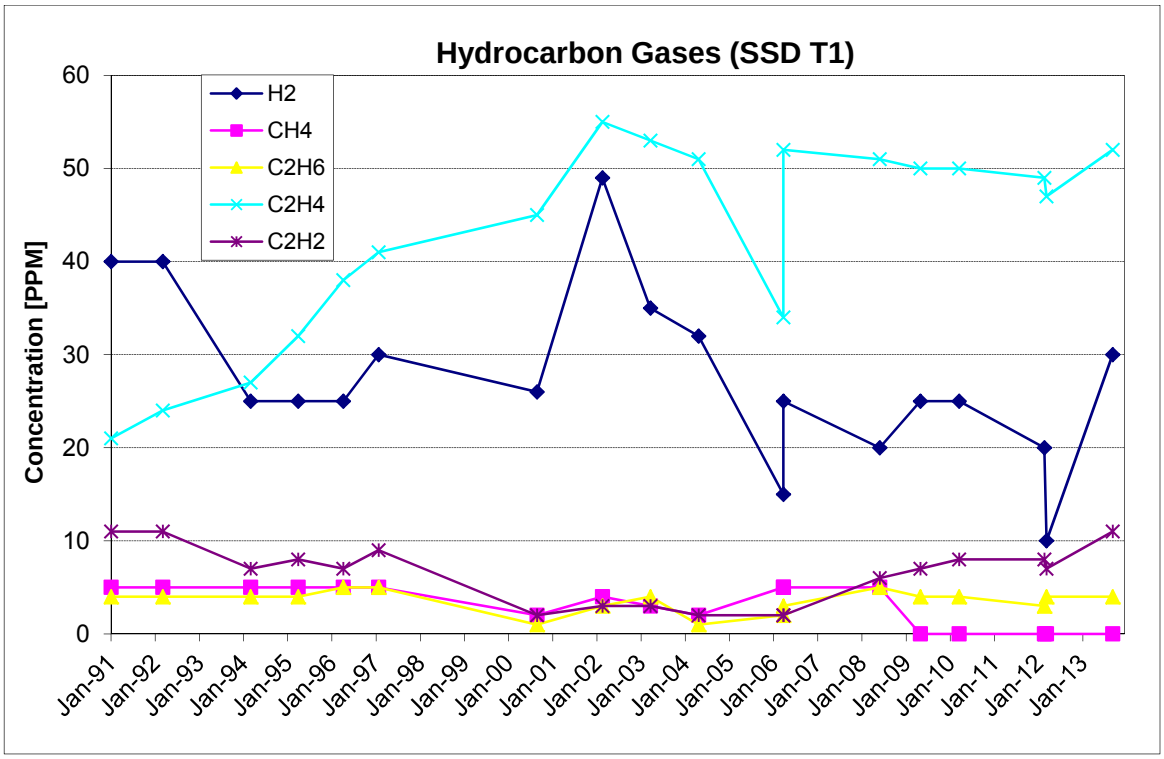


Figure 2 - Hydrocarbon Gas Concentrations

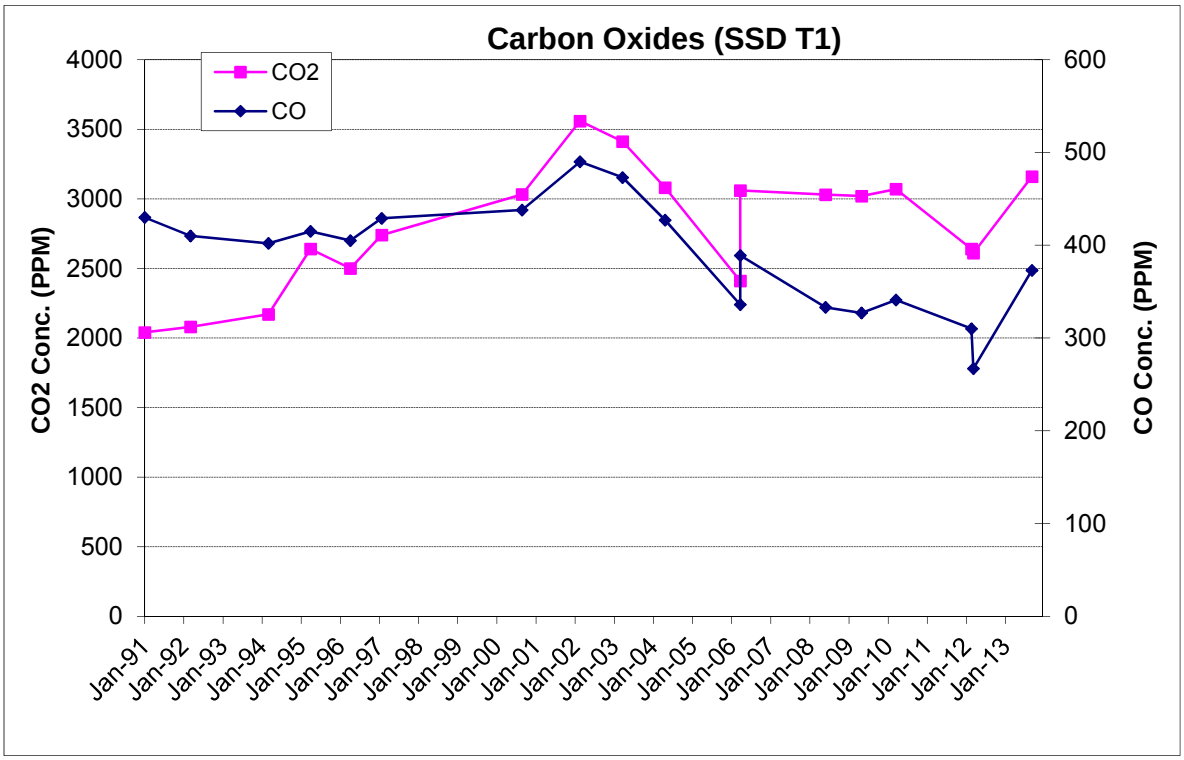


Figure 3 - Carbon Oxides Gas Concentrations

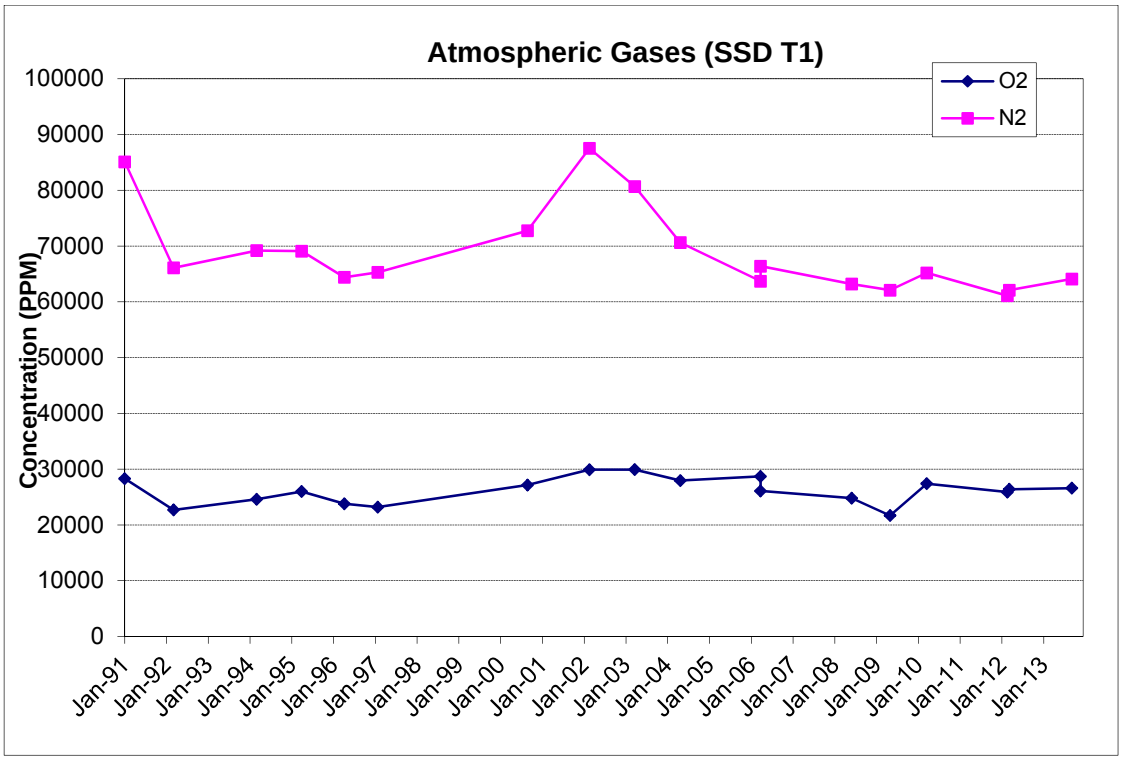


Figure 4 – Atmospheric Gases Concentrations

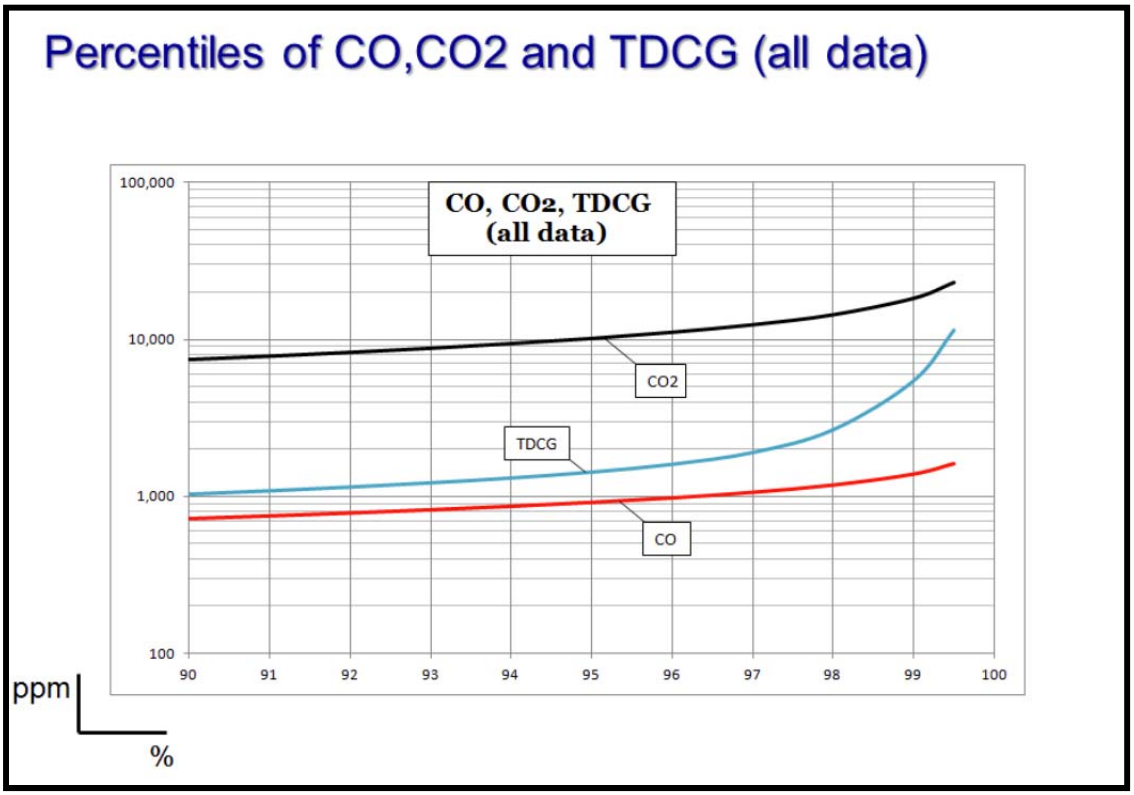


Figure 5 – IEEE Transformer Committee Carbon Oxide Survey Results

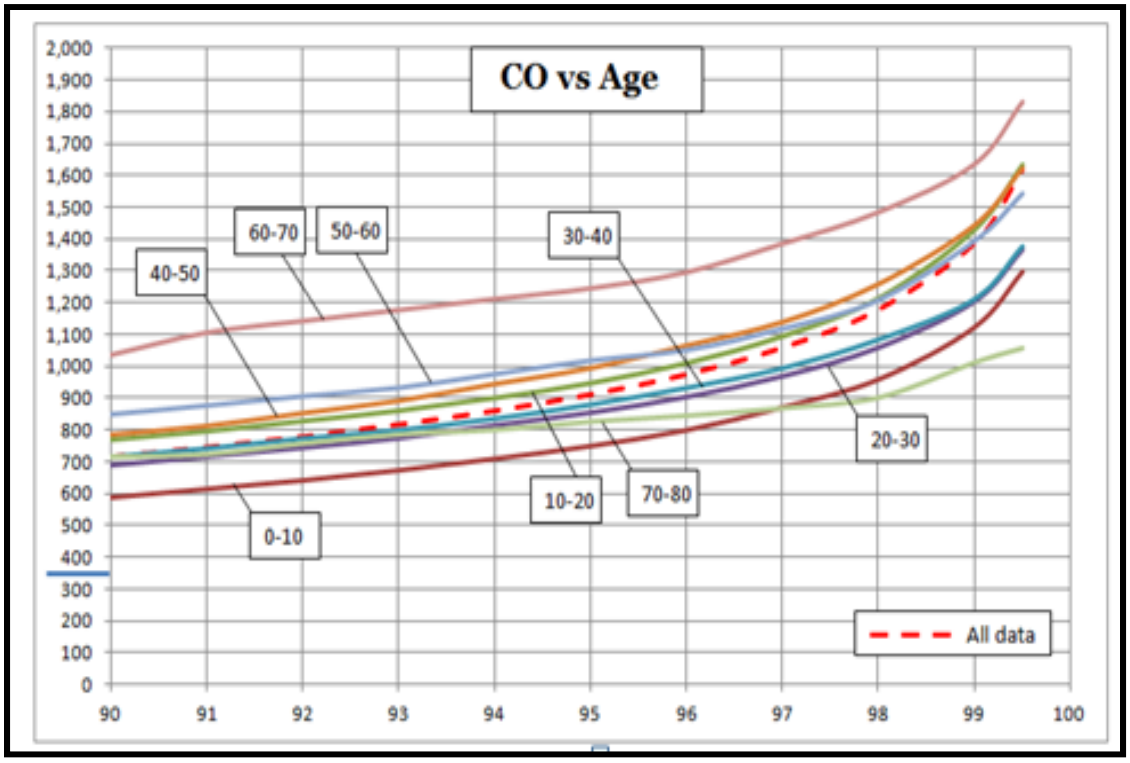


Figure 6 - IEEE Transformer Committee Carbon Oxide Survey Results (CO vs age)

4.2. SSD T4 – (CGE 288838)

Below is the report of the DGA data for the period of 1991 to 2013. The gas signatures for this transformer are shown in **Figure** to **Figure .**

The following is noted for the transformer DGA:

- The concentration of Hydrogen (H2) has been well below IEEE C57.104-2008 guide condition level 1 since 1991, the highest level is 30 ppm.
- The concentration of Methane (CH4) and Ethane (C2H6) have been steadily low for the period of the data provided. The Ethylene (C2H4) level is slightly above condition level one of the IEEE C57.104-2008 guide since 1991.
- The concentration of Acetylene (C2H2) has been above IEEE C57.104-2008 guide condition level 1 since 1991. The level went up and down since then but was almost stable around the 5ppm. This could be oil leaking from LTC diverter compartment.
- The carbon dioxide level has been below the IEEE C57.104-2008 guide condition level 1 for the time period provided. The carbon monoxide level is slightly above the IEEE C57.104-2008 guide condition level 1 between 1996 and 2004, however the level became normal after 2004. The ratio of CO2/CO is between 5 and 10. The normal CO2/CO ratios are typically in the range of 5-9. The ratio of the carbon oxides suggests that the concentrations are due to the normal aging process of the transformer.
- As can be seen from **Figure 5 & 6**, the 90th percentile levels are 700 ppm and 7500 for CO and CO2 respectively. The 90th percentile is about 700 ppm for the CO distribution by age categories and for 30 – 40 years category. The history gassing on this transformer was around 450 ppm and 3000 ppm for CO and CO2 respectively. Thus these levels are below the 90th percentile of the IEEE data for the age of this unit.
- The presence of large concentrations of oxygen in the oil can promote the formation of acids in the oil and cellulose and accelerate the aging rate of the cellulose insulation. It is recommended that the concentration of oxygen in the transformer be less than 2000 ppm (Refer to CIGRE report 323 – Aging of Cellulose in Mineral-Oil Insulated Transformers). The transformer maintenance record (09/06/2012) provided by the customer does not mention if the oil had ever been vacuum processed since 1991. The oil samples from this transformer have consistently shown very high oxygen concentrations (>20,000 ppm) of oxygen. The source of this high oxygen is the free-breathing oil conservator. To reduce the oxygen in the transformer oil and eliminate the uncertainty concerning the gas generation, it is recommended to add a conservator diaphragm. The diaphragm prevents oil from coming in contact with the air. This will prevent moisture, excessive atmospheric gases from dissolving into the oil and it also helps to keep all gases generated by the transformer in oil for more accurate diagnostics.

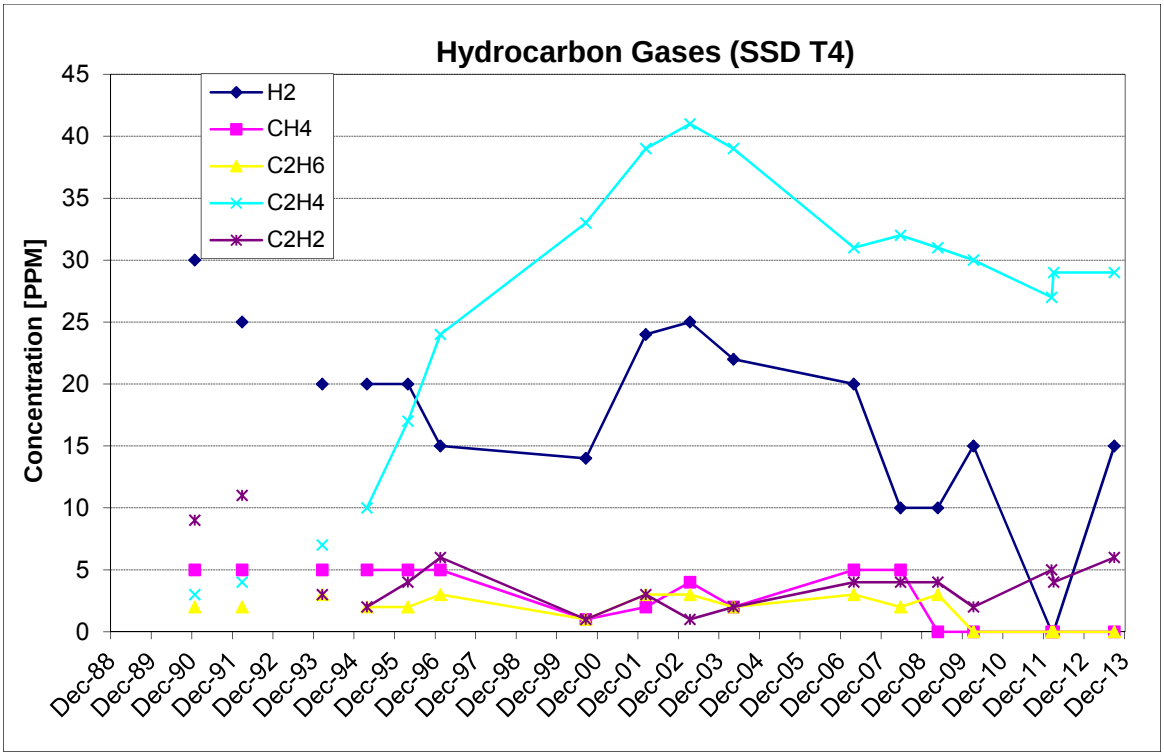


Figure 7 - Hydrocarbon Gas Concentrations

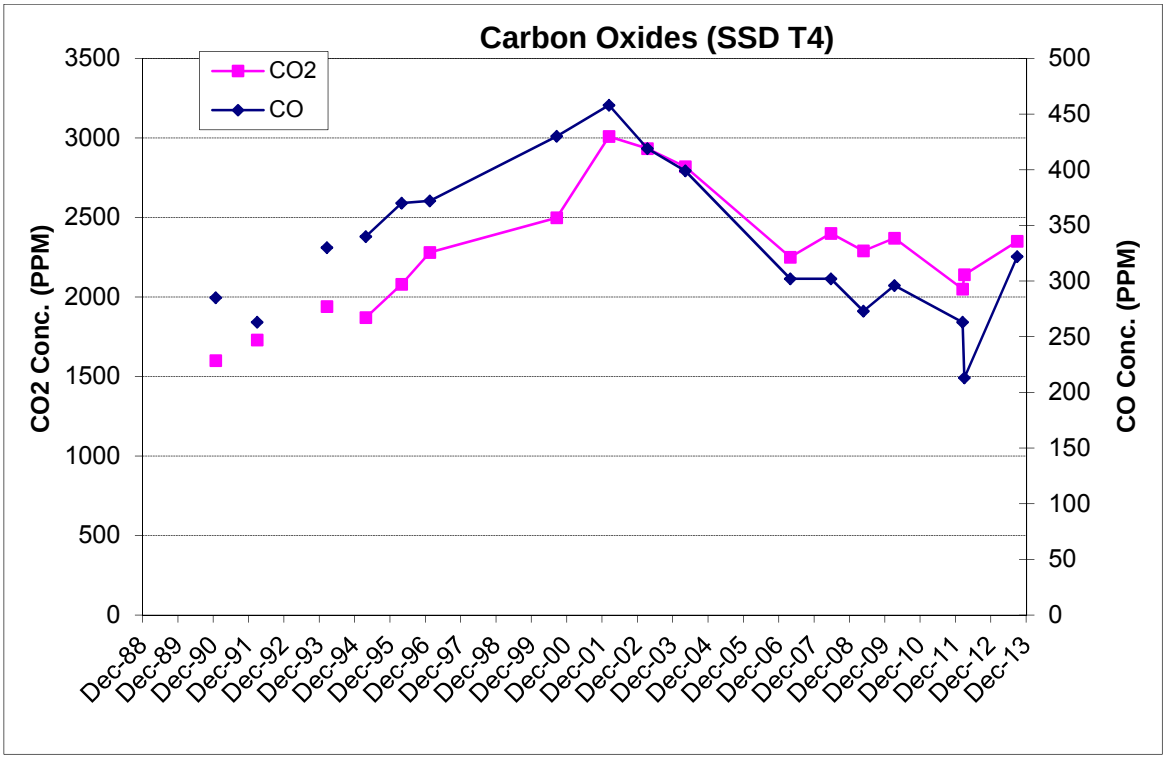


Figure 8 - Carbon Oxides Gas Concentrations

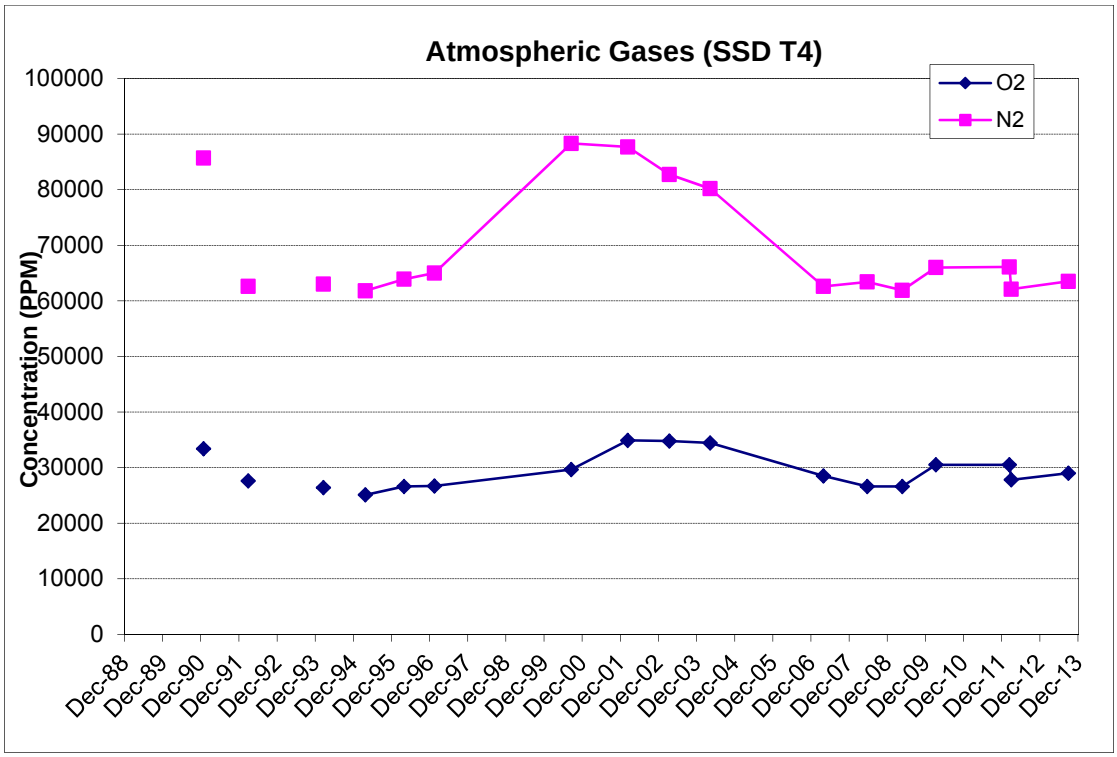


Figure 9 – Atmospheric Gases Concentrations

4.3. STB T1 – (CGE 288894)

Below is the report of the DGA data for the period of 1977 to 2013. The gas signatures for this transformer are shown in **Figure 10** to **Figure 12**.

The following is noted for the transformer DGA:

- The concentration of Hydrogen (H2) has been well below IEEE C57.104-2008 guide condition level 1 since 1977, the highest level is 75 ppm in 1979.
- The concentration of Methane (CH4) and Ethane (C2H6) have been steadily low for the period of the data provided. The Ethylene (C2H4) level has been below condition level 1 of the IEEE C57.104-2008 guide since 1977, except one sample (67 ppm) in 2009.
- The concentration of Acetylene (C2H2) has been below IEEE C57.104-2008 guide condition level 1 since 2009. However the DGA sample for the year 1979 shows high level of C2H2. This could be a bad oil sample.
- The carbon dioxide level has been above the IEEE C57.104-2008 guide condition level 1 for the most of time period provided. The carbon monoxide level is above the IEEE C57.104-2008 guide condition level 1 for most of time as well. However the ratio of CO2/CO is between 4 and 9. The normal CO2/CO ratios are typically in the range of 5-9. The ratio of the carbon oxides suggests that the concentrations are due to the normal aging process of the transformer.
- As can be seen from **Figure 5 & 6**, the 90th percentile levels are 700 ppm and 7500 for CO and CO2 respectively. The 90th percentile is about 700 ppm for the CO distribution by age categories and for 30 – 40 years category. The history gassing on this transformer was around 590 ppm and 4400 ppm for CO and CO2 respectively. Thus these levels are below the 90th percentile of the IEEE data for the age of this unit.
- The presence of large concentrations of oxygen in the oil can promote the formation of acids in the oil and cellulose and accelerate the aging rate of the cellulose insulation. It is recommended that the concentration of oxygen in the transformer be less than 2000 ppm (Refer to CIGRE report 323 – Aging of Cellulose in Mineral-Oil Insulated Transformers). The transformer maintenance record (09/22/2011) provided by the customer does not mention if the oil had ever been vacuum processed since 1991. The oil samples from this transformer have consistently shown very high oxygen concentrations (>20,000 ppm) of oxygen. The source of this high oxygen is the free-breathing oil conservator. To reduce the oxygen in the transformer oil and eliminate the uncertainty concerning the gas generation, it is recommended to add a conservator diaphragm. The diaphragm prevents oil from coming in contact with the air. This will prevent moisture, excessive atmospheric gases from dissolving into the oil and it also helps to keep all gases generated by the transformer in oil for more accurate diagnostics

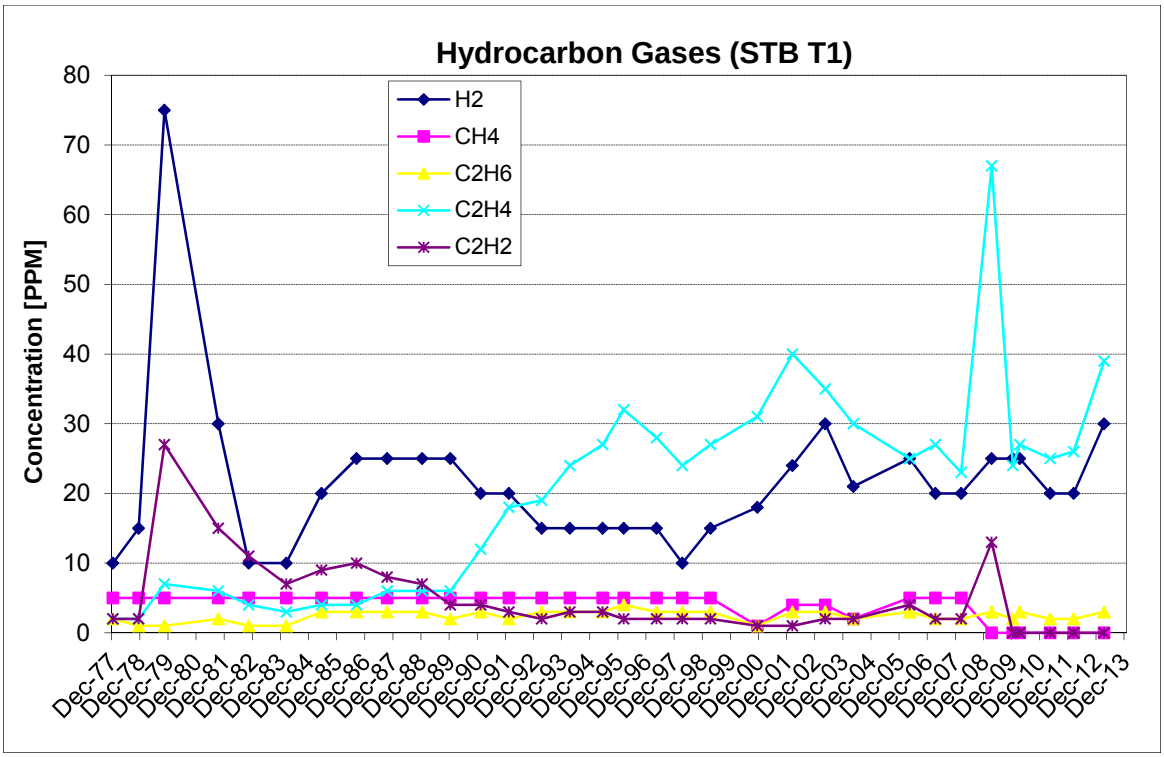


Figure 10 - Hydrocarbon Gas Concentrations

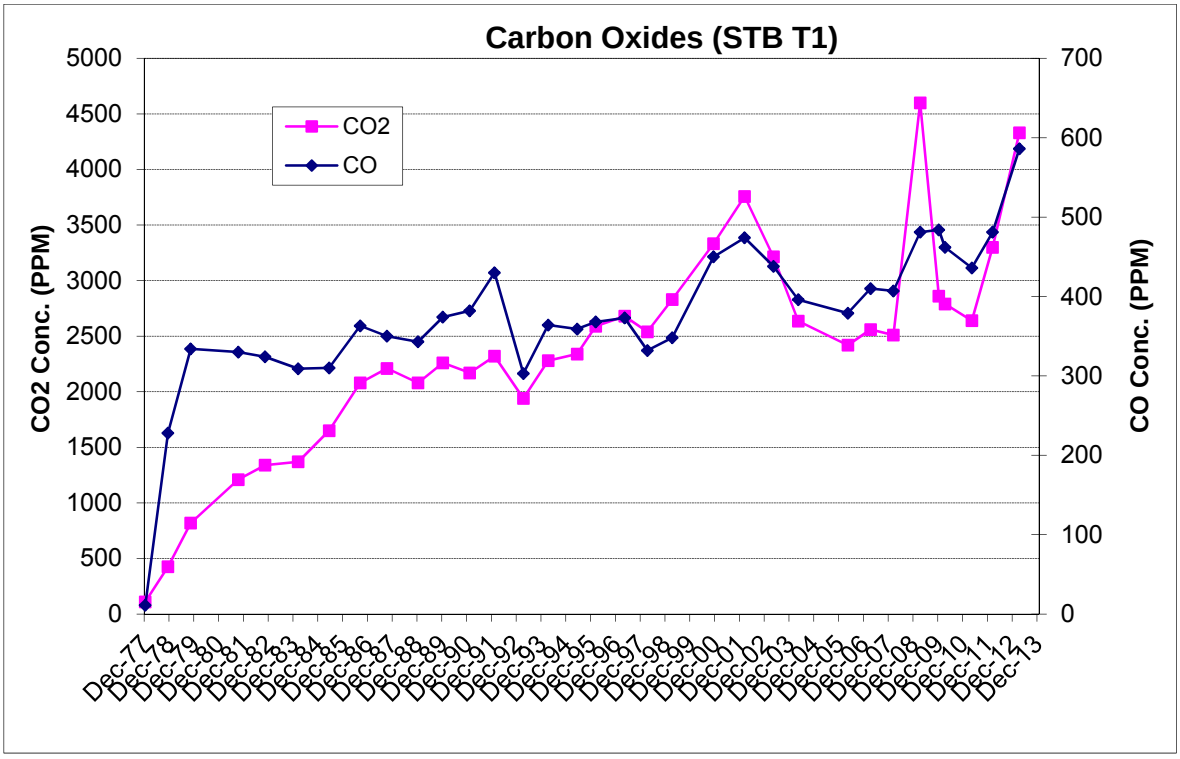


Figure 11 - Carbon Oxides Gas Concentrations

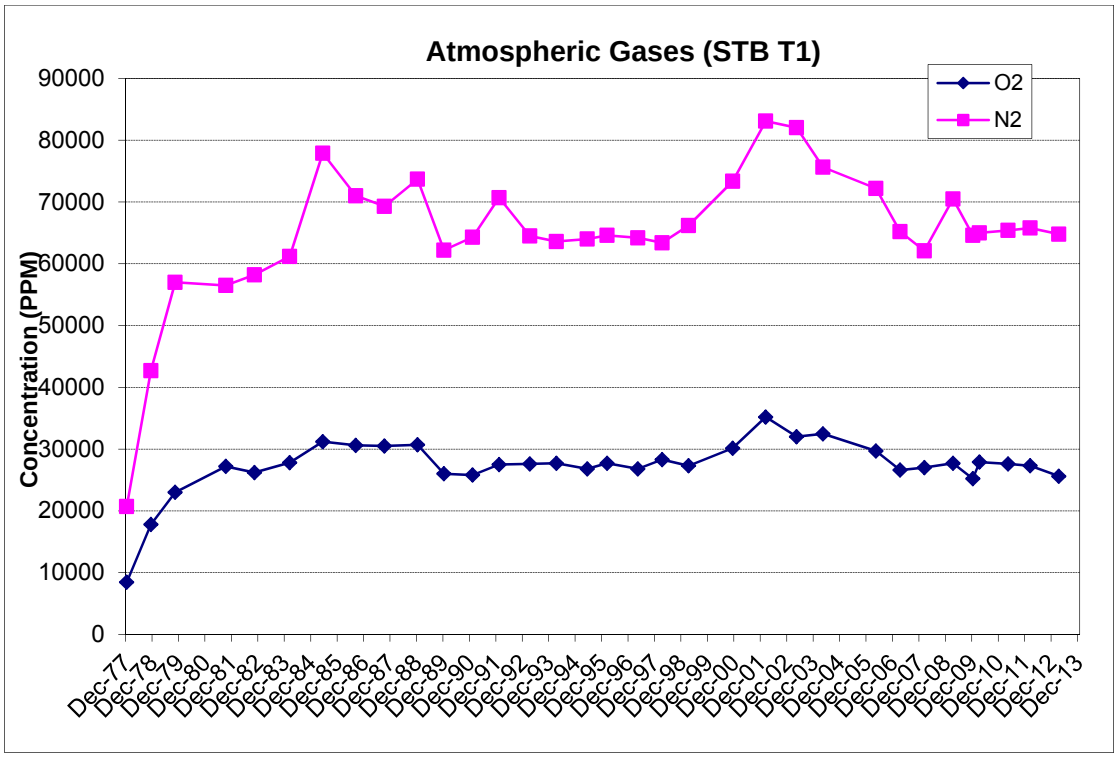


Figure 12 – Atmospheric Gases Concentrations

4.4. STB T2 – (CGE 288839)

Below is the report of the DGA data for the period of 1977 to 2013. The gas signatures for this transformer are shown in **Figure 13** to **Figure 15**.

The following is noted for the transformer DGA:

- The concentration of Hydrogen (H2) has been well below IEEE C57.104-2008 guide condition level 1 since 1977, the highest level is 50 ppm in 1987.
- The concentration of Methane (CH4) and Ethane (C2H6) have been steadily low for the period of the data provided. The Ethylene (C2H4) level has been in condition level 2 of the IEEE C57.104-2008 guide (50 ppm) since 2000.
- The transformer has consistently shown high concentrations (>20 ppm) of Acetylene (C2H2) since 1986, which is far above the IEEE C57.104-2008 guide condition level 2. The high concentration of C2H2 indicates that possible high energy arcing occurred somewhere inside the transformer. The other reason could be oil leaking from LTC diverter compartment. The Acetylene levels are about 10ppm foe few years now. This needs to be monitored closely. Any sudden increase of Acetylene needs to be investigated.
- The carbon dioxide level has been above the IEEE C57.104-2008 guide condition level 1 for the most of time period provided. The carbon monoxide level is above the IEEE C57.104-2008 guide condition level 1 for most of time as well. However the ratio of CO2/CO is between 5 and 10. The normal CO2/CO ratios are typically in the range of 5-9. The ratio of the carbon oxides suggests that the concentrations are due to the normal aging process of the transformer.
- As can be seen from **Figure 5 & 6**, the 90th percentile levels are 700 ppm and 7500 for CO and CO2 respectively. The 90th percentile is about 700 ppm for the CO distribution by age categories and for 30 – 40 years category. The history gassing on this transformer was around 560 ppm and 5500 ppm for CO and CO2 respectively. Thus these levels are below the 90th percentile of the IEEE data for the age of this unit.
- The presence of large concentrations of oxygen in the oil can promote the formation of acids in the oil and cellulose and accelerate the aging rate of the cellulose insulation. It is recommended that the concentration of oxygen in the transformer be less than 2000 ppm (Refer to CIGRE report 323 – Aging of Cellulose in Mineral-Oil Insulated Transformers). It is unknown if the oil had ever been vacuum processed since 1977. The oil samples from this transformer have consistently shown very high oxygen concentrations (>20,000 ppm) of oxygen. The source of this high oxygen is the free-breathing oil conservator. To reduce the oxygen in the transformer oil and eliminate the uncertainty concerning the gas generation, it is recommended to add a conservator diaphragm. The diaphragm prevents oil from coming in contact with the air. This will prevent moisture, excessive atmospheric gases from dissolving into the oil and it also helps to keep all gases generated by the transformer in oil for more accurate diagnostics

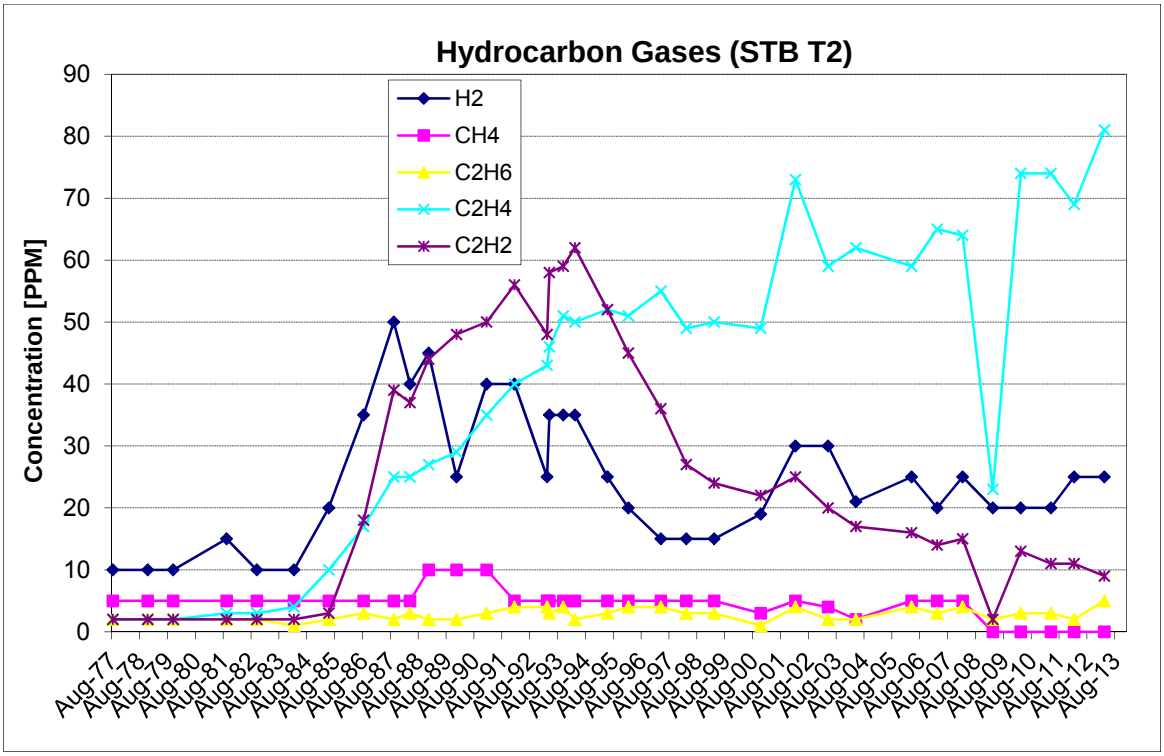


Figure 13 - Hydrocarbon Gas Concentrations

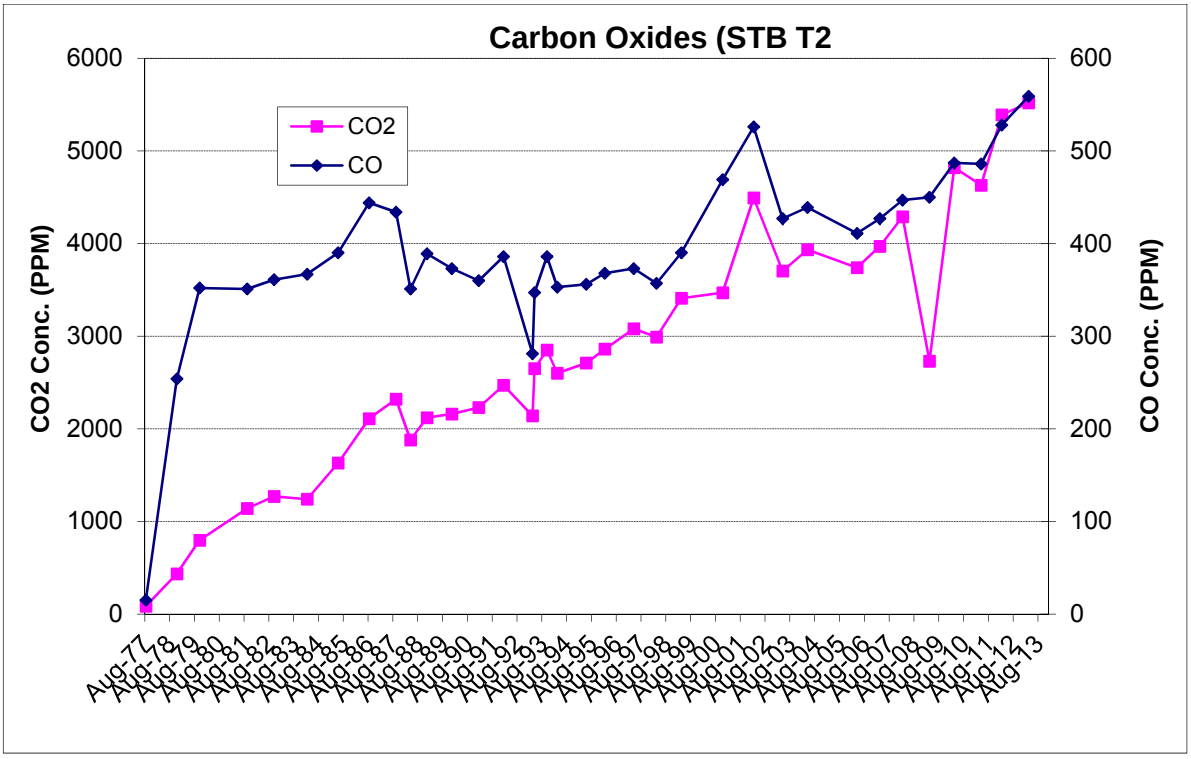


Figure 14 - Carbon Oxides Gas Concentrations

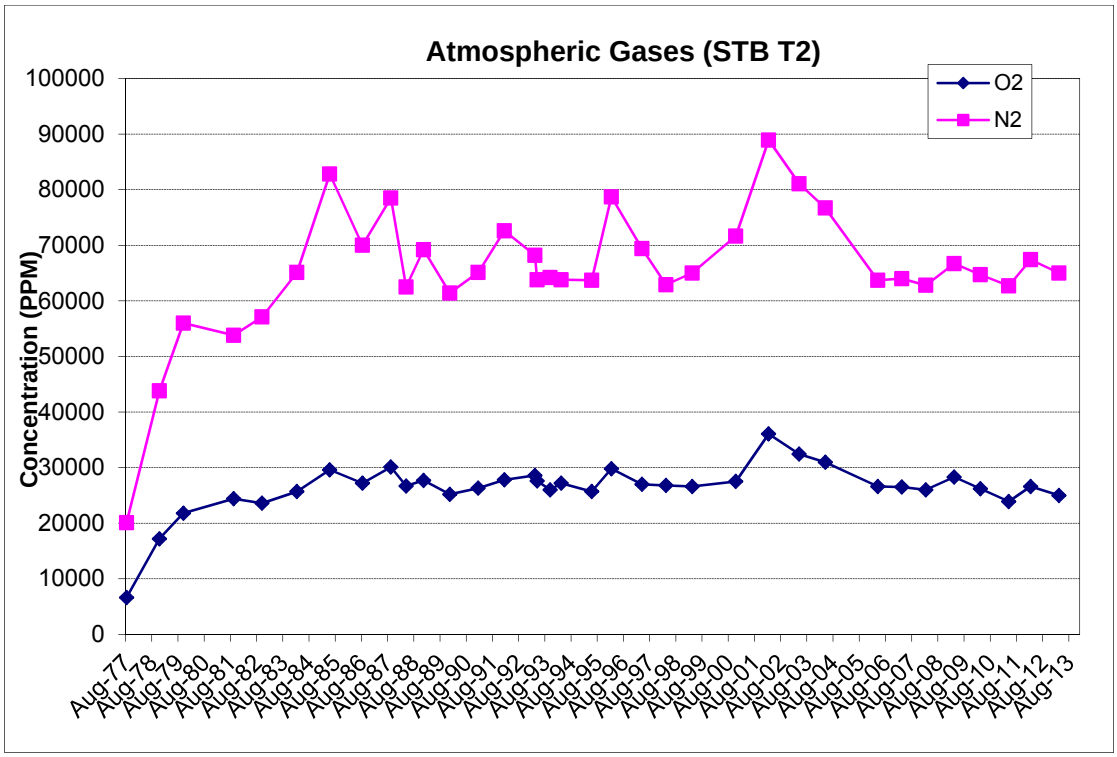


Figure 15 – Atmospheric Gases Concentrations

5. General Oil Quality

5.1. SSD T1 – (CGE 289147)

2.1.1 Main Tank

Below is the report of the oil quality data results from 2009 to 2013. The history of the oil quality data measured for this transformer is shown in **Table** .

The following can be observed:

- The latest measured breakdown voltage (52.0 kV/mm on 09/11/2013) is above the minimum requirement (30kV/mm) as outlined by Doble Engineering for ≥ 230kV transformers with service aged insulating oil based on D877 method. However ASTM D1816-97 is recommended for testing fluid that is being processed into transformers and load tap changers. The gap distance standard settings are 1 mm and 2 mm.

- The interfacial tension values are around 28.0 dynes/cm2 which are below the 32 dynes/cm2 limit recommended by IEEE C57.106-2002 for ≥ 230kV transformers. Lower values may indicate oil soluble contaminants and oxidation products in oil.

- The oxidation inhibitor values were not measured since 2009. The acceptable range is between 0.08 and 0.30%. Oxygen inhibitors are helpful to minimize the effects of oxidation of oil. The first choice of attack by oxygen in the oil is the inhibitor molecules. This keeps the oil free from oxidation and its harmful by-products. As transformer ages, the oxidation inhibitor is used up and need to be replaced.

- The measured Acid Numbers for the oil samples in the past years are all below the recommended limits (0.10 mg KOH/g) by IEEE C57.106-2002 for ≥ 230kV transformers.

- The measured power factor values at 25/100°C are all below the suggested limits as outlined in IEEE C57.106-2002 for continue use of service-aged insulating oil.

- IEEE C57.106-2002 Table 5 recommends that the maximum limit of water content in oil for 230kV transformers is not to exceed 10 ppm or 5% saturation at 50ºC. The oil samples taken from the main tank show moisture content of less than 10 ppm.

Table 8 - Oil Quality Data (Main Tank)

Sample Date	Fluid Temp (°C)	Dielectric Breakdown D877 (kV)	Acid Number D974 (mg KOH/g)	Interfacial Tension D971 (dynes/cm)	Visual Condition D1524	Power Factor D924 (%) 25°C / 100 C		Water (ppm)	% Satur.	Inhibitor (%)
05/05/2009	30	55	0.03	28.6	Clear	0.062	1.38	2	2	-
03/22/2010	25	45	0.03	27.8	Clear	0.035	1.28	5	7	-
02/24/2012	20	59	0.03	26.9	Clear	0.123	2.62	2	4	-
03/13/2012	20	49	0.03	27.5	Clear	0.115	3.28	2	4	-
09/11/2013	35	52	0.03	28.1	Clear	0.166	2.94	3	3	-

2.1.2 LTC Tank

Below is the report of the LTC oil quality data results for 2007, 2008 and 2012. The oil quality test is not available for LTC-B,C in 2007. The history of the oil quality data measured for LTC-A,B,C is shown in **Table** below.

The following can be observed:

- The measured breakdown voltage (around 22.0 kV/mm for LTC-A,B,C) is below the minimum requirement (28 kV/mm for 1 mm gap and 45 kV/mm for 2 mm gap) as outlined by IEEE C57.106-2002 for LTC mounted at line end with ≥ 69 kV rating and for service aged insulating oil in LTC based on D1816 method. However the oil test reports do not mention gap distance. (1 mm or 2 mm). If the dielectric strength of the oil drops below the suggested values given in IEEE C57.106-2002, the oil should be reconditioned or changed.

- The interfacial tension values are around 36.0 dynes/cm2. However IEEE C57.106-2002 does not specify any IFT limits for continued use of service aged insulating oil for load tap changers.
- The measured Acid Numbers for the oil samples are all below 0.10 mg KOH/g. However IEEE C57.106-2002 does not specify any Acid number limits for load tap changers
- IEEE C57.106-2002 Table 12 recommends that the maximum limit of water content in oil for LTC is not to exceed 25 ppm. The oil samples taken from the LTC-A tank does show moisture content of more than 25 ppm. If the water content exceeds the values given in IEEE C57.106-2002, the oil should be reconditioned or changed.

Table 9 - Oil Quality Data (LTC Tank)

Sample Date	LTC ID	Fluid Temp. (°C)	Dielectric Breakdown D1816 (kV)	Acid Number D974 (mg KOH/g)	Interfacial Tension D971 (dynes/cm)	Color # D1500	Water (ppm)
06/27/2007	A	30	14	0.012	35.0	<3.0	43
	B	-	-	-	-	-	-
	C	-	-	-	-	-	-
04/29/2008	A	45	25	0.016	36.3	<2.0	14
	B	35	22	0.014	35.5	<2.5	13
	C	35	22	0.016	36.8	<2.5	9
10/02/2012	A	35	22	0.011	38.7	<4.0	26
	B	35	22	0.015	38.1	<2.5	16
	C	35	23	0.014	38.3	<4.0	18

5.2. SSD T4 – (CGE 288838)

2.2.1 Main Tank

Below is the report of the oil quality data results from 2009 to 2013. The history of the oil quality data measured for this transformer is shown in **Table** .

The following can be observed:

- The latest measured breakdown voltage (52.0 kV/mm on 09/11/2013) is above the minimum requirement (30kV/mm) as outlined by Doble Engineering for 230kV transformers with service aged insulating oil based on D877 method. However ASTM D1816-97 is recommended for testing fluid that is being processed into transformers and load tap changers. The gap distance standard settings are 1 mm and 2 mm.

- The interfacial tension values are around 33.6 dynes/cm2 which is slightly above the 32 dynes/cm2 limit recommended by IEEE C57.106-2002 for 230kV transformers. Lower values may indicate oil soluble contaminants and oxidation products in oil.

- The oxidation inhibitor values were not measured since 2009. The acceptable range is between 0.08 and 0.30%. Oxygen inhibitors are helpful to minimize the effects of oxidation of oil. The first choice of attack by oxygen in the oil is the inhibitor molecules. This keeps the oil free from oxidation and its harmful by-products. As transformer ages, the oxidation inhibitor is used up and need to be replaced. It is highly recommended to add oxidation inhibitor in the oil.

- The measured Acid Numbers for the oil samples in the past years are all below the recommended limits (0.10 mg KOH/g) by IEEE C57.106-2002 for 230kV transformers.

- The measured power factor values at 25/100°C are all below the suggested limits as outlined in IEEE C57.106-2002 for continue use of service-aged insulating oil.

- IEEE C57.106-2002 Table 5 recommends that the maximum limit of water content in oil for 230kV transformers is not to exceed 10 ppm or 5% saturation at 50ºC. The oil samples taken from the main tank show moisture content of less than 10 ppm.

Table 10 - Oil Quality Data (Main Tank)

Sample Date	Fluid Temp (°C)	Dielectric Breakdown D877 (kV)	Acid Number D974 (mg KOH/g)	Interfacial Tension D971 (dynes/cm)	Visual Condition D1524	Power Factor D924 (%) 25°C / 100 C		Water (ppm)	% Satur.	Inhibitor (%)
05/05/2009	34	56	0.01	33.6	Clear	0.066	1.04	2	2	-
03/22/2010	30	36	0.01	31.7	Clear	0.015	0.63	7	8	-
02/24/2012	25	33	0.02	32.0	Clear	0.042	1.24	2	3	-
03/13/2012	25	57	0.02	33.1	Clear	0.054	1.17	2	3	-
09/11/2013	42	52	0.02	33.6	Clear	0.054	1.91	4	3	-

2.2.2 LTC Tank

Below is the report of the LTC oil quality data results for 2008 and 2012. The history of the oil quality data measured for LTC-A,B,C is shown in **Table** below.

The following can be observed:

- The measured breakdown voltage (between 22.0 kV/mm and 29.0 kV/mm for LTC-A,B,C) is below the minimum requirement (28 kV/mm for 1 mm gap and 45 kV/mm for 2 mm gap) as outlined by IEEE C57.106-2002 for LTC mounted at line end with ≥ 69 kV rating and for service- aged insulating oil in LTC based on D1816 method. However the oil test reports do not mention gap distance. (1 mm or 2 mm?). If the dielectric strength of the oil drops below the suggested values given in IEEE C57.106-2002, the oil should be reconditioned or changed.

- The interfacial tension values are around 39.0 dynes/cm2. However IEEE C57.106-2002 does not specify any IFT limits for continued use of service aged insulating oil for load tap changers.
- The measured Acid Numbers for the oil samples are all below 0.10 mg KOH/g. However IEEE C57.106-2002 does not specify any Acid number limits for load tap changers
- IEEE C57.106-2002 Table 12 recommends that the maximum limit of water content in oil for LTC is not to exceed 25 ppm. The oil samples taken from the LTC tank show moisture content of less than 25 ppm. If the water content exceeds the values given in IEEE C57.106-2002, the oil should be reconditioned or changed.

Table 11 - Oil Quality Data (LTC Tank)

Sample Date	LTC ID	Fluid Temp. (°C)	Dielectric Breakdown D1816 (kV)	Acid Number D974 (mg KOH/g)	Interfacial Tension D971 (dynes/cm)	Color # D1500	Water (ppm)
04/29/2008	A	33	-	-	-	-	21
	B	33	21	0.014	37.3	<4.5	18
	C	33	22	0.013	37.9	<4.5	14
08/28/2012	A	45	18	0.011	39.1	<4.0	18
	B	-	-	-	-	-	-
	C	-	-	-	-	-	-
10/02/2012	A	40	22	0.012	39.7	<4.0	11
	B	40	25	0.011	39.4	<4.0	12
	C	40	29	0.014	39.4	<2.5	24

5.3. STB T1 – (CGE 288894)

2.3.1 Main Tank

Below is the report of the oil quality data results from 2009 to 2013. The history of the oil quality data measured for this transformer is shown in **Table** .

The following can be observed:

- The latest measured breakdown voltage (62.0 kV/mm on 03/14/2013) is above the minimum requirement (50kV/mm) as outlined in IEEE C57.106-2002 for 230kV transformers with service aged insulating oil based on D1816-2mm method.
- The interfacial tension values are around 30.4 dynes/cm2 which is below the suggested limits (32 dynes/cm2) recommended by IEEE C57.106-2002 for 230kV transformers. Lower values may indicate oil soluble contaminants and oxidation products in oil.
- The oxidation inhibitor values were not measured since 2009. The acceptable range is between 0.08 and 0.30%. Oxygen inhibitors are helpful to minimize the effects of oxidation of oil. The first choice of attack by oxygen in the oil is the inhibitor molecules. This keeps the oil free from oxidation and its harmful by-products. As transformer ages, the oxidation inhibitor is used up and need to be replaced. It is highly recommended to add oxidation inhibitor in the oil.
- The measured Acid Numbers for the oil samples in the past years are all below the recommended limits (0.10 mg KOH/g) by IEEE C57.106-2002 for 230kV transformers.
- The measured power factor values at 25/100°C are all below the suggested limits as outlined in IEEE C57.106-2002 for continue use of service-aged insulating oil.
- IEEE C57.106-2002 Table 5 recommends that the maximum limit of water content in oil for 230kV transformers is not to exceed 10 ppm or 5% saturation at 50ºC. The oil samples taken from the main tank show moisture content of less than 10 ppm.
- The BDV measurement on 03/14/2012 (in RED) was based on D1816-2mm method.

Table 12 - Oil Quality Data (Main Tank)

Sample Date	Fluid Temp (°C)	Dielectric Breakdown D877 (kV)	Acid Number D974 (mg KOH/g)	Interfacial Tension D971 (dynes/cm)	Visual Condition D1524	Power Factor D924 (%) 25°C / 100 C		Water (ppm)	% Satur.	Inhibitor (%)
03/09/2009	35	53	0.02	32.6	Clear	0.043	0.98	2	2	-
03/15/2010	40	54	0.02	32.0	Clear	0.035	0.98	2	2	-
04/05/2011	40	45	0.02	31.0	Clear	0.065	1.49	4	3	-
02/13/2012	35	52	0.02	30.2	Clear	0.053	2.24	2	2	-
03/14/2013	40	62	0.02	30.4	Clear	0.058	1.39	3	2	-

2.3.2 LTC Tank

Below is the report of the LTC oil quality data results from 2007 to 2010. The history of the oil quality data measured for LTC-A,B,C is shown in **Table** below.

The following can be observed:

- The latest measured breakdown voltage is 30, 31 and 33 kV/mm for LTC-A,B,C. the suggested limits is 28 kV/mm for 1 mm gap and 45 kV/mm for 2 mm gap as outlined by IEEE C57.106-2002 for LTC mounted at line end with ≥ 69 kV rating and for service- aged insulating oil in LTC based on D1816 method. However the oil test reports do not mention gap distance. (1 mm or 2 mm?). If the dielectric strength of the oil drops below the suggested values given in IEEE C57.106-2002, the oil should be reconditioned or changed.

- The interfacial tension values are around 35.0 dynes/cm2. However IEEE C57.106-2002 does not specify any IFT limits for continued use of service aged insulating oil for load tap changers.
- The measured Acid Numbers for the oil samples are all below 0.10 mg KOH/g. However IEEE C57.106-2002 does not specify any Acid number limits for load tap changers
- IEEE C57.106-2002 Table 12 recommends that the maximum limit of water content in oil for LTC is not to exceed 25 ppm. The latest oil samples taken from the LTC tank show moisture content of less than 25 ppm. If the water content exceeds the values given in IEEE C57.106-2002, the oil should be reconditioned or changed.
- Note: The recorded temperature 22°C is much lower than the other phases.

Table 13 - Oil Quality Data (LTC Tank)

Sample Date	LTC ID	Fluid Temp. (°C)	Dielectric Breakdown D1816 (kV)	Acid Number D974 (mg KOH/g)	Interfacial Tension D971 (dynes/cm)	Color # D1500	Water (ppm)
08/06/2007	Left	45	22	0.027	35.6	<3.5	28
	Center	45	18	0.026	35.0	<3.5	29
	Right	45	24	0.026	33.9	<3.5	12
07/18/2008	Left	22	14	0.016	35.1	<2.0	42
	Center	72	14	0.016	34.4	<3.0	40
	Right	72	14	0.015	35.0	<2.5	41
05/27/2010	Left	-	31	0.016	35.5	<3.0	22
	Center	-	30	0.016	35.4	<3.5	15
	Right	-	33	0.016	35.7	<3.0	24

5.4. STB T2 – (CGE 288839)

2.4.1 Main Tank

Below is the report of the oil quality data results from 05/2009 to 09/2013. The history of the oil quality data measured for this transformer is shown in **Table** .

The following can be observed:

- The latest measured breakdown voltage (68.0 kV/mm on 03/14/2013) is above the minimum requirement (50kV/mm) as outlined in IEEE C57.106-2002 for 230kV transformers with service aged insulating oil based on D1816-2mm method.
- The interfacial tension values are around 28.7 dynes/cm2 which is below the suggested limits (32 dynes/cm2) recommended by IEEE C57.106-2002 for 230kV transformers. Lower values may indicate oil soluble contaminants and oxidation products in oil.
- The oxidation inhibitor values were not measured since 2009. The acceptable range is between 0.08 and 0.30%. Oxygen inhibitors are helpful to minimize the effects of oxidation of oil. The first choice of attack by oxygen in the oil is the inhibitor molecules. This keeps the oil free from oxidation and its harmful by-products. As transformer ages, the oxidation inhibitor is used up and need to be replaced. It is highly recommended to add oxidation inhibitor in the oil.
- The measured Acid Numbers for the oil samples in the past years are all below the recommended limits (0.10 mg KOH/g) by IEEE C57.106-2002 for 230kV transformers.
- The measured power factor values at 25/100°C are all below the suggested limits as outlined in IEEE C57.106-2002 for continue use of service-aged insulating oil.
- IEEE C57.106-2002 Table 5 recommends that the maximum limit of water content in oil for 230kV transformers is not to exceed 10 ppm or 5% saturation at 50ºC. The oil samples taken from the main tank show moisture content of less than 10 ppm.
- The BDV measurement on 03/14/2012 (in RED) was based on D1816 method

Table 14 - Oil Quality Data (Main Tank)

Sample Date	Fluid Temp (°C)	Dielectric Breakdown D877 (kV)	Acid Number D974 (mg KOH/g)	Interfacial Tension D971 (dynes/cm)	Visual Condition D1524	Power Factor D924 (%) 25°C / 100 C		Water (ppm)	% Satur.	Inhibitor (%)
03/09/2009	40	56	0.02	29.4	Clear	0.074	1.53	3	2	-
03/15/2010	49	56	0.02	29.4	Clear	0.059	1.59	2	1	-
04/05/2011	48	44	0.02	28.4	Clear	0.132	2.60	6	4	-
02/13/2012	43	45	0.03	27.1	Clear	0.098	2.98	3	2	-
03/14/2013	49	68	0.03	28.7	Clear	0.090	1.86	2	1	-

2.4.2 LTC Tank

Below is the report of the LTC oil quality data results from 2007 to 2011. The history of the oil quality data measured for LTC-A,B,C is shown in **Table** below.

The following can be observed:

- The latest measured breakdown voltage is 17, 21 and 23 kV/mm for LTC-A,B,C. the suggested minimum limits is 28 kV/mm for 1 mm gap and 45 kV/mm for 2 mm gap as outlined by IEEE C57.106-2002 for LTC mounted at line end with ≥ 69 kV rating and for service- aged insulating oil in LTC based on D1816 method. However the oil test reports do not mention gap distance. (1 mm or 2 mm?). If the dielectric strength of the oil drops below the suggested values given in IEEE C57.106-2002, the oil should be reconditioned or changed.

- The interfacial tension values are around 34.0 dynes/cm2. However IEEE C57.106-2002 does not specify any IFT limits for continued use of service aged insulating oil for load tap changers.

- The measured Acid Numbers for the oil samples are all below 0.10 mg KOH/g. However IEEE C57.106-2002 does not specify any Acid number limits for load tap changers

- IEEE C57.106-2002 Table 12 recommends that the maximum limit of water content in oil for LTC is not to exceed 25 ppm. The latest oil samples taken from the LTC tank show moisture content of more than 25 ppm for all three LTCs. If the water content exceeds the values given in IEEE C57.106-2002, the oil should be reconditioned or changed.

Table 15 - Oil Quality Data (LTC Tank)

Sample Date	LTC ID	Fluid Temp. (°C)	Dielectric Breakdown D1816 (kV)	Acid Number D974 (mg KOH/g)	Interfacial Tension D971 (dynes/cm)	Color # D1500	Water (ppm)
08/07/2007	Left	52	25	0.022	34.4	<3.5	16
	Center	52	20	0.024	33.8	<3.5	12
	Right	52	23	0.022	35.0	<3.5	19
07/16/2008	Left	42	17	0.015	35.5	<2.5	44
	Center	42	22	0.015	34.5	<2.5	35
	Right	42	25	0.018	32.6	<2.5	33
08/18/2011	Left	52	23	0.015	33.8	<2.5	34
	Center	52	17	0.016	33.8	<2.5	32
	Right	52	21	0.018	34.1	5.0	42

6. Transformer Power Factor Measurement

6.1. SSD T1 – (CGE 288147)

Doble test was available only for 2007. The overall test and bushings test results for this transformer are shown in **Tables 16** below.

The following is observed:

- The winding power factor values (CH & CT) are below 0.5%. The negative P.F for CHT is most likely because of the ground shield between the LV winding and the TV winding**. Table 16-1**
- The C1 power factor and capacitance values for HV & LV bushings are all acceptable. IEEE Std C57.19.01-2000 specifies a limit of 0.5% for C1 power factor for oil impregnated paper insulated bushings. ABB recommends that the bushings be replaced whenever the power factor is double the nameplate value. **Table 16-2**
- The measured C2 capacitance for HV & LV bushings is higher than the nameplate values by more than 10%. This needs to be compared to initial benchmark test results. **Table 16-3**
- The hot collar tests for TV bushings and neutral bushing are below recommended limit (0.1 W at 10 kV). **Table 16-4**
- The Doble exciting current test are normal. **Table 16-5**

Table 16-1 – Doble Overall Test Results (2007)

Meas.	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
CH + CHT	10.016	116.87	3.600	0.31	1.00	31000.6		
CH	10.010	116.15	3.605	0.31	1.00	30808.1	G	
CHT(UST)	10.008	0.7090	-000.02	-0.28	1.00	188.02	I	
CHT		0.720	-0.005	-0.07	1.00	192.500	I	
CT + CHT	5.001	132.63	5.960	0.45	1.00	35180.3		
CT	5.003	131.92	5.973	0.45	1.00	34991.9	G	
CHT(UST)	5.004	0.7070	-000.02	-0.28	1.00	187.58	I	
CHT		0.710	-0.013	-0.18	1.00	188.400	I	

Table 16-2 – Doble Bushing Test Results (2007)

Bushing C1

ID	Serial #	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap (pF)	IR_{auto}	IR_{man}
H1	250663	.28	431	10.006	1.599	0.0400	0.25	1.00	424.25	G	
H2	250881	.27	422	10.005	1.571	0.0350	0.22	1.00	416.75	G	
H3	251439	.27	420	10.005	1.564	0.0330	0.21	1.00	414.79	G	
X1	251307	.24	359	10.005	1.348	0.0310	0.23	1.00	357.50	G	
X2	251308	.24	359	10.005	1.350	0.0300	0.22	1.00	358.05	G	
X3	251311	.24	344	10.006	1.295	0.0180	0.14	1.00	343.54	G	

Table 16-3 – Doble Bushing Test Results (2007)

Bushing C2

ID	Serial #	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap (pF)	IR_{auto}	IR_{man}
H1	250663		379	2.001	1.606	0.0750	0.47	1.00	425.88	I	
H2	250881		384	2.000	1.613	0.0910	0.56	1.00	427.82	I	
H3	251439		390	2.000	1.643	0.0890	0.54	1.00	435.76	I	
X1	251307		339	2.000	1.432	0.0950	0.66	1.00	379.89	I	
X2	251308		341	2.000	1.434	0.0980	0.68	1.00	380.48	I	
X3	251311		366	2.000	1.535	0.1250	0.81	1.00	407.20	I	

Table 16-4 – Bushing Test Results (2007)

Hot Collar Test

Serial #	ID	Test Mode	Skirt #	Test kV	mA	Watts	IR_{auto}	IR_{man}
251458	Y1	GROUND	1	10.003	0.1170	0.0360	G	
251459	Y2	GROUND	1	10.004	0.1210	0.0370	G	
251457	Y3	GROUND	1	10.003	0.1210	0.0450	G	
251456	N	GROUND	1	10.003	0.1180	0.0790	G	

Table 16-5 – Exciting Current Test Results (2007)

Doble Exciting Current Test

			H1 - H0			H2 - H0			H3 - H0				
DETC	LTC	Test kV	mA	Watts	X	mA	Watts	X	mA	Watts	X	IR_{auto}	IR_{man}
	1	10.018	16.391	160.41	L	10.096	100.62	C	15.702	154.98	L	G	
	5	9.995	17.782	172.67	L	10.996	109.95	C	17.073	167.32	L	G	
	9	10.011	19.436	188.16	L	12.059	120.59	L	18.687	182.66	L	G	
	13	10.011	21.338	205.56	L	13.347	133.12	L	20.553	199.73	L	G	
	17	10.018	23.595	226.91	L	14.837	147.66	L	22.763	220.82	L	G	

6.2. SSD T4 – (CGE 288838)

Doble test was available only for 2012. The overall test and bushings test results for this transformer are shown in **Tables 17** below.

The following is observed:

- The winding power factor value CH is below the allowed limit, but CT is above 0.5%. Please compare to previous results. The negative P.F for CHT is most likely because of the ground shield between the LV winding and the TV winding. **Table 17-1**
- The C1 power factor and capacitance values for HV & LV bushings are all acceptable. IEEE Std C57.19.01-2000 specifies a limit of 0.5% for C1 power factor for oil impregnated paper insulated bushings. ABB recommends that the bushings be replaced whenever the power factor is double the nameplate value. **Table 17-2**
- The measured C2 capacitance for HV & LV bushings is higher than the nameplate values. This needs to be compared to initial benchmark test results. **Table 17-3**
- The hot collar tests for TV bushings and neutral bushing are below recommended limit (0.1 W at 10 kV). **Table 17-4**
- The Doble exciting current test are normal. **Table 17-5**

Table 17-1 – Doble Overall Test Results (2012)

Meas.	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
CH + CHT	10.010	121.82	3.893		1.00	32313.1		
CH	10.006	121.09	3.986	0.33	1.00	32119.9	G	
CHT(UST)	10.005	0.7240	-000.07	-0.97	1.00	192.10	I	
CHT		0.730	-0.093	-1.27	1.00	193.200	I	
CT + CHT	5.003	130.06	11.414		1.00	34497.8		
CT	5.002	129.35	11.458	0.89	1.00	34309.3	G	
CHT(UST)	5.003	0.7170	-000.06	-0.84	1.00	190.30	I	
CHT		0.710	-0.044	-0.62	1.00	188.500	I	

Table 17-2 – Doble Bushing Test Results (2012)

Bushing C1

ID	Serial #	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap (pF)	IR_{auto}	IR_{man}
H1	245304	.3	416	10.008	1.554	0.0450	0.29	1.00	412.28	G	
H2	245325	.25	421	10.008	1.575	0.0360	0.23	1.00	417.67	G	
H3	245303	.28	420	10.008	1.578	0.0430	0.27	1.00	418.47	G	
X1	245284	.23	353	10.008	1.305	0.0290	0.22	1.00	346.11	G	
X2	245279	.24	370	10.009	1.398	0.0310	0.22	1.00	370.75	G	
X3	245280	.24	359	10.009	1.367	0.0440	0.32	1.00	362.63	G	

Table 17-3 – Doble Bushing Test Results (2012)

Bushing C2

ID	Serial #	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap (pF)	IR_{auto}	IR_{man}
H1	245304		402	2.000	1.640	0.0540	0.33	1.00	434.90	G	
H2	245325		388	2.000	1.578	0.0520	0.33	1.00	418.49	D	
H3	245303		402	2.001	1.626	0.0550	0.34	1.00	431.23	I	
X1	245284		377	2.000	1.716	0.0900	0.52	1.00	455.10	G	
X2	245279		356	2.000	1.439	0.0470	0.33	1.00	381.61	G	
X3	245280		383	2.000	1.526	0.0450	0.29	1.00	404.71	G	

Table 17-4 – Bushing Test Results (2012)

Hot Collar Test

Serial #	ID	Test Mode	Skirt #	Test kV	mA	Watts	IR_{auto}	IR_{man}
244961	Y1	GROUND	1	10.006	0.1250	0.0740	G	
244966	Y2	GROUND	1	10.006	0.1150	0.0230	G	
244962	Y3	GROUND	1	10.007	0.1160	0.0250	G	
244699	N	GROUND	1	10.007	0.1150	0.0630	G	

Table 17-5 – Exciting Current Test Results (2012)

Doble Exciting Current Test

			H1 - H0			H2 - H0			H3 - H0				
DETC	LTC	Test kV	mA	Watts	X	mA	Watts	X	mA	Watts	X	IR_{auto}	IR_{man}
	1	10.027	14.950	147.67	L	10.418	104.09	L	15.931	152.39	L	G	
	9	10.025	17.799	174.37	L	12.231	121.75	L	19.059	180.30	L	G	
	17	10.035	21.646	210.67	L	15.000	148.47	L	23.184	218.38	L	G	

6.3. STB T1 – (CGE 288894)

Doble test was available only for 2011. The overall test and bushings test results for this transformer are shown in **Tables 18** below.

The following is observed:

- The winding power factor value CH & CT are below the allowed limit. The negative P.F for CHT is most likely because of the ground shield between the LV winding and the TV winding. **Table 18-1**
- The C1 power factor and capacitance values for HV & LV bushings are all acceptable. IEEE Std C57.19.01-2000 specifies a limit of 0.5% for C1 power factor for oil impregnated paper insulated bushings. ABB recommends that the bushings be replaced whenever the power factor is double the nameplate value. **Table 18-2**
- The measured C2 capacitance for HV & LV bushings is higher than the nameplate values. This needs to be compared to initial benchmark test results. **Table 18-3**
- The hot collar tests for TV bushings and neutral bushing are below recommended limit (0.1 W at 10 kV). **Table 18-4**
- The Doble exciting current test are normal. **Table 18-5**

Table 18-1 – Doble Overall Test Results (2011)

Meas.	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
CH + CHT	10.008	122.45	3.944		1.00	32481.4		
CH	10.005	121.72	4.017	0.33	1.00	32287.1	G	
CHT(UST)	10.005	0.7200	-000.08	-1.11	1.00	190.92	I	
CHT		0.730	-0.073	-1.00	1.00	194.300	I	
CT + CHT	4.001	129.24	4.660		1.00	34280.1		
CT	4.001	128.52	4.634	0.36	1.00	34090.1	G	
CHT(UST)	4.002	0.7160	0.0060	0.08	1.00	189.87	I	
CHT		0.720	0.026	0.36	1.00	190.000	I	

Table 18-2 – Doble Bushing Test Results (2011)

Bushing C1

ID	Serial	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
H3	247915	.24	417	10.008	1.544	0.0350	0.23	1.00	409.52	G	
X1	246782	.27	353	10.008	1.317	0.0280	0.21	1.00	349.37	G	
X2	246784	.27	353	10.008	1.321	0.0280	0.21	1.00	350.33	G	
X3	246618	.27	352	10.008	1.324	0.0280	0.21	1.00	351.12	G	
H2	248124	.26	415	10.008	1.536	0.0350	0.23	1.00	407.34	G	
H1	246741	.28	409	10.008	1.513	0.0420	0.28	1.00	401.26	G	

Table 18-3 – Doble Bushing Test Results (2011)

Bushing C2

ID	Serial #	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
H1	246741		391	2.001	1.649	0.0640	0.39	1.00	437.49	G	
H2	248124		392	2.000	1.637	0.0640	0.39	1.00	434.34	G	
H3	247915		387	2.001	1.651	0.0690	0.42	1.00	437.87	G	
X1	246782		359	2.000	1.440	0.0390	0.27	1.00	382.06	G	
X2	246784		355	2.001	1.413	0.0390	0.28	1.00	374.81	G	
X3	246618		354	2.000	1.403	0.0380	0.27	1.00	372.23	G	

Table 18-4 – Bushing Test Results (2011)

Hot Collar Test

Serial #	ID	Test Mode	Skirt #	Test kV	mA	Watts	IR_{auto}	IR_{man}
248098	Y1	GROUND	1	10.010	0.1020	0.0220	G	
248096	Y2	GROUND	1	10.009	0.1000	0.0270	G	
248097	Y3	GROUND	1	10.009	0.1030	0.0220	G	
248095	N	GROUND	1	10.006	0.1020	0.0240	G	

Table 18-5 – Exciting Current Test Results (2011)

Doble Exciting Current Test

			H1 - H0			H2 - H0			H3 - H0				
DETC	LTC	Test kV	mA	Watts	X	mA	Watts	X	mA	Watts	X	IR_{auto}	IR_{man}
	1	10.034	15.894	158.43	L	10.304	102.76	C	16.452	161.67	L	G	
	9	10.037	18.827	186.57	L	12.392	123.86	L	19.367	188.79	L	G	
	17	10.041	22.755	224.48	L	14.900	148.64	L	23.163	224.70	L	G	

6.4. STB T2 – (CGE 288839)

Doble test was available only for 2008. The overall test and bushings test results for this transformer are shown in **Tables 19** below.

The following is observed:

- The winding power factor value CH & CT are below the allowed limit. The negative P.F for CHT is most likely because of the ground shield between the LV winding and the TV winding. **Table 19-1**
- The C1 power factor and capacitance values for HV & LV bushings are all acceptable. IEEE Std C57.19.01-2000 specifies a limit of 0.5% for C1 power factor for oil impregnated paper insulated bushings. ABB recommends that the bushings be replaced whenever the power factor is double the nameplate value. **Table 19-2**
- The measured C2 capacitance for HV bushings is higher than the nameplate values by more than 10%. This needs to be compared to initial benchmark test results and investigated. The measured C2 capacitance for LV bushings is higher than the nameplate values but within 10%. **Table 19-3**
- The hot collar tests for TV bushings and neutral bushing are below recommended limit (0.1 W at 10 kV). **Table 19-4**
- The Doble exciting current test are normal. **Table 19-5**

Table 19-1 – Doble Overall Test Results (2008)

Meas.	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
CH + CHT	10.011	122.14	3.635	0.26	0.88	32399.5		
CH	10.004	121.38	3.650	0.26	0.88	32197.8	G	
CHT(UST)	10.003	0.7200	-000.01	-0.12	0.88	191.08	I	
CHT		0.760	-0.015	-0.18	0.88	201.700	I	
CT + CHT	4.001	132.53	4.722	0.32	0.88	35153.3		
CT	4.001	131.80	4.739	0.32	0.88	34961.5	G	
CHT(UST)	4.001	0.7180	-000.01	-0.12	0.88	190.36	I	
CHT		0.730	-0.017	-0.20	0.88	191.800	I	

Table 19-2 – Doble Bushing Test Results (2008)

Bushing C1

ID	Serial	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
H1	246350	.25	411	10.005	1.525	0.0330	0.21	0.96	404.45	G	
H2	246448	.28	433	10.005	1.611	0.0400	0.24	0.96	427.33	G	
H3	246447	.28	434	10.005	1.620	0.0420	0.25	0.96	429.61	G	
X1	245184	.26	369	10.005	1.386	0.0330	0.23	0.96	367.76	G	
X2	243251	.24	376	10.005	1.403	0.0330	0.23	0.96	372.10	G	
X3	246347	.25	352	10.004	1.322	0.0280	0.20	0.96	350.72	G	

Table 19-3 – Doble Bushing Test Results (2008)

Bushing C2

ID	Serial	NP %PF	NP Cap	Test kV	mA	Watts	%PF corr	Corr Fctr	Cap(pF)	IR_{auto}	IR_{man}
H1	246350		400	2.000	1.701	0.0850	0.50	1.00	451.28	I	
H2	246448		379	2.000	1.608	0.0730	0.45	1.00	426.63	I	
H3	246447		381	2.000	1.602	0.0760	0.47	1.00	424.85	I	
X1	245184		346	2.000	1.404	0.0500	0.36	1.00	372.34	D	
X2	243251		345	2.000	1.422	0.0540	0.38	1.00	377.08	D	
X3	246347		374	2.000	1.501	0.0500	0.33	1.00	398.04	D	

Table 19-4 – Bushing Test Results (2008)

Hot Collar Test

Term ID	ID	Test Mode	Skirt #	Test kV	mA	Watts	IR_{auto}	IR_{man}
244967	Y1	GROUND	1	10.003	0.1160	0.0240	G	
244953	Y2	GROUND	1	10.003	0.1160	0.0240	G	
244959	Y3	GROUND	1	10.003	0.1180	0.0260	G	
244964	N	GROUND	1	10.003	0.1140	0.0260	G	

Table 19-5 – Exciting Current Test Results (2008)

Doble Exciting Current Test

			H1 - H0			H2 - H0			H3 - H0				
DETC	LTC	Test kV	mA	Watts	X	mA	Watts	X	mA	Watts	X	IR_{auto}	IR_{man}
	1	10.017	15.471	153.74	L	9.875	98.173	C	15.410	151.83	L	G	
	9	10.010	18.174	179.19	L	11.737	117.36	C	18.256	178.57	L	G	
	17	10.016	22.002	215.40	L	14.332	142.83	L	22.102	214.90	L	G	

7. Maintenance History

7.1. SSD T1 – (CGE 289147)

Electrical testing was performed in this transformer on 2007. The tests included winding resistance, insulation resistance and polarization index test. The test results are shown in Error! Reference source not found.**20** below.

- The winding resistance test for HV winding is consistent between phases, however the measured resistance is much lower than the other results for the sister units.
- The winding resistance tests for LV & TV windings are consistent between phases, and also very close to the other sister units.
- The ratio test and core Megger test was not performed.
- The insulation resistance test was performed and results look normal in G-ohms, however the polarization index is lower than the ABB suggested value of 2.0 for HV/LV to ground.

Table 20-1 – Insulation Resistance and Polarization Index Test Results

Test Date: 2007/09/05 Test Completed By: GH J.D.E. W/O #:

y - HL Grounded	1 min - 1.84	10 min 5.95	3.18 %
[redacted]	1 min	10 min	
~~LTG~~	1 Min. Mega Ω	10 Min. Mega Ω	Index. %
HL-G y Grounded Tert. - Grounded	1 Min. 2.28 Mega Ω	10 Min. 3.46 Mega Ω	Index. 1.52 %

CORE GROUND: (500 Volt test)	
Externally Connected Yes ____ No ____	
RESISTOR: (Ohms)	CORE GROUND: (Mega Ohms)

Table 20-2 – Winding Resistance Test Results

TAP POSITION	WINDING TESTED	CURRENT RANGE	RESISTANCE RANGE	% CURRENT	RESISTANCE	RESISTANCE DELTA x 1.5
Found 6	6 Ø A	500 mA	2	106.6%	.405	
Found 6	6 Ø B	500mA	2	106.5%	.442	
Found 6	6 Ø C	500mA	2	106.6%	.412	
Max. Raise 17	Ø A	500mA	2	106.4	.485	
Max. Raise 17	Ø B	500 mA	2	106.5%	.461	
Max. Raise 17	Ø C	500mA	2	106.5%	.464	
Max. Lower 1	Ø A	500mA	2	106.4%	.452	
Max. Lower 1	Ø B	500mA	2	106.4%	.458	
Max. Lower 1	Ø C	500 mA	2	106.4%	.458	
Left 6	Ø A	500mA	2	106.5%	.407	
Left 6	Ø B	500mA	2	106.4%	.437	
Left 6	Ø C	500mA	2	106.5%	.401	
Non Tap Winding	Ø A	500mA	2	104%	.570	
Non Tap Winding	Ø B	500mA	2	104.1%	.577	
Non Tap Winding	Ø C	500mA	2	104.1%	.570	
Tertiary Winding	Ø A B and	500mA	200m	107.2	5.7	
Tertiary Winding	Ø B C and	500 mA	200m	107.2	5.5	
Tertiary Winding	Ø A C and	500 mA	200m	107.2	5.3	

Note: Observe Indicator Light & Record OHMS or MILLI-OHMS

7.2. SSD T4 – (CGE 288838)

Electrical testing was performed in 2012 including winding resistance, insulation resistance and polarization index test. The test results are shown in Error! Reference source not found. below.

- The winding resistance test for HV & LV & TV windings is consistent between phases.
- The ratio test was not performed.
- The core Megger test was performed and result looks normal.
- The insulation resistance test was performed and results look normal in G-ohms however the polarization index is lower than the ABB suggested value of 2.0.

Table 21-1 – Insulation Resistance and Polarization Index Test Results

CORE GROUND: (500 Volt test)

Externally Connected Yes ___ No ✓

RESISTOR: (Ohms)		1 min	10 min	CORE GROUND: (Mega Ohms) 720 mega Ω
Auto XFmer	H-Grn.	3.16	4.44	1.14 PI
	L-Grn.	3.60	5.00	1.39 PI
	H-Grn	3.82	5.25	1.37 PI

Sheet 2 of 3

Table 21-2 – Winding Resistance Test Results

TAP POSITION	WINDING TESTED	CURRENT RANGE	RESISTANCE RANGE	% CURRENT	RESISTANCE	RESISTANCE DELTA x 1.5
Found 4	H_1-H_0	500mA	2Ω	105.3%	x1.023	
Found 4	H_2-H_0	500mA	2Ω	105.3%	1.018Ω	
Found 4	H_3-H_0	500mA	2Ω	105.3%	1.018	
Max. Raise 17	H_1-H_0	500mA	2Ω	105.3%	1.083	
Max. Raise 17	H_2-H_0	500mA	2Ω	105.3%	1.054	
Max. Raise 17	H_3-H_0	500mA	2Ω	105.4%	1.052	
Max. Lower 1	H_1-H_0	500mA	2Ω	105.4%	1.053	
Max. Lower 1	H_2-H_0	500mA	2Ω	105.4%	1.049	
Max. Lower 1 x	H_3-H_0	500mA	2Ω	105.4%	1.046	
Left 4	H_1-H_0	500mA	2Ω	105.4%	1.023	
Left 4	H_2-H_0	500mA	2Ω	105.4%	1.019	
Left 4	H_3-H_0	500mA	2Ω	105.4%	1.018	
Non Tap Winding	X_0-X_1	500mA	2Ω	106.3	.592	
Non Tap Winding	X_0-X_2	500mA	2Ω	106.3	.590Ω	
Non Tap Winding	X_0-X_3	500mA	2Ω	106.3	.589Ω	
Tertiary Winding	Y_1-Y_2	5A	200m	99.9%	5.4mΩ	
Tertiary Winding	Y_1-Y_3	5A	200m	99.9%	5.6mΩ	
Tertiary Winding	Y_2-Y_3	5A	200m	100.0%	5.6mΩ	

7.3. STB T1 – (CGE 288894)

Electrical testing was performed in 2011 including winding resistance, insulation resistance and polarization index test. The test results are shown in Error! Reference source not found. below.

- The winding resistance test for HV & LV windings is consistent between phases.
- The deviation of the TV winding resistance between phases is 20%. It is recommended to repeat the TV windings resistance test and compare to the sister units.
- The ratio test was not performed.
- The core Megger test was performed and result looks normal.
- The insulation resistance test was performed and results look normal in G-ohms however the polarization index is lower than the ABB suggested value of 2.0 for HV to ground.

The tap changer inspection was performed on September 23rd, 2011 by GE, the following are found: Both two defects were corrected.

- One end of a resistor was misplaced and came into contact with another resistor.
- A loss bolt was found on resistor.

Other findings:

- One bearing in one of second stage fan motors was found to be broken.

Table 22-1 – Insulation Resistance and Polarization Index Test Results

DIELECTRIC ABSORBTION (5 KV): 10 MIN. ÷ 1 MIN. = INDEX								
HL-TG	1 Min.	4.08	Mega Ω	10 Min.	5.85	Index.	1.44	%
T-HLG	1 Min.	3.18	Mega Ω	10 Min.	13.8	Index.	4.34	%
HLT-G	1 Min.	2.04	Mega Ω	10 Min.	4.5	Index.	2.22	%

CORE GROUND: (500 Volt test)	
Externally Connected Yes ✓ No ____	
RESISTOR: (Ohms) N/A	CORE GROUND: (Mega Ohms) > 999

Table 22-2 – Winding Resistance Test Results

TAP POSITION	WINDING TESTED	CURRENT RANGE	RESISTANCE RANGE	% CURRENT	RESISTANCE	RESISTANCE DELTA x 1.5
Found 1	H_1 - HO	500 MA	2 Ω	105.1	1.035	
Found 1	H_2 - HO	500 MA	2 Ω	104.8	1.036	
Found 1	H_3 - HO	500 ma	2 Ω	105.0	1.031	
Max. Raise 9	H_1 - HO	500 ma	2 Ω	105.3	0.948	
Max. Raise 9	H_2 - HO	500 ma	2 Ω	105.3	0.952	
Max. Raise 9	H_3 - HO	500 ma	2 Ω	105.3	0.952	
Max. Lower 1	H_1 - HO	500 ma	2 Ω	105.2	1.035	
Max. Lower 1	H_2 - HO	500 ma	2 Ω	105.1	1.034	
Max. Lower 1	H_3 - HO	500 ma	2 Ω	105.2	1.035	
Left 1						
Left 1						
Left 1						
Non Tap Winding	X_1 - XO	500 ma	2 Ω	105.9	0.582	
Non Tap Winding	X_2 - XO	500 ma	2 Ω	105.9	0.582	
Non Tap Winding	X_3 - XO	500 ma	2 Ω	105.9	0.582	
Tertiary Winding	Y_1 - Y_2	500 ma	2 Ω	104.6	0.005	0.0075
Tertiary Winding	Y_2 - Y_3	500 ma	2 Ω	104.3	0.006	0.009
Tertiary Winding	Y_1 - Y_3	500 ma	2 Ω	104.4	0.006	0.009

7.4. STB T2 – (CGE 288839)

The maintenance test history is not available for this unit.

8. Inspection

The unit was inspected on January 21, 2014. Entry to the unit was made from the manhole located on the top cover between H2 and H3 bushings. Most of the other man holes and hand holes in the unit were opened also for inspection. It was possible to see and inspect all the active part components.

8.1. Findings and Observations

- Because of risk of broken bushing porcelain falling; H3 and L2 bushing were removed before the inspection. L1 bushing was removed during the inspection.
- Transformer cover was ripped open at the LV side. All the bolts on the LV side and some on the short sides were broken. **See Photos 1&2&3&4**
- All transformer bushings are damaged. The most damaged are the H1, L2 and TV bushings. **See Photos 5&6&7&8**
- The tap changer diverter cylinders of Phases 1 and 3 were separated from their aluminum flanges at the cover. This caused the tap changer assemblies, diverter and selector, to fall. The assemblies were found sitting at the bottom of the tap changer's pocket. No signs of flashover were seen at the selector switches or tap cables. **See Photos 9&10&11&12**
- The fire left indications of burning on the tank wall to a level about a foot above the windings. **See Photo 13**
- No signs of flash over were seen in the cleats and leads including tap leads.
- All windings looked good with no signs of failure within the windings. **See Photos 14&15**
- The L1 & L3 bushing's porcelain inside the transformer were shattered. Also marks of flashover were seen on core clamp just opposite to Phase 1 LV bushing. **See Photos 16&17&18**
- Each of the LV bushings in this transformer has two leads connected to them. One lead is connected to the winding and the other to the tap changer. **See Sketch 1**
- For Phases 1 and 2 the leads connecting the LV bushings to the windings are disconnected. It seems the two leads were mechanically pulled and cur at the crimp during the fault when the cover opened up. The insulation of the leads looks intact with no signs of failure. **See Photos 19&20&21&22**
- Spitting and melting cooper were seen on the LV windings conductor copper strands of phase one. **See Photo 23**

Photo 1 – Cover Open & Broken Bolts

Photo 2 – Cover Open & Broken Bolts

Photo 3 – Cover Open & Broken Bolts

Photo 4 – Cover Open & Broken Bolts

Photo 5 – LV2 Bushing

Photo 6 – LV2 Bushing

Photo 7 – **LV2 Bushing Porcelain**

Photo 8 – **HV1 Bushing Porcelain**

Photo 9 – LTC Compartment (Phases 2 & 3)

Photo 10 – LTC Compartment (Phases 2 & 3)

Photo 11 – LTC Compartment (Phase 3)

Photo 12 – LTC Compartment (Phases 2 & 1)

Photo 13 – Fire Line on Tank Wall & Core Clamp

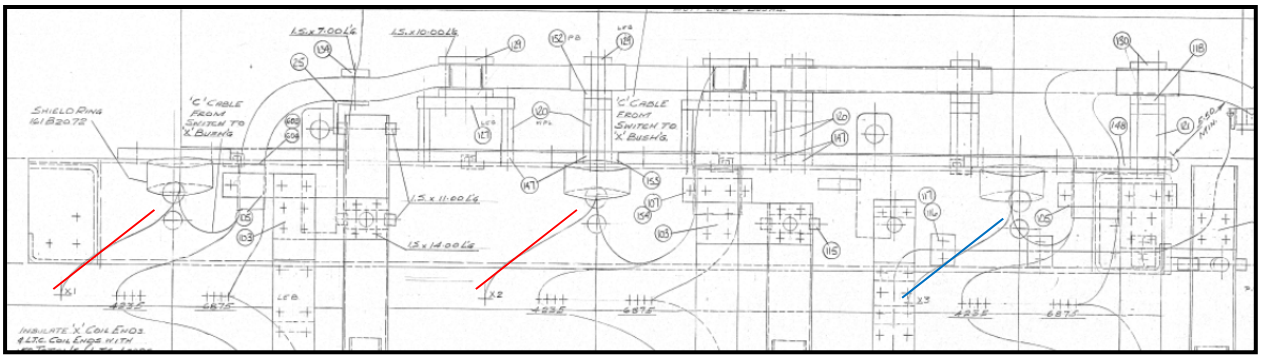
Photo 14 – Windings

Photo 15 – Windings

Photo 16 – LV1 Bushing & Flashover marks

Photo 17 – LV1 Bushing

Photo 18 – LV3 Bushing



Sketch 1: LV bushings Connected to the Windings & Tap Changers

Photo 19 – LV2 Winding Lead Broken

Photo 20 – LV2 Bushing Lead Broken at the Crimp

Photo 21 – LV1 Winding Lead Broken

Photo 22 – LV1 Bushing Lead Broken at the Crimp

Photo 23 – LV1 Winding Conductor Strand Copper Spitting

9. Conclusion

Comprehensive short circuit and dielectric study of the design is performed for transformer sn 289147 built in 1978 and failed in 2013. Review of maintenance data and DGA history was completed. Also failure investigation and inspection was performed.

The short circuit design study showed that HV and LV windings are able to withstand short circuit forces while TV winding end rings are not strong enough to withstand the short circuit forces.

The Dielectric study showed that all windings and cable clearances are within the acceptable design levels for the voltage stresses in this transformer.

The DGA, oil quality, transformer power factor and maintenance history of the four transformers were reviewed.

For SSD T1 – CGE 288147

The DGA results showed that:

- The concentration of Acetylene (C2H2) has been above IEEE C57.104-2008 guide condition level 1 (2 ppm) since 1991, The level went up and down since then but was almost stable around the 10ppm. This could be oil leaking from LTC diverter compartment.
- The oil samples from this transformer have consistently shown high oxygen concentrations.

The oil physical results showed that: (Main tank)

- The interfacial tension values are around 28.0 dynes/cm2 which are below the 32 dynes/cm2 limit recommended by IEEE C57.106-2002 for ≥ 230kV transformers.

The oil physical results showed that: (LTC tank)

- The measured breakdown voltage (around 22.0 kV/mm for LTC-A,B,C) is below the minimum requirement (28 kV/mm for 1 mm gap and 45 kV/mm for 2 mm gap) as outlined by IEEE C57.106-2002.
- The oil samples taken from the LTC-A tank does show moisture content of more than 25 ppm.

The power factor measurements showed that:

- The winding power factor values (CH & CT) are below 0.5%.
- The C1 power factor and capacitance values for HV & LV bushings are all acceptable.
- The measured C2 capacitance for HV & LV bushings is higher than the nameplate values by more than 10%.
- The hot collar tests for TV bushings and neutral bushing are below recommended limit.
- The Doble exciting current test are normal.

The maintenance history showed that:

- The winding resistance test for HV winding is consistent between phases, however the measured resistance is much lower than the other two sister units.
- The winding resistance tests for LV & TV windings are consistent between phases, and also very close to the other two sister units.

- The insulation resistance test was performed and results look normal in G-ohms, however the polarization index is lower than the ABB suggested value of 2.0 for HV/LV to ground.

For SSD T4 – CGE 288838

The DGA results showed that:

- The concentration of Acetylene (C2H2) has been above IEEE C57.104-2008 guide condition level 1 (2 ppm) since 1991, The level went up and down since then but was almost stable around the 5ppm. This could be oil leaking from LTC diverter compartment.
- The oil samples from this transformer have consistently shown high oxygen concentrations.

The oil physical results showed that: (Main tank)

- The latest measured breakdown voltage (52.0kV/mm) is above the minimum requirement (30kV/mm) as outlined by Doble Engineering for 230kV transformers.
- The interfacial tension values are around 33.6 dynes/cm2 which is slightly above the 32 dynes/cm2 limit recommended by IEEE C57.106-2002 for 230kV transformers. Lower values may indicate oil soluble contaminants and oxidation products in oil.
- The measured Acid Numbers for the oil samples are all below the recommended limits.
- The measured power factor values at 25/100°C are all below the suggested limits.
- The moisture in oil is within the acceptable limits.

The oil physical results showed that: (LTC tank)

- The measured breakdown voltage (between 22.0 kV/mm and 29.0 kV/mm for LTC-A,B,C) is below the minimum requirement (28 kV/mm for 1 mm gap and 45 kV/mm for 2 mm gap).
- IEEE C57.106-2002 Table 12 recommends that the maximum limit of water content in oil for LTC is not to exceed 25 ppm. The oil samples taken from the LTC tank show moisture content of less than 25 ppm.

The power factor measurements showed that:

- The winding power factor value CH is below the allowed limit, but CT is above 0.5%.
- The C1 power factor and capacitance values for HV & LV bushings are all acceptable.
- The measured C2 capacitance for HV & LV bushings is higher than the nameplate values. This needs to be compared to initial benchmark test results.
- The hot collar tests for TV bushings and neutral bushing are below recommended limit.
- The Doble exciting current test are normal.

The maintenance history showed that:

- The winding resistance test for HV & LV & TV windings is consistent between phases.
- The ratio test was not performed.
- The core Megger test was performed and result looks normal.
- The insulation resistance test was performed and results look normal in G-ohms however the polarization index is lower than the ABB suggested value of 2.0.

For STB T1 – CGE 288894

The DGA results showed that:

- The concentration of Acetylene (C2H2) has been below IEEE C57.104-2008 guide condition level 1 (2 ppm) since 2009. However the DGA sample for the year 1979 shows high level of C2H2. This could be a bad oil sample.
- The oil samples from this transformer have consistently shown high oxygen concentrations.

The oil physical results showed that: (Main tank)

- The latest measured breakdown voltage (62.0kV/mm) is above the minimum requirement (50kV/mm) as outlined in IEEE C57.106-2002 for 230kV transformers with service aged insulating oil based on D1816-2mm method.
- The interfacial tension values are around 30.4 dynes/cm2 which is below the suggested limits (32 dynes/cm2) recommended by IEEE C57.106-2002 for 230kV transformers. Lower values may indicate oil soluble contaminants and oxidation products in oil.
- The measured Acid Numbers for the oil samples are all below the recommended limits.
- The measured power factor values at 25/100°C are all below the suggested limits.
- The moisture in oil is within the acceptable limits.

The oil physical results showed that: (LTC tank)

- The latest measured breakdown voltage is 30, 31 and 33 kV/mm for LTC-A,B,C. the suggested limits is 28 kV/mm for 1 mm gap and 45 kV/mm for 2 mm gap as outlined by IEEE C57.106-2002.
- IEEE C57.106-2002 Table 12 recommends that the maximum limit of water content in oil for LTC is not to exceed 25 ppm. The latest oil samples taken from the LTC tank show moisture content of less than 25 ppm.

The power factor measurements showed that:

- The winding power factor value CH & CT are below the allowed limit.
- The C1 power factor and capacitance values for HV & LV bushings are all acceptable.
- The measured C2 capacitance for HV & LV bushings is higher than the nameplate values. This needs to be compared to initial benchmark test results.
- The hot collar tests for TV bushings and neutral bushing are below recommended limit
- The Doble exciting current test are normal.

The maintenance history showed that:

- The winding resistance test for HV & LV windings is consistent between phases.
- The deviation of the TV winding resistance between phases is 20%.
- The ratio test was not performed.
- The core Megger test was performed and result looks normal.
- The insulation resistance test was performed and results look normal in G-ohms however the polarization index is lower than the ABB suggested value of 2.0 for HV to ground.

For STB T2 – CGE 288839

The DGA results showed that:

- The transformer has consistently shown very high concentrations (>20 ppm) of Acetylene (C_2H_2) since 1986, which is far above the IEEE C57.104-2008 guide condition level 1 (2 ppm). The high concentration of C_2H_2 indicates that possible high energy arcing occurred somewhere inside the transformer. The other reason could be oil leaking from LTC diverter compartment. The Acetylene levels are about 10ppm foe few years now. This needs to be monitored closely. Any sudden increase of Acetylene needs to be investigated.
- The oil samples from this transformer have consistently shown high oxygen concentrations

The oil physical results showed that: (Main tank)

- The latest measured breakdown voltage (68.0kV/mm) is above the minimum requirement (50kV/mm) as outlined in IEEE C57.106-2002 for 230kV transformers with service aged insulating oil based on D1816-2mm method.
- The interfacial tension values are around 28.7 dynes/cm2 which is below the suggested limits (32 dynes/cm2) recommended by IEEE C57.106-2002 for 230kV transformers.
- The measured Acid Numbers for the oil samples are all below the recommended.
- The measured power factor values at 25/100°C are all below the suggested limits.
- The moisture in oil is within the acceptable limit.

The oil physical results showed that: (LTC tank)

- The latest measured breakdown voltage is 17, 21 and 23 kV/mm for LTC-A,B,C, which is below the suggested minimum limits (28 kV/mm for 1 mm gap and 45 kV/mm for 2 mm gap).
- IEEE C57.106-2002 Table 12 recommends that the maximum limit of water content in oil for LTC is not to exceed 25 ppm. The latest oil samples taken from the LTC tank show moisture content of more than 25 ppm for all three LTCs.

The power factor measurements showed that:

- The winding power factor value CH & CT are below the allowed limit.
- The C1 power factor and capacitance values for HV & LV bushings are all acceptable.
- The measured C2 capacitance for HV bushings is higher than the nameplate values by more than 10%. This needs to be compared to initial benchmark test results and investigated. The measured C2 capacitance for LV bushings is higher than the nameplate values but within 10%.
- The hot collar tests for TV bushings and neutral bushing are below recommended limit.
- The Doble exciting current test are normal.

The failure inspection showed the following:

- All transformer bushings are damaged.
- The tap changer diverter cylinders of Phases 1 and 3 were separated from their aluminum flanges at the cover.
- No signs of flash over were seen in the cleats and leads including tap leads.
- All windings looked good with no signs of failure within the windings. It is not possible to see the internal windings.
- The L1 & L3 bushing's porcelain inside the transformer were shattered. Also marks of flashover were seen on core clamp just opposite to Phase 1 LV bushing.
- For Phases 1 and 2 the leads connecting the LV bushings to the windings are disconnected. It seems the two leads were mechanically pulled and cur at the crimp during the fault when the cover opened up. The insulation of the leads looks intact with no signs of failure.
- Spitting and melting cooper were seen on the LV windings conductor copper strands of phase one.

We still need to review the fault current, voltage and sequence of events but it seems LV1 or LV2 bushing failed first and caused the fire.

10. Recommendations

The following is recommended for all three transformers:

- Comprehensive DGA, oil quality tests and transformer testing is to be planned.
- Consider replacing transformer bushings.
- Add a conservator diaphragm.
- Consider adding oxidation inhibitor to oil.
- Monitor Acetylene (C2H2) closely especially for (STB T2).
- Consider adding online monitor.
- Measure the oil break down voltage per ASTM D1816 (1mm or 2mm) method.
- Repeat the TV windings resistance test (on unit STB T1) and compare to the sister units.
- Repeat the HV resistance test (on unit SSD T1) and compare to the sister unit.
- Perform core Megger test on unit SSD T1.
- Any bushings with higher C2 capacitance need to be compared to initial benchmark test results.
- It is recommended to re-condition of oil in LTC tank or replace with new oil.
- Perform on site drying out on unit SSD T4.

Power Products Service Group

Nalcor order: 20649-000-OB

ABB job number: 557775-10

Breaker ID and Location: B1L03 at Sunnyside Terminal Station

Investigation Location: Nalcor Regional Facility – Bishop's Falls

Breaker type: DCVF245 mc6

Serial number: B142698

Mechanism type: Air Blast

Purpose for visit: Investigate B1L03 Breaker Failed to Trip

On site dates: 2014-02-03 to 2014-02-06

Report presented to: Mr. Hughie Ireland

SCOTT MORRIS
..... Date: February 10, 2014

Scott Morris

ABB **Power Products Service Group**

B1L03 Breaker Data

Type:	DCVF 245mc6
Serial Number	B142698

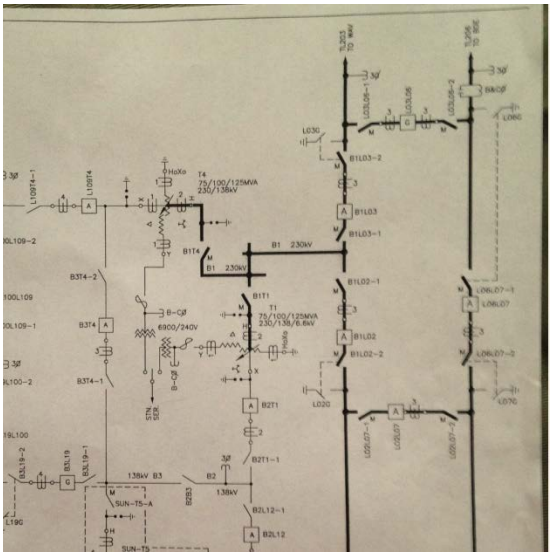
Maintenance History

Below is a summary of maintenance history relevant to the investigation extracted from the maintenance history provided.

Work Order	Date Comp.	Work Done	Investigation Comments
838346	4/8/2011	Function tests done after questionable operations during a fault.	All checked okay.
576789	3/6/2007	Breaker would not operate. Operated locally and ECC. Stayed in service	No cause found.
389723	6/1/2007	Re-lubrication of all interrupters and sub-assemblies	Last time breaker overhauled prior to event
263859	1/29/2003	Breaker overhaul of all interrupters and sub-assemblies	2nd last time breaker overhauled prior to event

Background

On Saturday January, 4 2014 the T1 transformer at Sunnyside Terminal Station faulted. The protections operated to clear the fault. Five breakers were sent trip signals. Three of these were 138 KV ABB DCF 170mc4 air blast breakers. The nomenclatures for these breakers are L109T4, B3T4 and B2T1. The other two breakers were 245 KV ABB DCVF 245mc6 air blast breakers. The nomenclatures for these breakers are B1L02 and B1L03. All indications are that four of the five breakers tripped okay except for the B1L03. With the B1L03 breaker failing to interrupt the next level of protections operated to clear the line. A portion of the station operating diagram showing the affected breakers is below.



The fault on the T1 transformer resulted in a fire which damaged the transformer.

Some field testing was done on the B1L03 breaker after the event. Some odd findings were noted. The breaker would not operate pneumatically. The breaker timing results were not normal or as expected. There was an un-commanded operation of the breaker. These will be discussed further in the investigation.

To ensure the reliability of the B1L03 breaker major work was done. This included the following:

- Removing all the nine interrupters and replacing them with overhauled spares
- Replacing all three servos with three overhauled spares
- Replacing "B" and "C" pole control boxes with rebuilt spares. "A" phase was to be replaced but issues with the overhauled pole box for the "A" phase prevented this. The original "A" phase pole control box was field overhauled at site.
- The main valves on the breaker were field overhauled at site.
- The air receivers were inspected and found to be okay
- The breaker was timed and function tested before being returned to service
- The removed sub-assemblies and interrupters were taken to the Bishop's Falls Regional Facility

The weather data from Environment Canada for Gander Airport was downloaded to get the daily high and low recorded temperatures for six days prior and the day of the event. These are in the table below.

Date	Maximum High Temperature	Minimum Low Temperature
December 29, 2013	-6.6	-15.7
December 30, 2013	-4.1	-15.6
December 31, 2013	-6.6	-16.5
January 1, 2014	-14.4	-19.2
January 2, 2014	-17.0	-22.5
January 3, 2014	-13.4	-22.2
January 4, 2014	-13.6	-18.9

Further detailed investigation on the B1L03 breaker was required to try and determine a cause for not tripping. ABB was contacted to provide support for the investigation. The investigation would take place at the Bishop's Falls Regional Facility.

Chronological Summary of Investigation

Monday February 3, 2014

- 08:30 we had a meeting to discuss the breaker failure to trip, sequence of events, general discussion and next steps.
- We felt we had two options. Nalcor has the capability to function test the servos; pole control boxes and interrupters on their air receiver in the shop. We could try and replicate the failure mode by testing in the shop. The other alternative was to take apart the interrupters and sub-assemblies to look for the problem. It was decided to take the interrupters and sub-assemblies apart for inspection. I felt it may be very difficult to replicate the failure in the shop with so many variables changed from the event.

- Three sets of double interrupter contacts were taken apart and inspected. A micro-ohm reading @ 100 amps was taken on each interrupter prior to dis-assembling. The chart below shows the micro-ohm readings. Some pictures are also inserted below.

Phase	Contacts	Micro-Ohm's
"B"	5 & 6	60.0
"B"	1 & 2	90.8
"C'	3 & 4	63.6

Observations:

1. Interrupter contacts showing no abnormal wear
2. Moving interrupter contacts were moving freely.
3. Micro-ohm readings acceptable.
4. The O-rings and seals showing no abnormal wear.
5. It was noted that some consumable parts and lubricants were not OEM.
6. The main and stationary contacts were lubricated with a thin film of graphite.
7. Renolit HLT2 lubricant was used on dissimilar metals.
8. Dow Corning 55 lubricant was used on static O-rings.

Stationary Contact

Moving Contact Gasket

Moving Contact Transfer Contact

Tuesday February 4, 2014

- Since nothing wrong was found on the three interrupters we decided to inspect the three servos from the breaker. Some pictures are below.

Observations

1. None of the three servos indicated any problems.
2. The parts were showing normal wear and nothing was binding.
3. Non OEM parts were found on the servos.

Servo Gasket

Servo Gasket

- The pole control boxes were the next focus for the investigation. "B" and "C" phase pole control boxes from the B1L03 were at the Bishop's Falls facility. As previously mentioned "A" phase pole control box on the B1L03 breaker was field rebuilt at Sunnyside and is installed on the breaker. "B" and "C" phase pole control boxes were dis-assembled. Prior to starting dis-assembly the trip, close and heater resistor values were recorded.

"B" phase pole control box was dis-assembled first. The table below shows the measured resistance values.

Close coil – terminals 1-2	74.1 ohms
Trip coil – terminals 3-4	11.8 ohms
Heater resistor – terminals 5-6	262 ohms

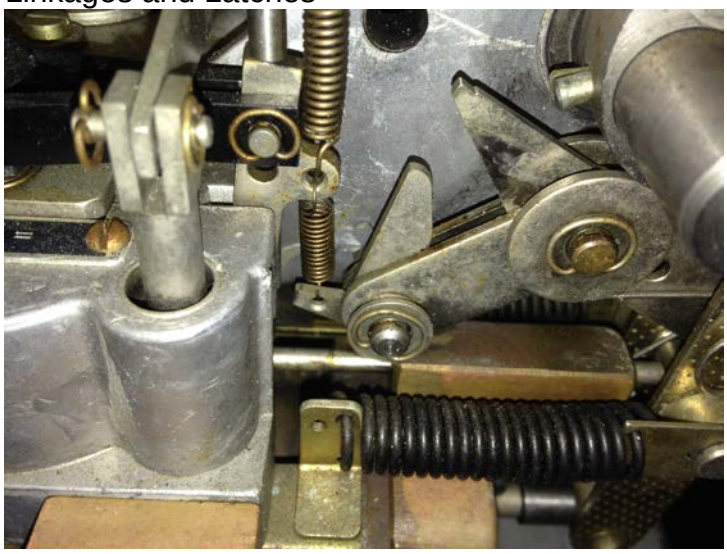
Observations

1. Lubrication with Dow Corning 55
2. The trip black piston showed signs of corrosion an indication of moisture being present at one time.
3. The housing the black trip piston fit into also showed signs of moisture being present at one time.
4. The linkages and latches for the mechanism were dirty. They did operate freely in the shop environment. In my opinion I felt the latches looked worn and I did not check the mechanism to see if it was properly adjusted. I was not aware of any field checks for the setup of the mechanism being done.
5. Some minor corrosion on parts of the control assembly possibly caused from the salt environment or sulphur from the nearby oil refinery.

Black Trip Piston

Housing for Black Trip Piston

Linkages and Latches



Linkages and Latches

"C" phase pole control box was dis-assembled next. The table below shows the measured resistance values.

Close coil – terminals 1-2	75.2 ohms
Trip coil – terminals 3-4	11.86 ohms
Heater resistor – terminals 5-6 was not measured	Heater was removed for use on other pole control box

Observations

1. This pole control box was in the same condition as the "B" pole control box with one noticeable difference. There was a wet stain spot on the control box that could not be explained or identified. It had no noticeable smell or taste. It seemed to be some type of solvent or chemical and I found it strange it was still wet. I am not sure if this is of any significance. A picture is below. The right side, a bit darker grey, is wet.

Wet Pole Control Box

- After lunch we had a meeting to discuss the findings to date and next steps. A high level summary of the notes are below. In parallel with this, the crew continued to dismantle the remaining six interrupters and documented the findings.

Meeting Notes

1. The as found timing results on the original B1L03 breaker were very interesting. These readings were done after the event with the TR3100 Doble Timer. The readings were not recorded and are based on memory from the crew.

Close Times "A" phase – 137 ms, "B" phase – 162 ms, "C" phase – 187 ms
These close times are too long and too much delta between phases. A test from 1980 was 116.2 ms

Trip Times "A", "B" & "C" phases all about 50 ms

The trips times are a bit too long compared a test from 1980 of 41.5 ms but with good deltas.

The disagreement times were inconsistent.
"A" phase was normal and cleared at 1599 ms (probably longer since the timer cuts off at 1600 ms)
"B" phase some of the contacts went at 800 ms, 300 ms and the other contact times could not be determined because of lead issues.
The comments for the "C" phase was "not good"

2. It was discussed if P&C could confirm the breaker trip coils did receive the trip command and if so for what duration. The trip coils were all found with good resistance readings. If the trip coils received a command for a long duration the coils would burn out. This was followed up at the meeting with P&C the next day.
3. In parallel with the trip coils not receiving a trip command, the "block trip" circuit was discussed. During the testing of the replacement breaker the block trip pressure switch hung up once. It never acted up again. The block trip relay is energized under normal conditions making it failsafe. If the relay was dropped out it would have alarmed. The relay and circuit was function tested prior the breaker returning to service. Prior to the event there were no alarms at Sunnyside.
4. Another meeting was held the next day to include P&C and maintenance staff to discuss the findings to date.

- The remaining six of double interrupter contacts were taken apart and inspected. A micro-ohm reading @ 100 amps was taken on each interrupter prior to dis-assembling. The chart below shows the micro-ohm readings. The condition of these contacts was found to be the same as the first three inspected.

Phase	Contacts	Micro-Ohm's
"A"	1 & 2	72.9
"A"	3 & 4	79.8
"A'	5 & 6	82.8
"B"	3 & 4	70.3
"C"	1 & 2	69.4
"C"	5 & 6	79.8

Wednesday February 5, 2014

- A meeting with maintenance and P&C was held to review all the details. P&C provided elementary drawings for the breaker and protections. Discussion was recorded into three categories "Confident", "Uncomfortable" and "Follow Up".

Meeting Notes

Confident

- Interrupters removed from B1L03 breaker are not a problem
- The replacement parts of the B1L03 breaker are functioning properly
- Function testing confirmed protection okay
- Protection operated correctly during the event but the B1L03 breaker did not respond
- Air pressure at the B1L03 breaker was normal at the time of T1 failure

- Trip circuit – coils, 52a contacts, resistor, capacitor, control switches, blocked trip relay and "T" relay okay
- No breaker / air system anomaly alarm
- Drained valves to check for moisture
- Dewpoint @ -34 before filling breaker

Uncomfortable

- Is moisture, cold, pollution, lubrication an issue in colder weather for the mechanisms?
- Air system leaks at Sunnyside.
- B1L03 operating times from sequence of events (SOE) seem to show slow operating times. There was a very slow open on January 4, 2014 for the B1L03. This was an un-commanded event.
- Field staff indicated that the breaker would not operate pneumatically from the control cabinet after the event

Follow-up

- Overhaul / re-lube criteria moving forward
- Should the block trip pressure switch be checked or replaced since it was sticky but operated fine during function testing.
- Determine if the historical B1L03 breaker operating times match those for the in service timing to determine if the breaker was slow previous to the event.
- Function test breaker latches in cold weather to see how they perform.
- Are the breakers exercised enough?
- Follow up on the maintenance history for the other breakers that tripped okay for the event.

The forecast for that night was a low of -15 C. I decided to place four pole control boxes outside overnight and test them in the morning. Two pole control boxes were from the "B" and "C" phases of the B1L03 breaker and two were spare boxes from the shop. They had their mechanisms latched.

Thursday February 6, 2014

- The four breaker pole control boxes were tested first thing in the morning. The temperature was -16 C. The test voltage was 90 and 125 volts. P&C's D.C power supply with the current limit at maximum was used. The results were as follows.

1. Both old pole control boxes operated @ 90 volts with no problems
2. "C" phase pole control box did not unlatch @ 90 or 125 volts. The coil was picking up.
3. "B" phase pole control box did not operate the first time @ 90 volts but did unlatch on the second attempt. The mechanism did appear slow to release.

Conclusions:

- The results from the old pole control boxes were not used. It was discovered after they had close coils in the trip coil housing. It was good to see they operated okay.
- "B" phase pole control box did show indications that the mechanism could be affected by cooler temperatures.

- It was discovered after the test that "C" phase pole control box was not latched. This test was not used.
- It was decided to try these tests on the two B1L03 boxes later that day again since it was going to be cold all day.

- The next test on the two pole control boxes was done later that day. The temperature was -14 C. Both pole control boxes tripped @ 90 volts on the first attempt. The mechanisms did not appear slow as the "B" phase the first time.

Conclusions:

- The testing showed indications that the mechanisms could be affected by colder temperatures in the condition they were found. How much is difficult to determine. The exact field conditions of the pole boxes during the event could not be replicated.

- It should be noted that an inspection of the control cabinet of the B1L03 breaker was not done by me for this investigation.

Summary of Findings from the Investigation

Here is the summary of the findings for what I believe happened for this event. This is based on physical evidence from the investigation, discussion with field staff and knowledge of the circuit breaker. There are some things that happened that I can't explain but have offered my opinion and rational. Any of my assumptions are open for discussion any time.

1. I find it interesting that the maintenance records show two previous events that the breaker had operating issues.

Work Order	Date Comp.	Work Done	Investigation Comments
838346	4/8/2011	Function tests done after questionable operations during a fault.	All checked okay.
576789	3/6/2007	Breaker would not operate. Operated locally and ECC. Stayed in service	No cause found.

The temperatures during these events were not cold as the January 4, 2014 event.

2. After dis-assembling the B1L03 breaker and knowing what work was completed at site on the breaker I came to the following conclusions.

1. In my opinion all nine breaker interrupters would have tripped if initiated by the main valves. It should be noted that ABB has never used Renolit as a lubricant on the DCVF breaker and has stopped using this lubricant on other equipment.
2. The main valves on the breaker were field rebuilt at Sunnyside. Indications were that there were no issues found with the original valves. No water or ice was found. I believe that the six main valves would have operated if initiated by the servos. I also believe that if one or up to five of the six main valves did not operate a disagreement would have occurred on the breaker. No disagreement occurred. If no main valves operated a disagreement would not occur.
3. The condition of all three servo valves indicates they would have operated if initiated by their respective pole control boxes. If one or two of the servos did not operate a

disagreement would have occurred. No disagreement occurred. If none of the servos worked a disagreement would not occur.

4. "B" and "C" phase pole control boxes were last maintained in 2007. Both had dirty latches and linkages. They were lubricated with Dow Corning 55 not graphite and showed minor signs of corrosion. "B" trip piston and housing showed signs of moisture and corrosion. "C" phase pole control box had an unexplained wet stain. The cold weather trip testing indicated colder temperatures could have some affect the operation. How much of an effect cannot be determined. In my opinion I believe the pole control boxes in their as found condition should have at least unlatched when called on to trip. The performance of the pole control boxes could be improved with the proper lubrication and confirmation they are properly adjusted. The condition of the pole boxes could possibly cause slow operations.

   If all three pole control boxes were unlatched when initiated by the trip coils the breaker would have attempted a trip. I do not believe the moisture presence found in the "B" phase would prevent an attempt to trip from that pole if the linkage was unlatched. If one or two of the pole control boxes were unlatched a disagreement would have occurred. No disagreement occurred. If none of the pole control boxes unlatched no disagreement would have occurred.

   I am of the opinion that none of the pole control boxes were unlatched when the trip command was sent. Why this occurred I cannot be sure. I am having a difficult time believing that all three pole control boxes would not operate when called upon. This can be caused by an electrical and or mechanical issue.

   A mechanical issue can be caused by many factors such a cold ambient temperatures, lubrication, out of adjustment, dirty latches and linkages, mechanism exercising or moisture in the air system. All these conditions could contribute to the linkage not unlatching or being slow. The condition of the pole control boxes was not determined at the time of the event. It is possible that some of the odd timing results done on the breaker after the event were caused by slow pole control boxes. I am of the opinion that all three pole control boxes would fail not mechanically to not unlatch at least one of the linkages. This would have given a disagreement alarm which we did not receive. The question could be asked why none of the other four breakers experienced any issues. It appears to be something common with the B1L03 breaker.

   The function testing of the rebuilt breaker indicates that no electrical issues existed after the event. There is a possibility that an intermittent electrical issue could have been present prior to the event. Since maintenance records from the two previous events indicate that nothing was found this is remote possibility and a very difficult thing to find.

2. These are the other issues that were discovered during the investigation I would like to discuss.

1. Field staff indicated that the breaker could not be operated pneumatically from the control cabinet. I can provide some reasons why this may have happened.

   The pneumatic trip and close on the breakers require really firm operation to get the breaker to operate. If this was not done the breaker may not operate.

   The other possibility is that the pneumatic control was defective. I have never seen one of these defective before. I believe the condition of the pole control boxes should have allowed the breaker to be operated pneumatically.

2. Historical trip operating times from the SOE for the B1L03 appeared to indicate slow operating times. This required further analysis which was not completed when I left site. If there was no noticeable difference in operating times then this is not significant. If this

does show longer operating times it is an indication the mechanism slowing the breaker down.

3. In conjunction with the slow operating times there was an un-commanded event on January 4th after the event when staff was on site. The timing shows it looks like it went into disagreement on a trip. I can't explain this. It appears the disagreement feature on the breaker was working shortly after the event.
4. The design of the "block trip" circuit is failsafe. If the block trip relay had open circuited or not energized by the breaker pressure switch, an alarm should have been received. There were no alarms at Sunnyside prior to event.

Conclusion

I believe that the three pole control boxes on the B1L03 breakers did not unlatch when the trip command was sent during the event. I believe that the cold temperatures that the breaker was experiencing for days up to the event and the condition of the pole control boxes are factors affecting the breaker operation. The pole control boxes should have operated under these conditions but may be slow.
With all the symptoms I am seeing here I would speculate that there is an intermittent voltage issue in the common part of the trip circuit probably in the form a high resistance connection. This may explain some of the things we have seen. It could explain the two previous issues in the maintenance history. It could explain the odd timing results we saw after the event. It may also explain why the pole control boxes did not unlatch during the event. The trip coils are 11.8 ohms each all in parallel. During the event we would have had fifteen of these coils being energized. This would put a large temporary load on the station battery. If there was a high resistance connection in the trip circuit to the B1L03 breaker there would be less current available for the trip coils with the reduced voltage. The problem is probably intermittent and I also believe temperature related. This would explain why things worked okay after with no problems.

Recommendations

I cannot say I have found the root cause for this event. I am very suspicious of the possible voltage issue with the trip circuit on the B1L03 breaker. I would recommend some follow up testing on the B1L03 breaker to see if this possible problem can be found or replicated again. It would be easier to find when it is colder. I believe it is a terminal connection from the relay to the breaker or it could the D.C. knife switch for the trip close circuits in the breaker control cabinet. I have found the hinge point of similar eight pole switches with high resistance. This was very difficult to find.

In my opinion there could be some improvements made in the lubrication used on certain subassemblies and adjustment checks verified on the pole control boxes.

Power Products Service Group

Nalcor order: 20582-00 OB

ABB job number: 555605-10

Breaker ID: B1L17

Site Location: Holyrood Terminal Station

Breaker type: DLF245 nc2

Serial number: 170-73-3/1973

Mechanism type: Air Blast

Purpose for visit: Investigate “A” Phase Flashover to Ground

On site dates: 2014-01-16 to 2014-01-21

Report presented to: Mr. Hughie Ireland

SCOTT MORRIS ..... Date: January 25, 2014

Scott Morris

B1L17 Breaker Data

Type:	DLF245 nc2
Serial Number	170-73-3/1973
Continuous Current	2000 amps
Maximum Voltage	245 KV
Maximum Voltage Full Wave	1050 KV
Short Circuit Current	12.8 KA symm.
Interrupting Time	2 cycles
Frequency	60 Hz
Operating Pressure: Normal	426 psi
Lockout Pressure: Close	382 psi
Lockout Pressure: Open	370 psi
Lockout Pressure: Reclosing	400 psi
Control Voltage	125 VDC
Customer Purchase Order	15463
As Found Breaker Counter	1885 operations

Background

On January 5, 2014 an “A” phase to ground fault occurred at the Holyrood Terminal Station. The event occurred when the air break switch was being closed on the B1L17 breaker. The sequence of events information indicated the problem to be in the B1L17 breaker zone at Holyrood. It was suspected the “A” phase of the B1L17 breaker was closed when air breaker switch was closed or the breaker flashed. The B1L17 breaker did have open indication when the air breaker switch was closed.

Site inspections by field staff could not find any signs of a flash on the breaker and other equipment in the B1L17 breaker zone.

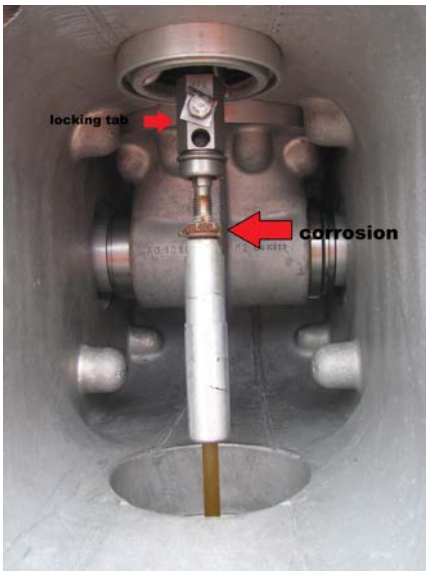
A few days after the event field staff were going establish a work permit on the breaker in the test condition. The intention was to determine if the “A” phase of the breaker was closed. Shortly after starting adding air the breaker the “A” phase interrupter developed a massive air leak. The leak was so loud it startled the worker and they rightfully, briefly exited the area. The worker made an assessment of the situation and returned to the breaker to close of the air supply to the breaker. Eventually all the air drained off the breaker and the all the poles went closed. It was never determined at this time if the “A” phase was actually closed.

Further detailed investigation on the B1L17 breaker was required. ABB was contacted to provide support for the investigation.

Chronological Summary of Investigation

Thursday January 16, 2014

- 09:30 site meeting to discuss breaker failure, sequence of events, general discussion and next steps
- The cover was removed on the “A” phase interrupter to inspect the top of the breaker control rod. The control rod was not under tension as I should be. The control rod adjustment locking tab was in place and one side was bent over the flat on the bolt. The other side of the locking tab was not bent over the hex flat of the control rod. The preferred method is to have both ends of the locking tab secured. Observed that the top nut of the control rod was corroded as shown in the picture below. It is not normal to see corrosion on an air blast breaker using dry air. At this point it was assumed the control rod was broken.



- The inspection cover on the top of the “A” phase air receiver was removed to inspect the breaker control rod drive. The control rod drive bolts were corroded. A picture is below. The control rod drive was not in the position to be expected considering the breaker was suspected of being closed and drained of air. The control rod drive was binding and not able to be moved freely. The bottom of the control rod could not be seen because of the air screen. Not much more could be learned in the tight working space. The control rod and control rod drive needed to be removed for closer inspection.

Friday January 17, 2014

- To remove the control rod the breaker drops were disconnected and the breaker gradient capacitors removed. The interrupters were rigged for lifting and removed. The control rod was disconnected from the control valve and the interrupters removed. After the interrupters were removed we learned that the control rod was not broken.
- The control rod drive was disconnected from the control rod. The control rod and control rod were removed from the breaker.
- Inspection of the control rod confirmed it was not broken. The control rod had signs of tracking near the top of the rod. It was observed that the surface of the control rod had an excessive amount of surface moisture on it considering that the control rod was just removed from a sealed breaker. There were some mechanical marks on the rod probably caused by touching parts of the insulator columns during removal and installation.
- The control rod drive was found seized to the point that it could not be moved at all. See picture below. When the control rod drive was inverted free water came out. The corrosion of the control rod drive was excessive. The screen was in bad shape. This corrosion would not be visible looking in from the bottom inspection cover of the air receiver when the control rod drive was installed.

- There is no indication at this time of a power arc occurring in the “A” phase.
- Suspicious of excessive moisture being present in the air receiver the lower air receiver inspection cover on the “A” phase air receiver was removed. An excessive amount of water was found in the bottom of the air receiver. A picture is below.

- There was discussion on how the water could have entered the breaker. Four breakers in the yard including the B1L17 had silicone put on the columns and interrupters. Two breakers were done consecutively one a time and the other two consecutively one a time too. There was a notable time difference between when the two sets of breakers were done. When this work was performed the breaker control rods were disconnected from the interrupters and left connected at the control rod drive. The control rods were supported on the unused overhead bus, covered up and sealed. It was suspected that water may have entered the B1L17 breaker at this time.
- The other two phases of the B1L17 breaker air receivers were inspected by removing the lower air receiver inspection cover. The "B" phase showed a very small amount of free water. The "C" phase had a moderate amount of water in it. A picture of the "C" phase air receiver is below.

- The next step was discussed. It was decided to check the three air receivers for moisture and one control rod drive for corrosion of another DLF breaker in the yard. The breaker selected was purposely not one of the three breakers that recently had silicone applied. We were trying to determine if the problem could be in all of the breakers.
- The B2L42 breaker was inspected by removing the bottom drain plug on the air receivers. The plugs could be easily resealed. There were no signs of moisture in the air receivers of the B2L42 breaker. The "B" phase control rod drive was inspected for signs of corrosion and showed no signs of corrosion.
- The drain plugs were removed from the B1L17 breakers allowing any water to drain out since colder temperatures were in the forecast.
- There was discussion at the end of the day what was learned so far the next steps.

Saturday January 18, 2014

- The "B" and "C" phases of the B1L17 were disassembled for inspection.
- The control rods of the "B" and "C" phases were found to be in the same condition. There were some marks on the rods that appear to be from scraping or wear. The nuts on the top of the control rod showed signs of corrosion. "C" phase showed the more corrosion compared to "B" phase which is supported by the amount of water in the poles. Pictures of each are below.

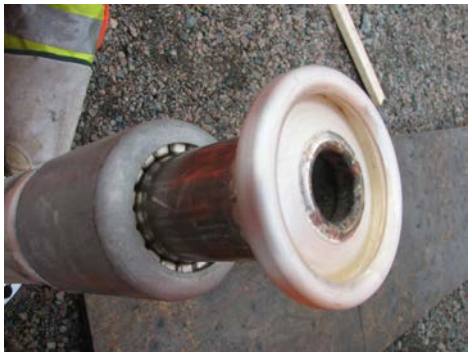
- The control rod drive on the “B” phase was tighter than normal to operate by hand. It was operable and not seized like the “A” phase.
- The control rod drive on the “C” phase was quite a bit tighter to operate than the “B” phase but again not seized like the “A” phase.
- In parallel with the B1L17 inspection two more DLF breakers were inspected for moisture in the air receivers. The breakers inspected were the B3B13 and B3L18. The two breakers had silicone installed on them about the same time. Both breakers showed no signs of free water in the air receivers. The control rod drive of the “B” phase on both breakers were inspected and showed no signs of corrosion.
- The control rod drive from the “A” phase was taken apart for inspection. The valve was very badly corroded and completely seized. It was very difficult to get apart. A couple is below.

- The “B” and “C” phase control rod drives were also taken apart. Both valves came apart easily and were not seized. The “B” phase valve had some corrosion on the inside but not as bad as the “C” phase. The “C” phase was corroded worse than the “B” phase but not as bad as the “A” phase. The flange bolts on the “C” phase were starting to corrode. This supports the as found condition of the valves being worse when exposed to more water.

Saturday January 18, 2014

- The B2B12 breaker air receivers and the “C” phase control rod drive inspected. There were no signs of moisture in the air receivers and the “C” phase control rod drive showed no signs of corrosion.
- A closer inspection of the “A” phase interrupters and control valve was done.
- The control valve of “A” phase interrupter had signs of water and moisture was present. The percussion gasket showed normal signs of wear and was in good condition. The valve was overhauled about one year ago. In my opinion the control valve would operate properly if properly initiated to do so. A picture is below.

- The blast valve from the “A” phase interrupter was not inspected.
- The two moving interrupter contacts from the “A” phase were removed for inspection.
- Both the main and stationary contacts for both interrupters showed what would be considered to be normal wear. The breaker has 1885 operations. A picture of a moving contact is below.



The tube on each of the moving contacts each showed some signs of heating. I do not believe these were from the recent event. These were not fresh and could not be removed. A picture of a moving contact showing the heating is below.

The stationary contacts looked fine. The inside barrels of the porcelains were cleans and had surface moisture on them.

- I did not see any indications of fault current flowing across an open set of contacts.
- P&C Doble tested the B1L17 oil filled current transformers.
-

- The pole control boxes were inspected. Externally they looked fine. It should be noted that all the linkages in all three pole control boxes were tripped. This is an indication that the air was drained off the breaker while the breaker was open. The inside components of the pole control boxes were not inspected. Considering the age of the breaker they could be overhauled.

Summary of Findings from the Investigation

Here is the summary of the findings for what I believe happened for this event. This is based on the physical evidence from the investigation, discussion with field staff and knowledge of the circuit breaker. There are some parts of the event that I have made some assumptions and I have acknowledged these. Any of my assumptions are open for discussion any time.

1. I believe the "A" phase of the breaker was closed prior to the event happening on January 5, 2014. This begs many questions such as how this can happen and go undetected.

    1. The failure mode of the control rod drive being seized at the time would not allow the "A" pole to operate. The pole control box was operating fine and would have sent a signal to the control drive but the control rod drive would not change state. Since the control box sent its signal to the "A" phase and the other two phases opened, the phase discrepancy feature (disagreement) would be satisfied and no alarm would be received. This failure mode is not sensed by the phase discrepancy.
    2. The other reason I believe the "A" pole did not open is the control rod drive was seized so bad that it would have never been able to complete its operation and the control valve would have developed a major air leak which would have not gone undetected. The "A" phase does develop a major lead post event which will be discussed later.
    3. To support the "A" phase of the B1L17 being closed after it was tripped last I have to assume that the other breakers in the zone had tripped okay. If any of the other breakers were closed the generator would have seen reverse power protections operate from the closed "A" phase on the B1L17. After the zone trip the air break switch to the generator would have been opened. The closed "A" phase on the B1L17 would go undetected until the breaker was energized again by the air break switch. I have not obtained the information if the last trip for the B1L17 was a zone trip.
    4. I believe another factor contributing to the control rod drive not operating was it was frozen in addition to being corroded. The weather historical date from Environment Canada for the St John's airport shows very cold daytime temperatures for the first five days of January.

2. On January 5, 2014 there was an "A" phase to ground fault in the B1L17 breaker zone.

    1. There was no evidence found to locate an "A" phase to ground fault internal to breaker, external to the breaker or in the zone.
    2. Free water was discovered in all three air receivers with the most being in the "A" phase.
    3. The as found condition of the control rod drive on the "A" phase did not make sense to me. If the control rod was in that position a massive air leak would have occurred at the control valve on the interrupter. What happened approximately two days after the event I believe explains the position of the control rod drive.

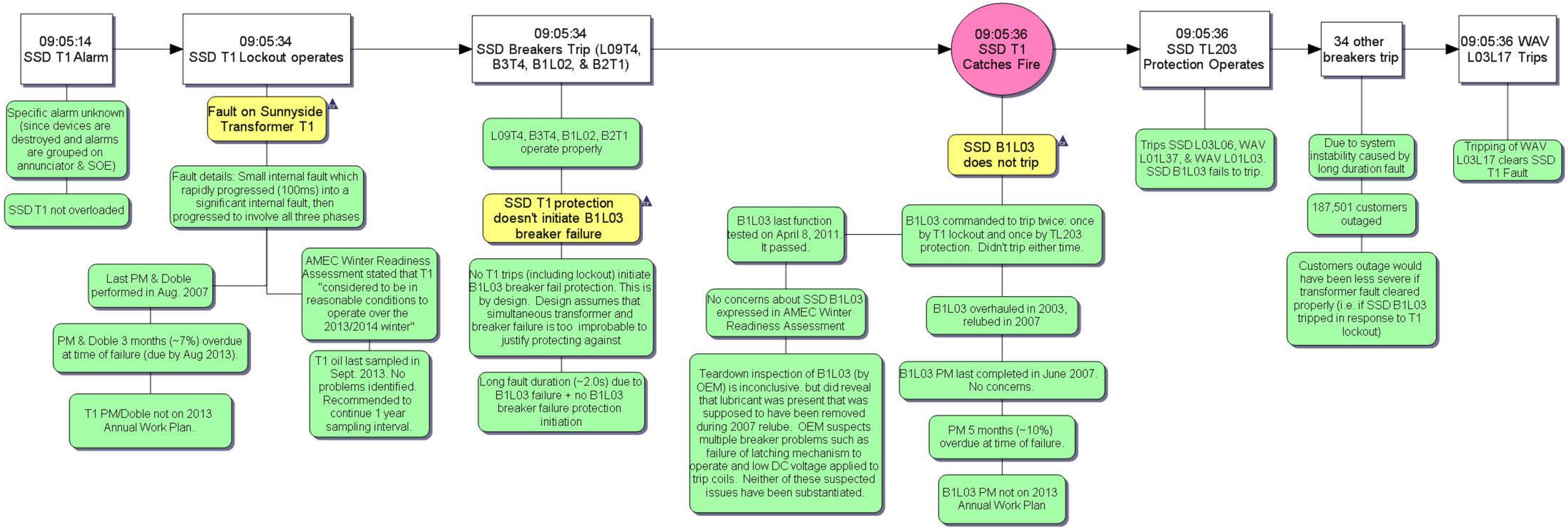
3. Approximately two days after the event when a trades administered work permit in test was being established a massive air leak developed on the “A” phase interrupter when the air pressure was being increased.

    1. I believe that the increase in air pressure caused the control rod to move on the ‘A” phase because the control rod drive had thawed enough for it to move. The weather data as mentioned above shows a high temperature of 9.6 degrees for January 7, 2014.
    2. This would explain why the control rod drive on the “A” phase was found in the position it was in.
    3. The massive air leak caused explains why all the pole control box mechanisms were found tripped. This situation occurs when the air is lost on the breaker with the breaker open. As previously mentioned the pole control box on the “A” phase would still think the breaker was open.

Conclusion

Although no “A” phase to ground path could be found it was quite clear the moisture in “A” phase air receiver was a factor causing the rod control drive to not function properly.

SUNNYSIDE T1 CATCHES FIRE



WESTERN AVALON T5 TAP CHANGER FAILURE

1/4/2014 09:05 AM
09:05:36 WAV T5 Protective Device Alarm Activates
- Occurs during SSD T1 failure.

1/4/2014 09:05 AM
09:05:36 WAV T5 Protective Device Alarm Resets
- WAV T5 de-energized due to additional breakers that tripped to clear SSD T1 fault (due to long duration).

1/4/2014 09:05 AM
09:05:38 WAV T5 Protective Device Alarm Activates

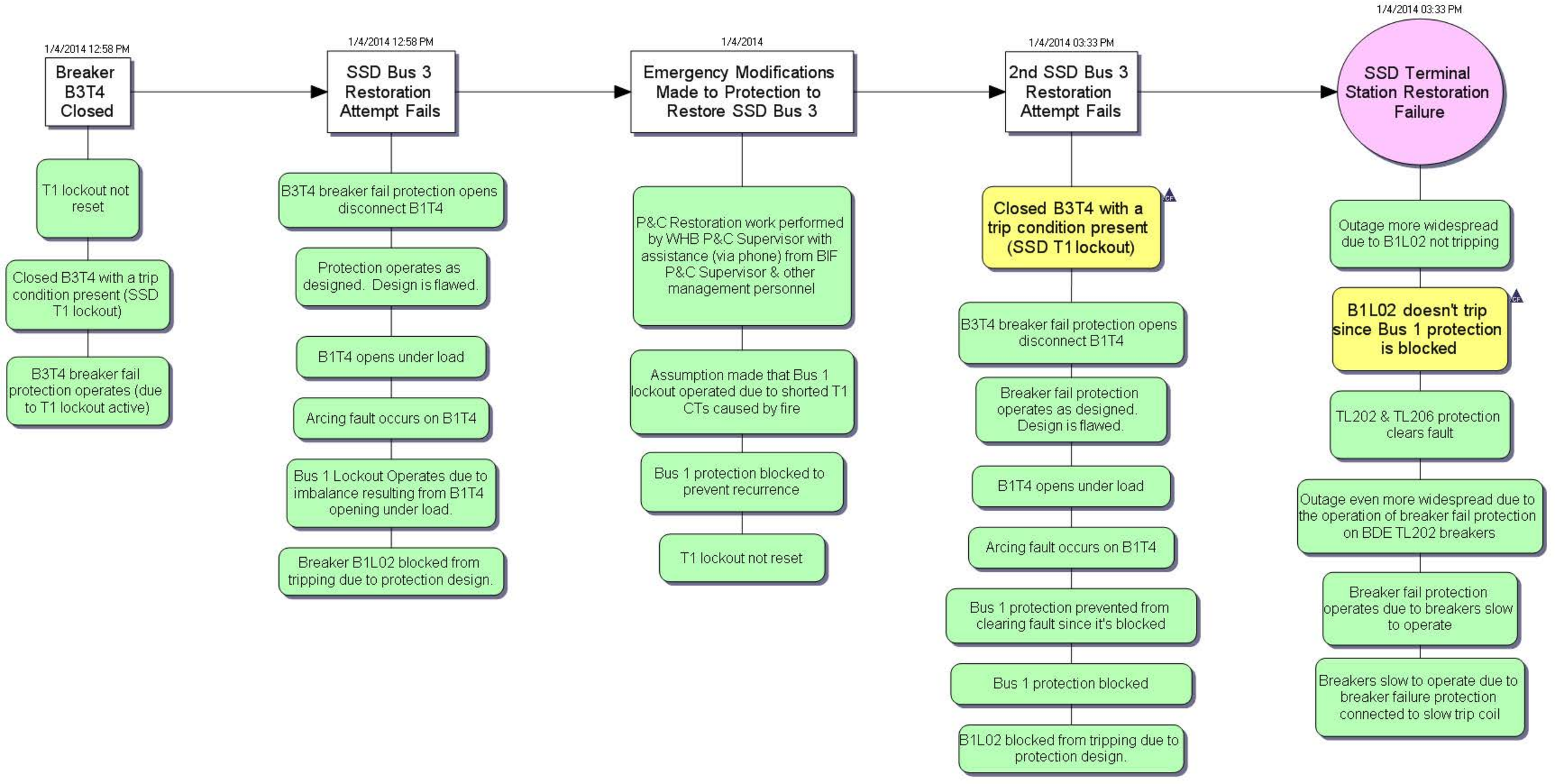
1/4/2014 09:41 AM
09:41:17 WAV T5 Protective Device Alarm Resets
- Operator Closes Breaker WAV B1L37
- WAV T5 Alarm resets, then immediately activates again
- WAV Breaker B1L37 tripped 1.1 sec after closing
- 15% overvoltage (264kV) applied to WAV T5 Phases "A" & "B" for the 1.1s (64 cycles) that B1L37 is closed
- WAV T5 tap changer phase-to-phase insulation 1 minute withstand rating is 285kV
- WAV Breaker B1L37 was not closing on Phase "C"
- Operator tries to close B1L37 two (2) more times and the same sequence of events occur.

1/4/2014 12:22 PM
12:22:15 WAV T5 Transformer Energized
- Energized via closing of WAV L01L03

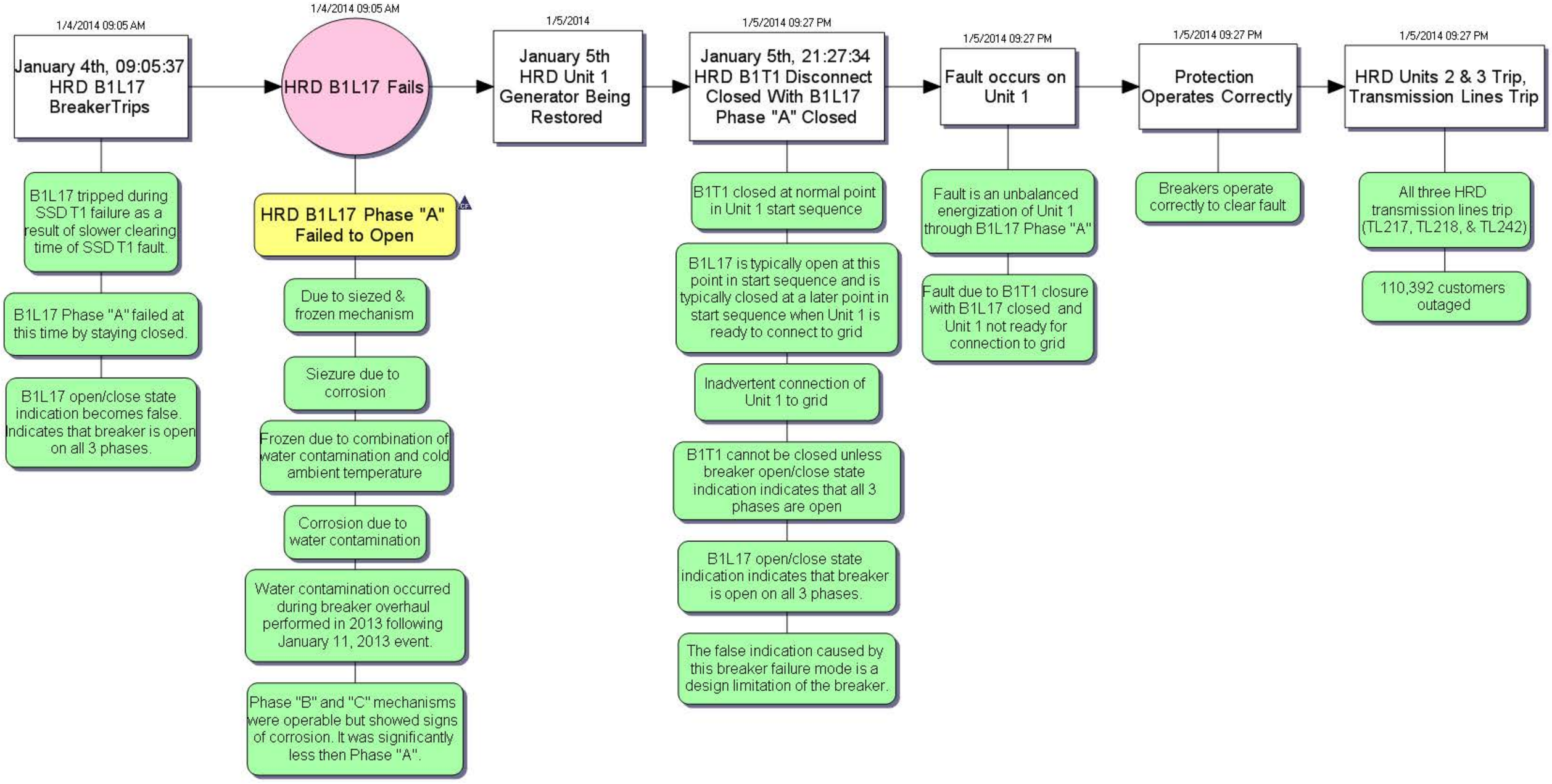
1/4/2014 12:22 PM
WAV T5 Tap Changer Failure
- Line-to-line fault on diverter switch
- WAV T5 fault pressure relay operates
- WAV T5 tap changer fault pressure relay operates

1/4/2014 12:22 PM
12:22:39 WAV T5 Lockout (86T5) Operated
- WAV Breakers B1B3 and B4B5 Operate Correctly to isolate T5
- No customer outages caused by WAV T5 failure

SUNNYSIDE BUS RESTORATION FAILURE



HOLYROOD BREAKER B1L17 FAILURE



ADDITIONAL FINDINGS AND AREAS FOR CONTINUOUS IMPROVEMENTS

In addition to the root causes and corrective actions identified via TapRooT®, several other conditions and their root causes were analyzed and recommendations made. These include areas for continuous improvement in preventative maintenance programs, safety systems, operating procedures, and systems design. Although these conditions did not directly cause the failures, their correction will improve the overall reliability of equipment and the safety of workers at Hydro.

Power Transformer Condition Assessment

Many of Hydro's transformers are original and operate reliably. The transformers reliable operation is credited in part to the current preventative maintenance program, timely corrective maintenance, and sound operating protocol. In addition, Hydro conducts on-going condition assessment of the transformers (which is performed by internal resources utilizing preventative maintenance and corrective maintenance data). An ongoing Power Transformer Upgrades capital program is in place to ensure reliable operation of the transformers over their entire lifecycle.

Finding #1: Condition Assessment Needs Continuous Improvement

The current condition assessments performed on power transformers are not comprehensive life assessments, nor do they include external validation to ensure long term plans are optimized.

Recommendation #1

Commission an engineering consultant to conduct a formal life assessment of Hydro's power transformers and use the results to revise the long-term plans for power transformer upgrades and replacements.

Station Service Transfer Switch Location

The station service transfer switch for the Sunnyside Terminal Station is located adjacent to transformer T1. This made operation of the transfer switch very difficult on January 4, due to the need to mitigate the hazards associated with personnel being in close proximity to the fire on T1. Operation of the transfer switch was needed to allow station service to be quickly restored to the Sunnyside Terminal Station.

Finding #2: Equipment Location Needs Improvement

Recommendation #2

Relocate the Sunnyside Terminal Station's station service transfer switch to the control building.

Recommendation #3

Specify in a Terminals Engineering Standard that the location of the station service transfer switch shall be in the control building in stations that have a control building, or in a location remote to the transformers for those that do not.

Recommendation #4

Review the current location of the station service transfer switches at other terminal station sites similar to Sunnyside to ensure their location is optimal.

Sunnyside Transformer T1 PM

A realignment of PMs on high voltage power transformers occurred in 2010. This caused work on some equipment to be done on a different timeframe than originally planned, meaning the PM on Sunnyside T1, originally intended for 2013, was deferred.

Finding #3: Scheduling Needs Continuous Improvements

Recommendation #5

When practical, complete PMs in accordance to normal scheduling.

Terminal Station Relay Target and Annunciator Cards

Terminal stations have relay target and annunciator cards. These cards are forms that are filled out by terminal maintenance personnel following the operation of protection. During the investigation it was discovered that some of the cards at the Sunnyside/Western Avalon/Holyrood Terminal Stations were incorrect (i.e. do not match the field devices) or unavailable, and also that some of the cards were filled out incorrectly.

Finding #4: Cards are Incorrect or Missing

Recommendation #6
Correct all incorrect cards at terminal stations.

Recommendation #7
Replace all missing cards at terminal stations.

Finding #5: Cards are Incorrectly Filled Out

Recommendation #8
Review and update Operating Instruction 002 as required to ensure relay target cards are completed in a timely manner for all system events and ensure the process for resetting devices is documented. Review the updated operating instruction with all P&C technologists and electricians.

Alarm Naming

Many of the alarms that come back to the ECC for various terminal stations throughout the system are grouped alarms (i.e. multiple devices trigger the same alarm). Some of these grouped alarms are inconsistent in naming, and in some cases, consistently named alarms are triggered by inconsistently grouped devices. These inconsistencies created problems during the investigation, including the inability to identify root causes.

Finding #6: Alarm Naming Needs Improvement

Recommendation #9
Conduct a review of the alarms that are generated from the various stations and, where practical, ensure that alarms from the various stations are consistent in their naming and triggers.

Personnel Availability

In preparation for potential system issues that may arise as a result of the storm that was forecasted for evening of January 3 and early morning of January 4, workers were asked to work on the morning of January 4. As a result of personal commitments and sickness, P&C technologists were not available to work on the day of the incident.

Finding #7: Scheduling Needs Improvement

Recommendation #10

Development of a plan for TRO and PETS personnel availability during emergency situations, which should include but not be limited to the following resources; P&C technologists, Electrical Maintenance A, Terminal Maintenance A, Mechanical Maintenance A, Lineworker A and PCC Engineering.

Sunnyside Terminal Station Air System Leaks

In 2013, a PM was conducted on the air system and identified one air leak in the Sunnyside Terminal Station. In January, while crews were working at the Sunnyside Terminal Station following the breaker B1L03 failure, two air leaks were identified on breaker B1L03 and four other leaks were identified on breakers B1L02, B3T4, L06L07 and L02L06.

Finding #8: Preventative Maintenance Needs Continuous Improvement

The annual air system leak check PM needs improvement to better detect leaks.

Recommendation #11

Conduct a review of the annual air system leak check PM to ensure that it is adequate in both scope and timing of execution to accurately identify leaks at the Sunnyside Terminal Station.

Slow Air Blast Breaker Trips

In reviewing the 100+ air blast breaker trips that occurred as a result of the incidents on January 4 and 5, there were occasions when breakers were slow to trip. The timing test in the air blast breaker PM check sheet does not state a pass/fail criteria. In addition, slow trips of breakers at Bay d'Espoir caused expansion of the outage area during an attempt to reenergize Sunnyside Terminal Station on January 4, 2014.

Finding #9: Preventative Maintenance Needs Improvement

Recommendation #12

State a specific pass/fail criteria for the timing test on the air blast breaker PM check sheet.

Recommendation #13

Check protection connections to all 230 kV breakers ABB type DCVF 245 MC6, in which trip coil No. 2 is not intended to produce the rated interrupting speed performance of the breaker. In cases where protection P2 is connected to a slow trip coil, add an additional P2 trip contact to the trip coil 1 initiation. If additional spare contacts are not available, re-direct the P2 tripping from trip coil No. 2 to trip coil No. 1.

DCF/DCVF Air Blast Breaker Re-lubrication

The task of re-lubricating DCF/DCVF breakers is usually performed in the field where weather conditions can affect the quality of the work. Maintaining a clean environment (with low moisture and free or airborne contaminants such as dirt and dust) during the re-lubrication of the breakers is important. This can become challenging when this task is performed in an outdoor environment. In addition, the work environment can have adverse effects on the quality of the work performed.

Finding# 10: Work Environment Needs Improvement (Cold/Wet)

Recommendation #14

Review the current approach to DCF/DCVF air blast breaker re-lubrication. The review should consider the environment that the lubrication is being performed in and the effects it may have on work comfort and quality control.

DCF/DCVF Air Blast Breaker Re-lubrication

In 2007, breaker B1L03 was re-lubricated to replace DOW 55 grease that was suspected to cause problems during breaker operations in low temperatures. During the inspection of breaker B1L03 in February of 2014, DOW 55 lubricant was found in the interrupters.

Finding #11: Work Execution Needs Continuous Improvement

Recommendation #15

Determine why the DOW 55 grease was not removed during the 2007 re-lubrication and implement the appropriate corrective action.

Sunnyside B1L03 Breaker PM

A realignment of PMs on high voltage breakers occurred in 2010. This caused work on some equipment to be done in a different time frame than originally planned. In result, the PM on Sunnyside B1L03, originally intended for 2013, was deferred.

Finding #12: Scheduling Needs Continuous Improvements

Recommendation #16

When practical, complete PMs in accordance to normal scheduling.

Emergency Backup Station Service Supply

The Sunnyside Terminal Station does not have an emergency backup station service supply (i.e. black start capability). Station service power is required for station equipment to operate properly. During the incidents of January 4, the Sunnyside Terminal Station was without station service power on three occasions for a total outage time of eight hours and two minutes. This both delayed restoration of power to customers, and increased the pressure on personnel to restore station service as soon as possible in order to avoid further delays to customer restoration.

Finding #13: Problem Not Anticipated

The problem that was not anticipated was that both Sunnyside T1 and Sunnyside T4 would be out of service for an extended period of time.

Recommendation #17

Conduct a risk/reward review of the requirements for additional station service

redundancy supply at all 230kV terminal stations and install backup station service supply where recommended by the review.

Breaker Failure Protection Philosophy

Hydro's protection philosophy, which includes the philosophy on breaker failure protection, isn't documented. This increases the risk of designing inconsistent protection schemes.

Finding #14: Protection Philosophy Not Documented

Recommendation #18

Document protection philosophy as a Protection and Control Engineering Standard.

Breaker Replacement Prioritization

Based on the report by ABB of the inspection of B1L03 the findings are not conclusive and point to additional issues such as: some corrosion of components, moisture contamination contributing to failure to operate correctly in low temperatures, and/or dirty linkages. Testing conducted could not repeat the failure mode of the breaker. This non-repeatability of the breaker failure mode and undependability of the breaker to operate correctly, suggests that this breaker is approaching end of life. This breaker was scheduled for replacement in 2015.

Finding #15: Scheduling Needs Continuous Improvement

Recommendation #19

Consider accelerating the replacement of air blast circuit breakers in the existing circuit breaker replacement program. Prioritization criteria of the air blast breakers should include but not be limited to condition assessment and system criticality.