

NEWFOUNDLAND AND LABRADOR HYDRO

Sequence of Events

Following Sunnyside Transformer Fault on January 4, 2014

February 2014



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

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		<p>TL203 was open at the WAV end and SSD Bus B1 and transformer T1 were de-energized.</p> <p>Backup protection also operated on transmission line TL237 at Come by Chance (CBC) and WAV. The following breakers opened for this event:</p> <p style="padding-left: 40px;">CBC B1B2 open WAV L01L37 open</p> <p>Circuit breaker B1L37 at WAV appeared to have been delayed in opening by two seconds for the protection trip.</p> <p>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.</p>
	09:05:37	Normal Newfoundland Power supply to Hydro Place was lost; Hydro's EMS switched to battery power.
	09:05:37	<p>Units at Holyrood cannot supply the load. Holyrood Units 2 and 3 are tripped and isolated from the system by unit breakers.</p> <p>Unit 1 trip is initiated and unit breaker B1B11 opened three phases. Unit breaker B1L17 opened only on two phases during the trip.</p> <p>Backup protection operated on transmission line TL242 at Hardwoods Terminal Station (HWD). Breaker B1L42 opened at HWD.</p> <p>Backup protection operated on transmission line TL218 at Oxen Pond Terminal Station (OPD). Breaker B1L18 opened at OPD.</p> <p>Holyrood Unit 3 was isolated from the system.</p> <p>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.</p>

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	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.

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	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.

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	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	<p>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.</p> <p>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.</p> <p>WAV busses B1 (230 KV) and B2 (66 KV) were restored.</p>
	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	<p>Switching at SSD to restore the load side of transformer T4 (138 KV).</p> <p>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.</p> <p>Investigation determined the Bus B1 differential protection operated upon closure of B3T4, likely caused by the current transformers and</p>

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		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

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		<p>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.</p> <p>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.</p>
	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	<p>Primary one protection operated on the following transmission lines:</p> <p style="text-align: center;"> 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 </p> <p>Associated line breakers opened for these line protection trips.</p>
	15:39	<p>ECC initiated a breaker group open at WAV.</p> <p>Transmission Line TL206 was restored (BDE – SSD). Power was restored to SSD TS, TL207 and North Atlantic Refining at Come by Chance.</p>
	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.

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	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)

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	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.

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		<p>Breaker failure lockout protection operated on the following circuit breakers at HRD.</p> <p style="text-align: center;">HRD B3L18 HRD B3B130 HRD B1L17</p> <p>Breaker failure lockout protection operated on circuit breaker B1L17 at WAV and Bus B1 at WAV.</p> <p>The unit lockout switch operated on HRD Unit 3.</p> <p>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.</p> <p>22:19 Transmission Line TL242 (HWD – HRD) restored.</p>
Jan. 6, 2014	<p>02:02</p> <p>03:34</p> <p>05:29</p> <p>05:46</p> <p>07:17</p>	<p>Circuit breaker B1L17 was isolated at HRD.</p> <p>Transmission Line TL217 was energized from WAV to HRD to test for line or Bus fault. No fault was found and TL217 was restored.</p> <p>Holyrood Unit 2 back on-line at 165 MW, with a minor de-rating of 5 MW.</p> <p>Transmission Line TL218 (OPD – HRD) restored.</p> <p>HRD Unit 3 on-line at 50 MW.</p>
Jan. 8, 2014	<p>15:27</p> <p>15:38</p>	<p>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.</p> <p>Holyrood Unit 1 on-line at 165 MW, with a minor de-rating of 5 MW.</p>