BC HYDRO

T&D SYSTEM OPERATIONS

SYSTEM OPERATING ORDER 7T-40

CHEEKYE–DUNSMUIR 500 kV SYSTEM

Supersedes SOO 7T-40 issued 23 November 2021

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Original signed by:

APPROVED BY:____________________

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- Requires same day posting on bchydro.com and on BCRC Extranet upon release.
- Requires same day MRS conveyance notification upon posting

Highlight Indicates Revision

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1.0 GENERAL

This System Operating Order (SOO) describes the operation of the Cheekye-Dunsmuir (CK5-DMR) 500 kV System. The system consists of:

- Two 500 kV overhead circuits: 5L30 and 5L32 from CK5 to MSA,
- Two 500 kV combined overhead and submarine cable circuits: 5L29 and 5L31 from MSA to DMR, and
- A reactor station, Texada Island Reactor Station (TIR), connected to the Texada Island overhead sections of 5L29 and 5L31.

Together with a single 230 kV AC circuit connecting Arnott (ARN) to Vancouver Island Terminal (VIT) designated 2L129 and it's phase shifting transformer VIT PST1, the 500 kV system and 230 kV circuit form the Vancouver Island – Lower Mainland (VI-LM Interconnection).

Operation of the 2L129 and the VI 230/132 kV transmission network is described in SOO 7T-41 "Vancouver Island System Operation".

The purposes of this System Operating Order and SOO 7T-41 are to provide the operating instructions, operating limits, alarms, outage and RAS arming requirements, for the operation of the Vancouver Island – Lower Mainland Interconnection and Vancouver Island load supply.

The requirements in these operating orders cover the worst case operating conditions. Variations from the instructions, limits and arming conditions will be provided through additional Operating Plans, for specific operating conditions on a case basis. Operating Plans are engineered to support outages and short term operating requirements, superseding as necessary **any** requirements in this order.

References:

SOO 1J-11 "Power System Operation – Authority and Responsibility"
SOO 1T-11A "Operating Responsibility and Operating Authority Assignment to Desks"
SOO 2T-34C "5L29/31, DMR T1/T2 Remedial Action Scheme"
SOO 5T-02 "Automatic Reclosing Facilities and Blocking Requirements"
SOO 6T-32 "Automatic Overfrequency Load Restoration – Lower Mainland and Vancouver Island Regions
SOO 6T-34 "Automatic Undervoltage Load Shedding (AUVLS)"
SOO 7T-22 "System Voltage Control"
SOO 7T-41 "Vancouver Island System Operation"
LOO 3T-CCB-01 "Cape Cockburn Cable Terminal Station Operation"
LOO 3T-CK5-01 "Cheekye 500kV Substation"
LOO 3T-DMR-01 "Dunsmuir Substation (DMR) Operation"
LOO 3T-NCT-01 "Nile Creek Terminal Station Operation"
LOO 3T-TIR-01 "Texada Island Reactor Station"
LOO 3T-TXE-01 "Texada East Cable Terminal Station"
LOO 3T-TXW-01 "Texada West Cable Terminal Station"

Definitions:

ARN refers to the Arnott Substation located in Lower Mainland South operating area. The station ties the Lower Mainland 230 kV network to Vancouver Island.

CK5 refers to Cheekye 500 kV Station. The designation is used for operating orders, and refers to the operating one-line CKY Sheet 1. This 500 kV station's operating one-line has no electrical connection to the CKY 230 kV station, but is the first sheet of a combined station operating one-line.

CFT Catalyst Paper - Crofton Division in Central Vancouver Island – Transmission Voltage

Customer mill, included in load shedding RAS schemes.

CLD Colwood Substation – distribution load in North Vancouver Island included in load shedding RAS schemes.

CMX Comox Substation, included in load shedding RAS schemes.

DMR refers to the Dunsmuir Substation, located 15 km north of Qualicum at Qualicum Bay and is the major 500 kV transmission interconnection point from the Lower Mainland supplying Vancouver Island.

ESQ Esquimalt Substation is a South Vancouver Island distribution substation with load included in load shedding RAS schemes.

GOW Goward Substation is a South Vancouver Island 230/132 kV Switching Station and a 25 kV distribution substation, with load that is included in load shedding RAS schemes.

GTP George Tripp Substation is a South Vancouver Island is a 12 kV distribution substation and a 132/230 kV transmission substation. The distribution load in included in load shedding RAS schemes.

KSH Koksilah Substation is a South Vancouver Island 132/25 kV substation with distribution load included in load shedding RAS schemes.

HSY Horsey Substation is a South Vancouver Island 230/25 kV substation with distribution load in included in load shedding RAS schemes.

KTG Keating Substation is a South Vancouver Island 230/60 switching station and a 25 kV distribution substation in, with load that is included in load shedding RAS schemes.

HWD Harwood Substation is a 132/25 kV substation with Central Vancouver Island distribution load that is included in load shedding RAS schemes.

LDY Ladysmith Substation is a Central Vancouver Island 132/25 kV substation with distribution load that is included in load shedding RAS schemes.

LTZ Lantzville Substation is a Central Vancouver Island 132/25 kV substation with distribution load that is included in load shedding RAS schemes.

MDN refers to Meridian 500 kV Substation, located in Lower Mainland, and is a major 500/230 kV transformer station supplying Metro North.

MSA refers to the Malaspina Substation, located north of Petrocan Station, located on the Sunshine Coast, and is a major 500/230/138 kV switching and transformer station supplying Vancouver Island.

NFD Northfield Substation is a Central Vancouver Island 132/25 kV substation with distribution load that is included in load shedding RAS schemes.

OLTC refers to on-load tap changer.

PAL Port Alberni Substation is a Central Vancouver Island 132/12 kV substation, feeding 12 kV customer load at Norske Canada (APP), and also a 132/25 kV substation with distribution load that is included in load shedding RAS schemes.

PIK Pike Lake Substation has reactive equipment to support voltage control on the Vancouver Island transmission network.

PVO Prevost Substation is a Central Vancouver Island 132/60 kV switching station, and also a 132/25 kV substation with distribution load that is included in load shedding RAS schemes.

QLC Qualicum Substation is a Central Vancouver Island 132/25 kV substation with distribution load that is included in load shedding RAS schemes.

SHA Shawnigan Lake Substation is a 138/25 kV Central Vancouver Island substation with distribution load that is included in load shedding schemes.

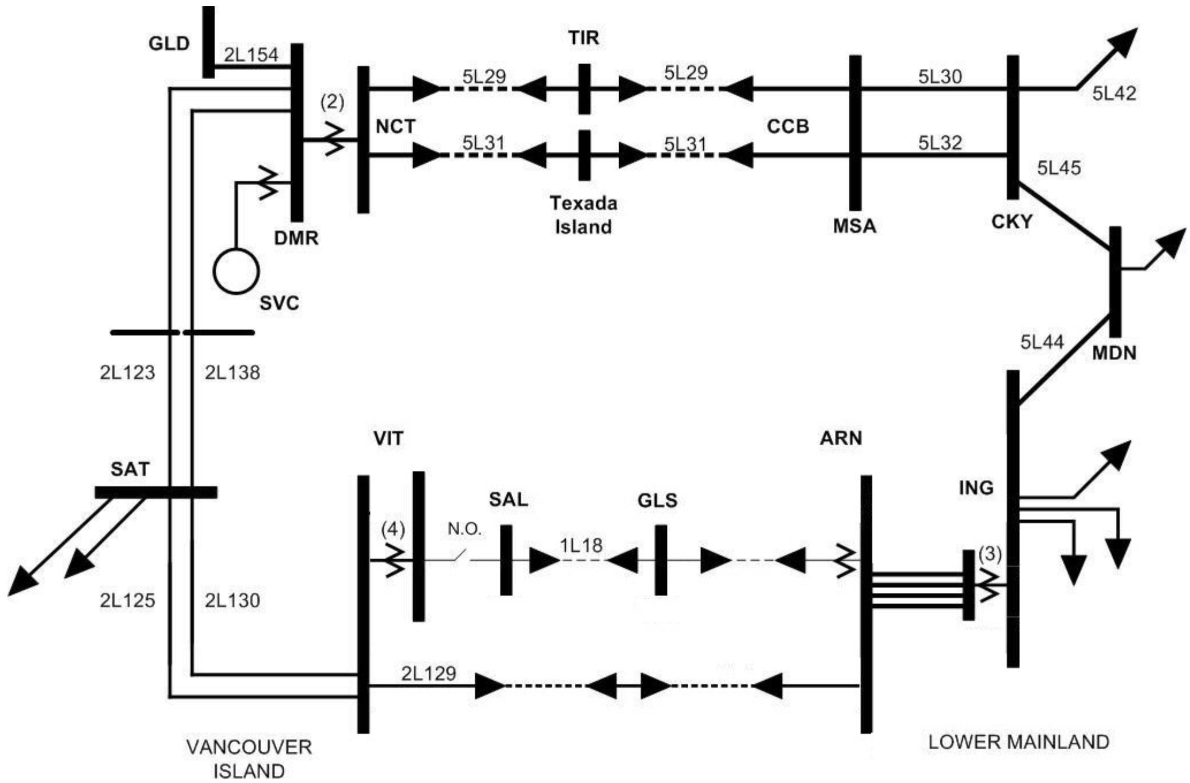
SNY Sidney Substation is a 60/25 kV South Vancouver Island distribution substation, supplied by transmission from KTG, with distribution load that is included in load shedding RAS schemes

SVC refers to static VAR compensator.

TIR refers to the Texada Island Reactor Station, located on Texada Island, and is a station that provides reactive compensation to mitigate voltage rise on 5L29 and 5L31.

TSC refers to thyristor switched capacitor.

VIT refers to the Vancouver Island Terminal Station, located in the Central Vancouver Island operating area, connecting the Vancouver Island 230 kV network to the Lower Mainland.



VI-LM Interconnection Overview
(not an operating drawing)

2.0 RESPONSIBILITIES

BC Hydro operation and maintenance responsibilities are defined in SOOs 1J-11 and 1T-11A.

The BC Hydro Control Centre (BCHCC) is responsible for all interconnection operations as the facilities are entirely within the BCH operating area.

The BCHCC has control over the arming of the 5L29/5L31 RAS.

3.0 VOLTAGE CONTROL

During normal system operation, the 5L29 and 5L31 circuit voltage shall be operated below 540 kV (544 kV max. continuous). The DMR 230 kV voltage should be maintained below 242 kV, (253 kV max. continuous). Refer to SOO 7T-22 “System Voltage Control” for specific voltage limits at other Vancouver Island and Lower Mainland stations.

Voltage control is provided by eight 500 kV line reactors for each of the cable circuits 5L29 and 5L31, and two 12 kV tertiary reactors at MSA (see Attachment 1). The DMR SVC can also be used for voltage control as described in Section 4.0.

There are four 3-phase 500 kV reactors on each of 5L29 and 5L31 at DMR, which have circuit switchers/circuit breakers for on-line switching. As of July 2007, DMR 5CB15 and DMR 5CB24 have been replaced with new SF6 circuit breakers without Point-on-Wave (POW) Controllers and may be used for reactor-only switching. There is now no restriction on any of the 500 kV circuit breakers at DMR.

Three single-phase reactors on each circuit at TIR must only be switched when the associated circuit is de-energized. Refer to Section 3.0 in LOO 3T-TIR-01.

Although the DMR and MSA 500 kV reactors may be used as bus reactors when the associated circuit is Out-Of-Service (OOS) it is recommended that the DMR reactors be first used rather than the MSA reactors. Switching a DMR reactor has about the same effect on the 500 kV system voltages as switching a MSA reactor.

The two 12 kV tertiary reactors at MSA may be switched on-line. All available TIR and MSA 500 kV reactors should be in service when the associated circuit is energized. The DMR 500 kV reactors and MSA 12 kV reactors should be used for voltage control.

High voltages on the CK5-DMR 500 kV system can be reduced by the following steps listed in order of preference:

1. Switch in available reactors at DMR, CK5, MSA and Kelly Lake Substation (KLY).
2. With the DMR SVC on line to control the DMR 132 kV bus, disable the automatic OLTC control, and request the BCHCC Operator to manually change the taps on the 230/132 kV transformers to reduce the DMR 230/500 kV voltage. (Note: Increasing the tap position number will reduce the DMR 230/500 kV voltage).
3. Use VIT synchronous condensers to control VIT voltage to 138 ± 3 kV.
4. Switch out the higher order harmonic filters in HF2 and also switch out high pass filter HP2 at VIT and ARN.
5. Switch in PIK reactor.
6. When no other options are available, one of 5L29 or 5L31 should be switched out to make additional reactors available at DMR.

4.0 DMR STATIC VAR COMPENSATOR

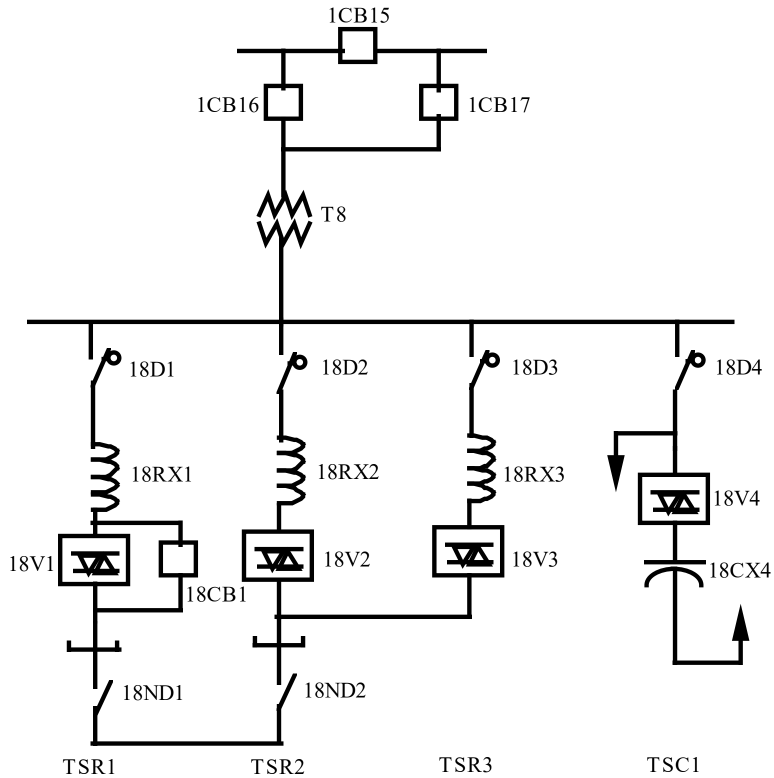
4.1 General

A -135/+165 MVAR, 132 kV static VAR compensator (SVC) has been installed at DMR primarily to maintain adequate voltage stability limits for the bulk transmission system. The SVC will also help control high voltage in the DMR and MSA area during light load periods, and to facilitate maintenance of the 500 kV reactors at DMR, TIR, and MSA.

The SVC is connected to the DMR 132 kV bus via T8, and consists of four three-phase branches, three Wye-connected thyristor switched reactors (TSR) and one delta-connected thyristor switched capacitor (TSC). By selectively switching these branches with thyristor valves, the SVC output will range from -135 MVAR to +165 MVAR (at DMR bus voltage of 132 kV) in 15 discrete steps. Thyristor switching is extremely fast, approximately 0.5 - 1.0 cycle. To minimize energy losses on valve group 18V1 for TSR1 after continuous firing, 18CB1 will automatically close to bypass 18V1 after a fixed time delay presently set at 10 minutes.

The SVC TSC and TSR branches are nominally rated as shown:

TSC1	165 MVAR
TSR1	77 MVAR
TSR2	19 MVAR
TSR3	39 MVAR



4.2 SVC Control Modes

Voltage control functions for the SVC are performed by three main computers that make up the VARMaster control system. The VARMaster controls the timing and polarity of the trigger pulses sent to each of the four SVC branches. It can also be used to automatically switch one or more of the eight DMR 500 kV reactors and the taps for the DMR 230/132 kV OLTC transformers (T4, T5, T6 and T7).

The DMR SVC will normally be operated in the automatic mode and its output will range from -135 MVAR to -35 MVAR (@ 132 kV) to provide a minimum 200 MVAR of dynamic VAR boost to support system voltage following 500 kV line outages and to prevent voltage instability.

The Gain Optimizer should normally be enabled to maintain SVC stability and optimal performance for changing system conditions.

4.2.1 Automatic Control

The SVC will control the DMR 132 kV voltage to a desired level set by either local or remote control. As the bus voltage changes, the SVC output will rapidly change in discrete steps to maintain the desired voltage level. A slope that is calculated by Network Performance Planning governs the sensitivity of the SVC. It is set at 1% which means that a 1% drop in the DMR 132 kV bus voltage will cause a 100 MVAR increase.

The SVC will try to maintain at least 200 MVAR of capacitive dynamic VAR reserve by switching DMR 500 kV reactors in or OOS so that the output of the SVC will stay below -35 MVAR (inductive).

The SVC will also control the DMR 230 kV bus voltage using the 230/132 kV tap-changing transformers. Control on the OLTC is time delayed to react after SVC control and automatic reactor switching.

When the SVC output has exceeded a set level (-25 MVAR), the VARMaster will, if this feature is enabled, switch in or out one or more DMR 500 kV reactors, after a variable-step time delay. Individual DMR 500 kV reactors can be excluded from automatic switching via a local panel at DMR Substation.

Switching a DMR reactor OOS will commence when the output has exceeded at a set level (-25 MVAR) but switching is blocked if the DMR 500 kV voltage is higher than a set level (535 kV).

Switching a DMR reactor in service will commence when the output has exceeded its inductive limit and if the 132 kV bus voltage is greater than a set level (143 kV). However, switching will be blocked if the DMR 500 kV voltage is lower than a set level of 520 kV.

When starting the SVC in a very weak electrical system (e.g. loss of all 500 kV and 138 kV AC connections between VI and LM), the Operator should put the SVC to its **Low Gain Mode** to avoid SVC instability (i.e. oscillation of the SVC output between its inductive and capacitive limits).

4.2.2 Manual Control

The SVC will maintain a constant VAR output (in nominal steps of 20 MVAR) and, if enabled, the DMR SVC OLTC control will keep the 132 kV bus within a desired range. While operating in manual mode, the VARMaster will disable its automatic control of switching the DMR reactors.

4.2.3 Degraded Mode Operation

When one or more SVC branches are unavailable, the VARMaster will automatically adjust its deadband for switching to account for the largest step in the available output range of the SVC.

4.2.4 No Bus Mode

When the VARMaster is defective, the SVC automatically transfers to NO BUS mode. In this mode, the TSR and TSC branches can only be switched in and out manually from the local control panel.

4.3 Start/Stop Control

The VARMaster supervises the start/stop sequence. For more details on operation of the DMR SVC, refer to OO 3T-DMR-01.

4.3.1 Start Sequence

1. Check for SVC Ready to start indication.
2. Set voltage regulator mode to MANUAL.
3. Initiate Start to the SVC and wait for "OK to Close CB" indication (about 30 seconds). The thyristor cooling system starts up and completes its self-checking sequence.
4. Close 1CB16 and/or 1CB17 to energize the SVC.
5. Adjust the SVC output to achieve a desired DMR 132 kV bus voltage of 141 ± 2 kV. (Normal operating range is 139 to 143 kV).

6. If there are no AC connections to LM, enable the LOW GAIN mode.
   Note: LOW GAIN mode is not required and should be disabled when:
   - there is at least one 500 kV connection to the LM, or
   - there is at least one 132 kV AC connection to the LM AND at least half of the John Hart Substation (JHT) units are on line AND at least half of the VIT S/Cs are on line.
7. Set voltage regulator mode to AUTO. Vref will automatically be set at the existing DMR 132 kV bus voltage until it is adjusted.
8. Enable Gain Optimizer if LOW GAIN mode has NOT been enabled.
   Note: The gain optimizer cannot be enabled in LOW GAIN mode.
9. Enable RX/CX automatic control.
10. Enable OLTC automatic control.

4.3.2 Stop Sequence

1. Disable RX/CX automatic control.
2. Disable OLTC automatic control.
3. Set voltage regulator mode to MANUAL.
4. Slowly change the SVC output to zero while controlling the DMR 132 kV bus voltage using the 230/132 kV transformer OLTC.
5. Stop the SVC. Circuit breaker 1CB16 will automatically open immediately and 1CB17 will open after 3 seconds. Thyristor cooling system will run for one minute and then shut down.

4.4 Protection

Protection for the DMR SVC consists of conventional relays that act independently of the VARMaster and protective functions that are associated with the VARMaster. In addition to tripping the SVC, VARMaster protective functions may block firing of the thyristors, maintain firing or initiate continuous firing of the thyristors.

5.0 GUIDELINES FOR ENERGIZING 5L30, 5L32, 5L29 AND 5L31

5.1 Normal Energizing

5.1.1 Energizing 5L30 And 5L32

5L30 and 5L32 are normally energized from CK5, the "LEAD" end. 5L30 and 5L32 may also be energized from MSA.

The closing of 5L30/5L32 line end breakers at MSA are supervised by a synchro-check relay set at ± 20 degrees. This applies when the parallel circuit is OOS.

Supervisory indication of 5L29, 5L30, 5L31 and 5L32 phase angle at MSA is available.

See Attachment 2, Tables 1, 2 and 3 for expected voltage rise during switching.

5.1.2 Energizing 5L29 And 5L31

5L29 and 5L31 are normally energized from MSA, the "LEAD" end. Prior to energizing a circuit from MSA, all available line reactors for that circuit at DMR, TIR and MSA should be (but not mandatory) in service. The two MSA 12 kV reactors should be (but not mandatory) in service if the MSA bus voltage is above 537 kV. Each MSA 12 kV reactor reduces the MSA 500 kV bus voltage by about 4 kV.

If the parallel circuit is in service, 5L29 or 5L31 may be energized from DMR. All available reactors should be in service at DMR and MSA.

With the parallel circuit OOS, 5L29 or 5L31 are ONLY to be energized from MSA. The closing of 5L29/5L31 line-end breakers at DMR are supervised by a synchro-check relay set at ± 18 degrees.

Telemetry of 5L29 and 5L31 phase angle and percent slip at DMR is available.

See Attachment 2, Tables 4, 5 and 6 for expected voltage rise during switching.
See Section 10 for cable alarm confirmation requirements prior to energizing following a trip out.

5.2 Emergency Energizing

When energizing 5L29, 5L31, 5L30 or 5L32 with any of the CK5-DMR or integrated system elements, OOS precautions should be taken to prevent high voltages.

5.2.1 Energizing 5L29 Or 5L31 With Parallel Circuit OOS

In this case, 5L29 or 5L31 are ONLY to be energized from MSA. The circuit may be energized from MSA when the parallel 500 kV circuit is OOS with a minimum of seven reactors connected to the circuit.

The MSA 500 kV bus voltage should be 525 kV or less if only seven reactors are available, 537 kV or less if eight reactors are available. MSA 500 kV voltage will rise by 4 kV if 5L30 and 5L32 both are in service, and by 5 kV if only one of these lines is in service. Each MSA 12 kV reactor will reduce the 500 kV voltage by 4 kV. A shunt reactor from the parallel line can also be used to reduce voltage. The circuit should be closed in as quickly as possible when the voltage difference between the open circuit and the 500 kV bus at DMR is less than 75 kV.

If MSA 500 kV voltage is above 544 kV after energizing 5L29 or 5L31, the DMR end must be synchronized in less than 8 minutes to prevent the overvoltage protection, set at 544 kV and 8 minute timing, from tripping the energized line. The system can be configured at DMR so that the line is picked up with nine reactors.

See Section 10 for cable alarm confirmation requirements prior to energizing following a tripout.

5.2.2 Energizing 5L29 Or 5L31 With Parallel Circuit OOS And 5L30 And 5L32 OOS

No restoration of 5L29 or 5L31 is to occur until 5L30 or 5L32 is returned to service. See Section 5.2.3 and Section 6.

5L29 or 5L31 **MUST NOT** be energized from DMR when there is no 500 kV connection between the LM and VI.

See Section 10 for cable alarm confirmation requirements prior to energizing following a tripout.

5.2.3 Energizing 5L30 Or 5L32 with Parallel Circuit OOS

With 5L30 and 5L32 OOS, the first circuit to be energized should be from CK5. The MSA synchro-check relay will block closing of the line circuit breakers at MSA if the voltage angle across the selected circuit breaker is greater than ± 20 degrees.
See Attachment 2, Table 3 for expected voltage rise during switching.

6.0 RESTORATION OF THE VI TO LM SYNCHRONOUS CONNECTION

1. Loss of 5L42 and 5L45 will trip 5L30 and 5L32, and 5L31 and 5L29. Synchronize VI to the LM via 500 kV lines.
2. Loss of 5L30 and 5L32 will trip 5L29 and 5L31. Synchronize VI to the LM via 500 kV lines.
3. Loss of 5L29 and 5L31 with 5L30 or 5L32 in-service. Synchronize VI to the LM via 5L29 or 5L31.

6.1 5L30, 5L32, 5L29 And 5L31 OOS

If the MSA 500/230 kV transformers are open on the high side, and cannot be closed, then a 500 kV reactor from the parallel line can be used in place of the MSA 12 kV reactors when switching a single 500 kV cable into service (see 5.1.2). Another option is to use a reactor from the parallel line at DMR thus picking up the line with nine reactors. **This should be done if MSA voltage is above 544 kV.** MSA 500 kV voltage will increase by 5.6 kV when 5L29 or 5L31 is energized. If MSA voltage is above 539 kV when 5L29 or 5L31 is energized, then synchronizing should be done within 8 or 14 minutes depending on the line otherwise overvoltage protection will trip the line. If synchronizing the 500 kV lines is a problem, the Operator should try to synchronize 2L129 first (if available).

1. If 2L129 is still in service, go to step 4.
2. If 2L129 is OOS as well, then stabilize VI frequency and voltage.
3. Check 500 kV cable alarms. If there are any cable pressure alarms then it should be investigated before the cable is energized (see Section 10). **Cable flow alarms do come up when there is no station service.** This is normal.
4. Energize one of 5L30 or 5L32 from CK5 (see Section 5.1.1).
5. 5CB1 and 5CB2 can be closed (sync bypass) to pick up MSA T1/T5 and T2.
6. 5L29 or 5L31, with eight 500 kV reactors connected should be energized at MSA (see Section 5.2.1), and switched into service at DMR. Synchronize via DMR 500 kV breaker. The DMR end closing is supervised by the synchronizing relay is set at 0.5 % slip and voltage difference of 75 kV.
7. Correct integrated system voltage.

6.2 5L29 And 5L31 OOS With 5L30 Or 5L32 In Service

1. If 2L129 is still in service, go to step 3.
2. Stabilize VI frequency and voltage.
3. Correct generation and voltage problems on the Integrated System.
4. **If there are any cable pressure alarms then they should be investigated before the cable is energized** (see Section 10). **Cable flow alarms do come up when there is no station service.** This is normal.
5. Energize 5L29 or 5L31 from MSA, with eight 500 kV reactors connected. A DMR reactor from the parallel line may be used if required (see Section 5.2.1).
6. Synchronize via DMR 500 kV breaker. The DMR end closing is supervised by the synchronizing relay is set at 0.5 % slip and voltage difference of 75 kV.
7. The parallel 500 kV circuit should be switched into service.

7.0 CIRCUIT LOADING

7.1 5L29 and 5L31

The continuous rating of each of 5L29 and 5L31 is 1321 A without shore-end cooling in service. This rating is increased to 1410 A after shore-end cooling has been in service for two weeks which is long enough to cool the buried cables on land in order to achieve this rating. If the cable shore-end cooling is restored after being OOS for 24 hours or less, the rating of 5L29 or 5L31 can resume to 1410 A. 5L29 and 5L31 can be operated above the continuous rating for a short period of time. However, the 5L29/5L31 RAS (see Section 13) will initiate sequential load shedding if the loading on the cable exceeds 1962 A at DMR for 70 seconds, or if the loading exceeds the RAS setpoint of 1410 A for 1 hour. The RAS will trip the cable if the loading on the cable exceeds 1962 A for 15 minutes. Use of the above rating is dependent on all pumping stations being in service.

In normal operation, when the ground ambient temperature is less than 11°C, there is no derating of 5L29/5L31. No forced cooling is required.

When the ground ambient temperature reading is not available, and the operating period is between November 15 and March 15, there is no derating of 5L29/5L31. No forced cooling is required.

5L29/31 Real Time Temperature And Current Monitoring

DTS (distributed temperature monitoring systems) have been installed at Nile Creek Terminal Station (NCT) and Cape Cockburn Cable Terminal Station (CCB) on the shore section of the cables. The DTS provides real-time temperature data on each cable phase to the BCHCC. This is a monitoring tool to ensure cable temperatures do not exceed the 85°C continuous thermal rating. Analog alarms have been set to initiate an Over Warning Limit alarm at 75°C and an Over Operating Limit alarm at 85°C.

Real-time current monitoring is also available to the BCHCC for each cable phase on 5L29 and 5L31 at both NCT and CCB. The measuring point for triggering 5L29/5L31 thermal overload RAS is located at DMR. The threshold is calculated by vector summing the currents into DMR bus and shunt RXs, which is very close to measuring 5L29/5L31 conductor current at NCT.

7.2 DMR T1 And T2

The continuous rating for each of DMR T1 and DMR T2 is 1200 MVA OFAF. The 20 minute overload capability for these transformers is 1860 MVA.

8.0 OPERATING PROCEDUES – OUTAGES AND SYSTEM RE-CONFIGURATION

8.1 Normal Operating Configuration

The operation strategy for loading on 5L29 and 5L31 is to keep the total MW flow on the cables to below 1450 MW which will ensure that the post-disturbance current on the remaining cable following a contingency outage of one cable will be below 1962 A, its overload rating. Recent studies support that this operating strategy will result in cable temperatures less than the thermal rating of 85°C.

The following resources can be used to keep 5L29 + 5L31 loading below 1450 MW during normal operating configuration:

- Increase transfer on 2L129 by adjusting the VIT PST MW setpoint.
- Issue Reliability Must-Run Restriction (RMR) for increased total VI dependable generation output.

Additional RMR and VAR requirements and assumptions for System Normal condition are listed in Table 1.1.1 of Attachment 1 of SOO 7T-41.

8.2 Special Operating Considerations

8.2.1 5L29 Or 5L31 Out Of Service

If 5L29 or 5L31 is forced OOS, the remaining 500 kV cable may result in moderate overload. Immediate manual operation, as listed below, is required to reduce the loading to below its continuous rating to avoid the operation of the 5L29/5L31 RAS:

- Increase VI Generation up to its maximum based on information stipulated on the daily Power Supply Plant Generation Instructions.
- Arm the VI AULS as outlined in SOO 6T-34.
- Monitor cable temperatures on the remaining circuit using DTS facilities referred to in Section 7.1.1.
- All steps should be taken including manual load shedding to ensure that cable temperatures do not exceed their continuous rating of 85°C.

When 5L29 or 5L31 is planned OOS:

- Keep all available VI generation on-line.
- Arming of the VI AULS as outlined in SOO 6T-34.
- Operate VIT bus voltage at maximum 140 kV.
- RUN VIT S/C close to -50 MVARs by switching in and out the shunt capacitor banks.
- Ensure DMR SVC in-service in automatic mode.

Additional pre-outage RMR and VAR requirements are listed in Table 1.1.2 of Attachment 1 of SOO 7T-41.

De-Energizing 5L29 Or 5L31

5L29 and 5L31 will normally be off-loaded at the follow end (DMR) and de-energized at the lead end (MSA). Open terminal transfer tripping is provided on 5L29 and 5L31, which will cause the remote end to trip when the circuit is open ended.

DMR Reactors

The reactors on the out of service circuit at DMR can be used as bus reactors. However, Operators must assess and be prepared to switch out the reactor to prevent DMR 500kV bus low voltage on loss of the remaining circuit.

8.2.2 <u>5L30 Or 5L32 Out Of Service</u>

When one of 5L30 or 5L32 is switched out in order to isolate station equipment, there are no special requirements provided that duration of the circuit OOS is less than 20-30 min, and there is no significant risk to the remaining line (i.e. no lightning activity or severe storms, etc.).

When one of 5L30 or 5L32 is planned out of service or unavailable, the following action is recommended to improve system security:

- Keep all available VI generation on-line.
- Arm the VI AULS as outlined in SOO 6T-34.
- Operate VIT bus voltage at maximum 140 kV.
- Run VIT S/Cs close to 0 MVARs by switching in and out the shunt capacitor banks.
- Ensure DMR SVC in-service in automatic mode.

Note: When 5L30 and 5L32 simultaneously or sequentially tripped, VI RAS will DTT trip 5L29 and 5L31. The RAS will prevent the Sunshine Coast (SC) load being fed from Vancouver Island and potential high voltage. See SOO 7T-41 Section 5.2.3.

More requirements are also listed for voltage stability are found in Table 1.1.4 of Attachment 1 of SOO 7T-41.

<u>De-energizing 5L30 Or 5L32</u>

5L30 and 5L32 will normally be off-loaded at the follow end (MSA) and de-energized at the lead end (CK5). Open terminal transfer tripping is provided on 5L30 and 5L32, which will cause the remote end to trip when the circuit is open ended.

8.2.3 <u>MSA Separation And Load Shedding Schemes</u>

Howe Sound Pulp and Paper – Port Mellon (HSP) and Catalyst Paper – Powell River (POW) at MSA are designed to be shed under the occurrence of any of the following events involving loss of the 500 kV connection at MSA or receipt of DTT from LM AUVLS.

	Event (Contingency Or Switching out for Planned Outages)	**Remedial Action**
1	T1 and 5L32	Trip 2L48 and Trip 2L47 if power flow is greater than 5 MW into or from HSP
2	T1 and T2	Trip 2L48 and Trip 2L47 if power flow is greater than 5MW into or from HSP
3	5L30 and 5L32	Trip 2L48 and Trip 2L47 if power flow is greater than 5MW into or from HSP
4	5L30 and T2	Trip 2L48 and Trip 2L47 if power flow is greater than 5MW into or from HSP
5	DTT received from LM Load Shed Scheme	Trip 2L48 (not in-service)

Malaspina Voltage

MSA 12RX1 and MSA 12RX2 will trip automatically when their associated high side 500 kV breakers (5CB1 and 5CB2) open. This will prevent low voltage at MSA and the Sechelt 138 kV system when there are no 500 kV connections into MSA.

8.2.4 5L30 And 5L32 Out Of Service Contingency Plan

Should both 5L30 and 5L32 fail due to a snow or earth slide or any condition that indicates a long duration outage, there is a contingency plan to supply the Sunshine Coast via a 230 kV supply from CKY. This is accomplished by energizing one of 5L30 or 5L32 at 230 kV from the CKY 2L9 position, jumper from 500 kV circuit to 1L31 west of the tap to Western Forest Products Ltd. Woodfibre Generating Station (WFR). 1L31 is built to 230 kV standards. At HSP, 1L31 is then jumpered to 2L47. The details of this contingency plan are located in the documents titled “5L30/5L32 Summary Information”, which includes drawings for the temporary by-pass, copies of which are held by Performance Planning and Operations Planning.

For contingency planning, studies show that the 230 kV bypass (using the 1L31 conductor) would be capable of transmitting 270 MW, limited by voltage constraints at HSP. Clowhom Generating Station (COM), Cheakamus Generating Station (CMS), and local IPP generation should be operated to minimize the risk of low voltage on the remaining radially operated 138 kV system, when both 5L30 and 5L32 are OOS and the VI and South Coast systems are operated separately.

The on-shift System Control Manager (SCM) should assess the field information on the status of both circuits, and to initiate the TECMP process through the Operations Planning Engineers. The TDSO Operations Planning Engineers will contact BC Hydro Asset Management to invoke Part 4.1 of the plan, for supply of the Sunshine Coast. The section discusses the 230 kV bypass circuit option. Refer also to SOO 7T-41 Section 3.

Stability studies indicate that the 230 kV bypass can be operated with one 500 kV circuit in service and the Sunshine Coast system will survive the loss of the remaining 500 kV circuit without the need to shed SC load. Automatic load shedding for POW and HSP is not required in this configuration.

8.2.5 5L42 OR 5L45 Out Of Service

When one of 5L42 or 5L45 is switched out in order to isolate station equipment, there are no special requirements provided that duration of the circuit OOS is less than 20-30 minutes, and there is no significant risk to the remaining line (i.e. no lightning activity or severe storms, etc.).

When one of 5L42 or 5L45 is OOS and unavailable, the following action is recommended to improve system security:

- Keep all available VI generation on-line.
- Arming of the VI and LM AULS as outlined in SOO 6T-34.
- Adjust VIT synchronous condenser output to close to 0 MVARS by switching in and out the shunt capacitor banks.
- Put DMR SVC in-service in automatic mode.
- With 5L45 (or 5L42) is OOS, 3-phase reclosing on 5L42 (or 5L45) is automatically blocked (see Section 9.0).

Load Shedding

VI load shedding will occur following loss of the remaining source to CK5 (5L42 or 5L45) if the VI area loads are greater than the total of VI generation plus 2L129 transfer capability.

8.2.6 2L129 Single Contingency

Losing 2L129 may cause the loading on the 500 kV cables to exceed 1450 MW. The following actions should be taken to reduce the cable loading to below 1450 MW where applicable:

- Increase VI Generation up to its maximum based on information stipulated on the daily Power Supply Plant Generation Instructions.
- The BCHCC should initiate peak shaving with industrial customers if required.
- Allow 5L29 + 5L31 MW to exceed 1450 MW. DMR T1/T2 RAS will operate and dump load if transformer is overloaded for more than 5 minutes.
- Manually shed load if required to keep 5L29 + 5L31 MW below 1804 MW.

More requirements are also listed for voltage stability in Table 1.2.8 of Attachment 1 of SOO 7T-41.

8.2.7 Multiple Contingencies

The operating strategy for multiple contingencies is to reduce the loading on the 500 kV cables that remain in-service: avoid the operation of 5L29/31 RAS by ramping up 2L129 transfer, maximize VI generation, and shed load manually if required as last resort.

9.0 AUTOMATIC RECLOSING

See SOO 5T-02 "Automatic Reclosing Facilities and Blocking Requirements" as a reference for use with the information in this section.

Remote reclose blocking for 5L29, 5L30, 5L31, 5L32, 5L42 and 5L45 is available.

Reclosing for 5L29, 5L30, 5L31 and 5L32 will normally be in Position 5. See LOO 3T-DMR-01 for more details on positions of the reclosing ON/OFF switch and the selector switch for these circuits.

5L30 and 5L32: have single phase reclosing and three-phase single shot reclosing with parallel line current and voltage supervision at MSA, the FOLLOW end.

If either 5L30 or 5L32 is OOS, there is **no** requirement to turn off the automatic reclosing for the remaining circuit.

5L29 and 5L31: have single phase reclosing and three-phase single shot reclosing with parallel line current supervision at MSA, the LEAD end, and voltage supervision at DMR, the FOLLOW end. The reclosing logic on these circuits is designed to reclose for faults on the overhead sections between MSA and CCB only. This is accomplished with two specialized relay elements. At DMR, a zone impedance element is configured to identify faults on the circuit between DMR and CCB and block reclosing at MSA, the LEAD end, by sending a non-recloseable Direct Transfer Trip signal. At MSA, arc extinction detection logic is utilized to ensure that any primary and secondary arcs associated with a fault on the MSA-CCB overhead section have extinguished before a reclose can take place. If these specific conditions are not satisfied, reclosing will not occur.

If either 5L29 or 5L31 is OOS, there is **no** requirement to turn off the automatic reclosing for the remaining parallel circuit.

5L45 and 5L42: 5L45 reclosing will normally be set in Position 5 as the circuit has single phase reclosing and three-phase reclosing. While 5L45 does not have line end reactors, 5L45 is capable of clearing secondary arcs for successful single phase reclose since the line is short (only of 67km).

5L42 reclosing will normally be set in Position 3. While the circuit has single phase reclosing facilities, there is insufficient clearing of secondary arcs because of the present configuration/components for the line end reactors. 5L42 reclosing must **never** be set for single phase reclose operations.

With 5L45 OOS, 3-phase reclosing on 5L42 is automatically blocked. 5L42 Reclosing can/should be left in Position 3. There is no need to block the reclosing manually.

With 5L42 OOS, 3-phase reclosing on 5L45 is automatically blocked. 5L45 Reclosing can/should be left in Position 5. There is no need to block the reclosing manually.

If 5L42 and 5L45 are OOS with a 500 kV connection to VI, 5L42 should be energized on a supervisory close from KLY end, as there is insufficient VI generation to control voltage from the CK5 end.

10.0 MANUAL RECLOSING OF 5L29 OR 5L31

10.1 Auto-Reclosing In ON Position

Response to circuit trip and NO auto reclose.

A Protection Engineer must be consulted to analyze why the circuit did not auto reclose and determine the health of the cable circuit. If the analysis shows that the cable circuit is OK and there are no station alarms as listed in Section 10.2 then one manual reclose may be attempted with the approval of the BCHCC Operator.

Response To Circuit Trip And Failed Auto Reclose

NO manual reclosing shall be attempted after an auto reclose failed to hold. In this case a circuit patrol must be ordered and a Protection Engineer contacted to determine the fault location. The results of the circuit patrol and the protection analysis will be used by the BCHCC in consultation with Transmission Cable Manager to determine whether a manual reclose will be attempted.

10.2 Auto-Reclosing In OFF Position

Station alarms should be examined from CCB, Texada East Cable Terminal Station (TXE), Texada West Cable Terminal Station (TXW), and NCT before a manual reclose is attempted. If a "low pothead pressure" or “frequent pumping” alarm is present on the circuit which has tripped, a supervisory manual reclose shall not be attempted.

Following confirmation of the absence of any such alarms, one supervisory close attempt may be tried if there is a known disturbance such as wind or lightning in the overhead region of the tripped circuit or kick out caused by personnel error. Otherwise, the Transmission Field Manager or their delegate must be contacted and consulted prior to attempting a reclose, **except when both circuits are OOS**. In that case ONE manual reclose may be tried in the absence of low pothead pressure alarms.

After an earthquake, if there is no pothead pressure or frequent pumping alarm, ONE supervisory close attempt may be tried. Otherwise, the Transmission Field Manager or their delegate must be contacted and consulted prior to attempting to reclose.

Reclosing into a leaking cable or pothead could, in the worst case, result in higher oil leak rates into the sea or a violent explosion of a pothead.

11.0 SYNCHRONIZING

Synchronizing facilities with synchro-check and fast/slow indication are provided at MSA and CK5. MSA 5CB1 and MSA 5CB2 do not have synchronizing facilities. At DMR, the percent slip and phase angle is telemetered to the BCHCC. Phase angle is also telemetered from MSA to the BCHCC.

The DMR end closing is supervised by the synchronizing relay is set at 0.5% slip and voltage difference of 75 kV.

12.0 PROTECTION

12.1 Line Protection

5L29, 5L30, 5L31 and 5L32 line protection consists of a primary and standby phase and ground distance directional comparison scheme supplemented by primary and standby zero-sequence current directional comparison schemes for higher resistance ground faults.

The primary and standby protections each have a separate permissive trip channel for the phase distance and directional ground protection. Failure of all four channels will result in slower clearing for line faults on the affected circuit. Telecom Network Controllers should be notified immediately and a callout initiated if required.

5L29, 5L30, 5L31 and 5L32 are equipped with open terminal transfer trip schemes which will trip the remote terminal.

12.2 MSA Transformer 500 kV Circuit Breaker Tripping

For a single phase fault on 5L30 and 5L32, the circuit breakers are tripped single phase and auto reclose, when reclosing is in position 5. MSA 5CB1 and MSA 5CB2 have been have single phase trip and reclose capability.

12.3 Overvoltage Protection

The maximum voltage for continuous operation of 5L29 and 5L31 is 544 kV. For voltages > 544 kV, overvoltage tripping will occur. See SOO 7T-22 for more detailed information on the overvoltage protection settings for these circuits.

12.4 Reactor Protection

12.4.1 Dunsmuir (DMR)

The 500 kV reactor protection at DMR will trip the associated line, 5L29 or 5L31. Re-energizing of the associated line is blocked until the faulted reactor has auto-isolated.

12.4.2 Malaspina (MSA)

The 500 kV reactor protection at MSA will trip the associated line 5L29 or 5L31. Re-energizing the associated line is blocked until the faulted reactor has auto-isolated.

MSA 12RX1 and MSA 12RX2 reactor protection will trip the associated transformer protection zone. Closing of the transformer zone circuit breakers is blocked until the reactor has auto-isolated.

12.4.3 Texada Island Reactor (TIR)

5L29 and 5L31 are each connected to three banks of single-phase reactors at TIR. These nine single-phase reactors, comprising the three reactor banks at TIR, each have primary and standby protection and single-phase reactor disconnects.

Operation of any reactor protection will trip the associated circuit. Re-energization of the associated line will be blocked until the faulted single-phase reactor has auto-isolated. Remote indication of the reactor protection operation will be sent to the BCHCC via supervisory. The reactor loading on the circuit should be balanced on a three-phase basis, by switching OOS a single-phase reactor on each of the other two phases prior to returning the circuit to service.

All TIR reactors have surge arrestors. For each circuit, there must be at least one surge arrestor per phase in service.

12.5 Auto-Isolation And Transfer Tripping

Auto-isolation of the 500 kV reactors at TIR and MSA, following a protection operation, is delayed by 10 seconds due to the long circuit voltage ring-down time. The DMR auto-isolation delay is 2 seconds.

The 500 kV reactor protection at MSA, DMR and TIR sends a transfer trip to the remote terminal of the associated circuit to clear reactor faults. There are transfer trip channels from MSA to DMR, DMR to MSA, and TIR to MSA and DMR. The MSA and DMR transfer trip channels are also used for line protection, open-terminal transfer trip and breaker failure protection.

12.6 Over Frequency (O/F) Protection

ICG O/F trip setting is 64 Hz and 0.5 sec.

O/F Auto Load Restoration is installed in four stations on VI. Refer to SOO 6T-32 for details of the load restoration program.

13.0 5L29/5L31 REMEDIAL ACTION SCHEME (RAS)

The 5L29/5L31 RAS must be normally be continuously armed. The BCHCC has control over the arming and disarming. Normally, the RAS will be armed by TSA-PM to a fixed pattern for location blocks and timing as prescribed in Attachment 3 of this System Operating Order. The recommended shedding pattern may be changed to support outages or operational needs, with direction provided in a Daily Operating Plan for manually arming.

The 5L29/5L31 RAS installed at DMR is designed to protect the 500 kV cables on 5L29 and 5L31. This protection will prevent the cables from being damaged by excessive load, in the event of loss of a parallel circuit during contingency situations. The scheme will first shed load at various VI locations, and will eventually trip the line if load current is not reduced below the overload rating.

The 5L29/5L31 RAS monitors cable current on each circuit using two SEL-351 overcurrent relays ("50L1" and "50L2"). The cable current on each circuit is calculated by taking the vector sum of the current entering DMR on the circuit and the current of the shunt reactors at DMR connected to the circuit. Cable protection consists of load shedding with:

- a slow trigger (following a 1 hour delay) for moderate overloads; and
- a faster trigger (following a 70 second delay) for severe overloads; and
- direct tripping of the line (after a 15 minute delay) if severe overloading persists.

If cable overload current is moderate (greater than cable rating of 1410 A/circuit), a **"Slow Load Shed Timer On"** alarm will occur. If the current remains above 1410 A for 1 hour, a load shed signal will be keyed to VIT, which in turn will initiate shedding of customer load in sequential blocks. The load-shed signal will remain keyed until the cable current drops below 1410 A/circuit. Either of the two overcurrent relays on a line can individually initiate load shedding.

Whenever load shedding occurs due to moderate overloads for 1 hour, a **"Dynamic Overload Capability Exhausted"** alarm will occur and will remain in effect for 48 hours. During this 48 hour period, load shedding will occur immediately when current exceeds 1410 A/circuit (i.e. the 1-hour timer is bypassed). This is to prevent cumulative damage to the cables through a series of overloads that would ratchet the cable temperature upwards.

If cable overload current is severe (greater than 1962 A/circuit for more than 10 seconds), "a **"Severe Cable Overload"** alarm will occur, which will be accompanied by a fast trigger of the load shedding after 60 seconds (i.e., 70 seconds after the cable overload current exceeds 1962 A/circuit). The fast load shed signal will remain keyed until current drops below 1800 A, or if an elapsed time of 2 minutes expires, whichever occurs first. If current remains above 1962 A for 15 minutes, direct tripping of the line will occur. **Both of the overcurrent relays for a line must call for a trip in order for one to occur**.

NOTE: If there is a cable shore-end cooling or oil-pumping station alarm, the RAS scheme must be put in a DERATED mode by the BCHCC, either by supervisory control or done locally at DMR (the RAS does not change to DERATED mode automatically). The DERATED mode reduces the moderate overload setting to 1321 A.

Refer to SOO 2T-34C for more details on the 5L29/31 RAS.

Refer to Attachment 3 of this SOO for further information on the forecasted loads for summer and winter peaks for the block locations, recommended arming timing, and cumulative load shedding totals for each timing block.

13.1 RAS Alarms

The following RAS alarms are sent to the BCHCC:

Dynamic Overload Capability Exhausted
The cable has had a thermal overload. Further overloads will result in immediate load shedding. This resets in 48 hours but no overloads are allowed until the Transmission Resource Manager authorizes them in consultation with Engineering.

Slow Load Shed Timer Started
VI load shedding will start in 1 hour unless the cable current is reduced below the set point of 1410 A for NORMAL mode or 1321 A in DERATED mode.

Severe Cable Overload
Indicates the cable current exceeded 1962 A for 10 seconds. VI load shedding will start 60 seconds after this alarm occurs, and the circuit will trip if alarm not reset within 15 minutes.

50L1 Derated or 50L2 Derated
The RAS had been placed in the DERATED mode (1321 A setting) by the BCHCC supervisory or at the station panel at DMR. Four alarms will annunciate: one for each relay on each circuit.

14.0 CABLE OIL SYSTEMS AND PUMPING STATIONS

5L29 and 5L31 have single-phase oil-filled submarine cables. For each circuit, there are three cables across Malaspina Strait (CCB - TXE), and three cables across Georgia Strait (TXW - NCT). No spare phase is provided.

The cables are manufactured by Pirelli and by STK. The Pirelli cables are filled with synthetic oil and the STK cables with mineral oil:

5L29 cables: A-phase = Pirelli
B-phase = Pirelli
C-phase = STK
5L31 cables: A-phase = STK
B-phase = Pirelli
C-phase = STK

There is an oil pumping station at each of the four cable terminals (CCB, TXE, TXW, and NCT).

Each pumping station has two pumping plants, one for the Pirelli cables and one for the STK cables. Both pumping systems are similar. When the cables are energized, the pumping plants operate in the pressure mode to maintain adequate pressure for electrical insulation and to prevent the ingress of water should the cable leak.

The pumping plants operate in the flow-limiting mode when the cables are de-energized. Flow limiting takes place in progressive steps so that adequate pressure is maintained during the cable cool down period, even if the cable is completely severed. **Do not override the flow limiting mode. This is especially critical during the cable cool down period.**

Note: The pumping plants can supply oil to a severed cable for a minimum of 30 days.
Note: Load shall not be applied to a cable from the de-energized state with only one pumping plant functional for each crossing.

The pumping plant at either end of each cable section is capable of maintaining adequate pressure on its own. However, load shall not be applied from the de-energized state with only one pumping plant function for each crossing, otherwise maximum allowable cable oil pressures could be exceeded, unless special steps are taken by pumping plant maintenance crews. If the pumping plants at both ends of a cable fail, i.e. due to loss of station service at both pumping stations, the cable pressure should be closely monitored and action taken to restore the pumping plants as soon as possible.

The cable loading should be held constant, if possible, when both pumping plants for a cable section are OOS. Reduction in cable loading will lower the cable oil pressure as the cable cools. If the oil pressure falls below minimum levels, the cables shall be de-energized.

The BCHCC grid desk has supervisory control and indication, including alarms, for the four oil-pumping stations. The transmission desk must be notified without delay of any alarms that indicate a requirement to de-energize the circuit.

Operation of the pumping stations is detailed in LOOs 3T-CCB-01, 3T-TXE-01, 3T-TXW-01 and 3T-NCT-01.

15.0 CABLE OIL LEAK OR LOW OIL PRESSURE ALARM

Do not override the flow limiting mode. This is especially critical during the oil leak to protect the cable by preventing moisture or water getting into the cable. The system designed is such that it is okay to leak the oil into the water to protect the cable. The Operator should monitor the automatic scheme and should only override the scheme if it is not working correctly, i.e. the timer fails to shut off the oil valve after many hours. The timers must not be bypassed to close the valve.

16.0 REVISION HISTORY

Revised by	Revision Date	Summary of Revision
Bob Cielen/ YanLing Cong	09 November 2018	• Section 8.2.4 clarified. • Section 8.2.5 revised to remove reclose position recommendations and add reference to Section 9.0 • Section 9.0 revised to restore statements about 3 phase reclosed blocking, provide technical rational, and re-organize and format the section.
YanLing Cong/ Ehson Syed	19 January 2019	• Section 1.0 - added SOO 2T-34C to reference listing. • Section 8.2.1 rewrite DMR reactor operation • Section 13 added reference to SOO 2T-34C for 5L29/31 RAS.
YanLing Cong	13 May 2020	• Section 8.2.3 update MSA separation RAS to clarify 2L47 tripping condition --- 2L47 power flow exceeding 5MW either into or from HSP.
Bob Cielen/ Lili Bu/ Yingwei Huang/ YanLing Cong	23 November 2021	• Replaced Appendices with Attachments. • Added Attachment 3 for 5L29/31 OL RAS • Sections 7.1, 8.1, and 13.0: updated 5L29/5L31 ratings and RAS action settings.
Lili Bu/ YanLing Cong	24 June 2022	• Section 1.0 updated for Definitions • Section 13.0 revised for new TSA-PM arming of the recommended load shedding pattern. • Attachment 3 Table 3.2 has been revised for the new TSA-PM arming. Figure 3 has been replaced with a recent screen capture.

ATTACHMENT 1 – REACTIVE EQUIPMENT FOR VOLTAGE CONTROL

The following reactive equipment has been installed for voltage control on 5L29 and 5L31:

DUNSMUIR (DMR)

Station equipment	5L29	5L31
	5RX1 (135 MVAR, 525 kV) 5RX2 (135 MVAR, 525 kV) 5RX3 (135 MVAR, 525 kV) 5RX4 (135 MVAR, 525 kV)	5RX5 (135 MVAR, 525 kV) 5RX6 (135 MVAR, 525 kV) 5RX7 (135 MVAR, 525 kV) 5RX8 (135 MVAR, 525 kV)

MALASPINA (MSA)

Station Equipment	5L29	5L31
12RX1 (75 MVAR) 12RX2 (75 MVAR)	5RX1 (135 MVAR, 525 kV),	5RX2 (135 MVAR, 525 kV),

TEXADA ISLAND REACTOR (TIR)

5L29			5L31		
A Ø	**B Ø**	**C Ø**	**A Ø**	**B Ø**	**C Ø**
5RX1,	5RX2,	5RX3	5RX4	5RX5	5RX6
5RX11,	5RX12,	5RX13	5RX14	5RX15	5RX16
5RX21*	5RX22*	5RX23*	5RX24	5RX25*	5RX26*
1. These are single-phase reactor banks each rated 45 MVAR, 525 kV 2. These reactor banks cannot be switched under load. Note: * There are no surge arrestors on these single-phase reactors.			1. These are single-phase reactor banks each rated 45 MVAR, 525 kV 2. These reactor banks cannot be switched under load. Note: * There are no surge arrestors on these single-phase reactors.		

ATTACHMENT 2 – EXPECTED VOLTAGE RISE TABLES

The following tables indicate the voltage rises that will occur when 5L30, 5L32, 5L31 and 5L29 are energized, and the effect of various system conditions on these voltage rises. The tables list the change in voltage at the energizing bus and the difference between the circuit open-end voltage and the energizing bus voltage, following energization.

Table 1: Energizing 5L30 or 5L32 from CK5 with Parallel Circuit in Service

Equipment OOS	Rise in CK5 Bus Voltage	Voltage Difference Between Circuit Open-End and CK5 Bus (Ferranti Rise)
None	3 kV	3 kV
5L29 or 5L31	4 kV	3 kV
5L29 & 5L31	5 kV	3 kV
5L45	8 kV	3 kV

Table 2: Energizing 5L30 or 5L32 from MSA with Parallel Circuit in Service

Equipment OOS	Rise in MSA Bus Voltage	Voltage Difference Between Circuit Open-End and MSA Bus (Ferranti Rise)
None	5 kV	3 kV

Table 3: Energizing 5L30 or 5L32 from CK5 with Parallel Circuit O.O.S.

Equipment OOS	Rise in CK5 Bus Voltage	Voltage Difference Between 5L30 Open-End and CK5 Bus (Ferranti Rise)
5L30 or 5L32	5 kV	3 kV
5L30 or 5L32 & 5L41	5 kV	3 kV
5L30 or 5L32 & 5L42	6 kV	3 kV
5L30 or 5L32 & 5L45	10 kV	3 kV

Table 4: Energizing 5L29 or 5L31 from MSA with Parallel Circuit in Service

Equipment OOS	Rise in MSA Bus Voltage	Voltage Difference Between Circuit Open-End & MSA Bus (Ferranti Rise)
None	4 kV	0 kV
5L30 or 5L32	4 kV	0 kV
1 DMR RX of energized circuit	11 kV	4 kV
2 DMR RX of energized circuit	18 kV	9 kV

Table 5: Energizing 5L29 or 5L31 from DMR with Parallel Circuit in Service

Equipment OOS	Rise in DMR Bus Voltage	Voltage Difference Between Circuit Open-End & MSA Bus (Ferranti Rise)
None	5 kV	2 kV
1 DMR RX of energized circuit	12 kV	2 kV
1 MSA RX of energized circuit	14 kV	6 kV
2 DMR RX of energized circuit	23 kV	2 kV

Table 6: Energizing 5L29 or 5L31 from MSA with Parallel Circuits O.O.S.

Equipment OOS	Rise in MSA Bus Voltage	Voltage Difference Between Circuit Open-End & MSA Bus (Ferranti Rise)
5L29 or 5L31	4 kV	0 kV
5L29 or 5L31 & 5L30	5 kV	0 kV
5L29 or 5L31 & 1 DMR RX of energized circuit	12 kV	4 kV

ATTACHMENT 3 – 5L29/31 OL RAS Load Blocks and Timing

Table 3.1 The 5L29/31 OL RAS - Forecast Loads by Load Block[Note1]

Substation Load Blocks Note 5	Load Shed Actions Note 4	MW Load (Summer)	MW Load (Winter)	Area
CFT-A	CFT 6 Grinders (Trip CBs)	80	80	CVI
KTG-A	25 kV feeders: KTG 25CB111-115, 121-123	29.5	75.4	SVI
ESQ-A	12 kV feeders: ESQ 12CB7, 10, 21, 40, 51-58, 72	38.9	79.0	SVI
GOW-A&C	25 kV feeders (50 series): GOW 25CB1, 2, 10	48.2	82.1	SVI
KTG-B	Shed KTG 60 kV (SNY Loads): KTG 60CB1, 2, 3, 4	25.7	71.4	SVI
GTP-A	25 kV feeders (40 series): GTP 25CB11, 13	20.7	56.5	SVI
GTP-B	25 kV feeders (50, 60 series): GTP 25CB12, 14, 21, 22	46	79.1	SVI
HSY-A	12 kV feeders (60, 300, 400 series & 12kV Capacitors): HSY 12CB4, 32, 31, 33, 36, 38	46.1	80.6	SVI
HSY-B&C	12 and 25 kV feeders (50,70,80, 100, 200 series) : HSY 12CB4, 34, 35, 37, 25CB1, 2, 10	70.4	133.4	SVI
PAL-B	25 kV feeders (all): PAL 25CB11, 12	40.8	59.9	CVI
PVO-B	PVO capacitors: PVO 1CB25, 26, 27	-	-	CVI
PVO-A	25 kV feeders except 25F51 (hospital) and including LCW Station: PVO 25CB52-57, 60CB3	42.5	61.6	CVI
NFD	All feeders except 25F54 (hospital): NFD 25CB50-53, 55-56, 60-66	58.9	94.6	CVI
CLD	25 kV feeders: CLD 25CB51-58, 61-63, 71-78, 81-83, 23, 24	77.3	138.0	SVI
SNY Note2	25 kV Feeders excluding SNY 25F54 & 65 (BC Ferries, airport): SNY 25CB22, 53, 55,62-64, 66	22.5	62.5	SVI
KSH	25 kV Feeders: KSH 25CB2, 3	35.4	58.3	CVI
SHA	25 kV Feeders: SHA 25CB1, 2	23.9	48.1	CVI
QLC	25 kV Feeders excluding QLC 25F52 (medical clinic): QLC 25CB51, 53, 61, 62	21.2	42.6	CVI
LTZ	25 kV Feeders: LTZ 25CB111-114, 121-124	43.9	66.2	CVI
CMX	25kV Feeders excluding 25F31, 25F32 and 25F36: CMX 25CB33, 34, 35, 37, 51, 52	42.5	80.1	NVI
LDY	25 kV Feeders excluding LDY 25F53 & 65 (medical clinic, BC Ferries): LDY 25CB51, 52, 55, 63, 64	29.3	52.4	CVI
HWD	25 kV Feeders excluding HWD 25F51 (Duke Point Ferry), HWD 25F38 (health clinic on Gabriola Island) and HWD 25F36 (Nanaimo Airport): HWD 25CB31-35, 37, 52	32.6	54.5	CVI
	Total Eligible Load Note3	853.8	1493.8	

Note 1: Based on 2021 Vancouver Island Load Forecast F22 Winter/Summer Ref Values Uncompensated Station Peak with DSM.
Note 2: SNY Block pro-rated as 7/8 of station forecast load.
Note 3: Total Eligible Load excludes SNY as it is previously counted under KTG-B block.
Note 4: Refer to SOO 2T-34 Appendix 2 "RAS General Description", Section 5.14 "Action Outputs" table for source information.
Note 5: Station blocks ordered as displayed in EMS 7T-40 5L29_31 OVERLOAD RAS display.

Table 3.2 5L29/31 OL RAS - Shedding Blocks– Recommended Timing/Cumulative Load

This table provides the recommended timing block order for TSA-PM arming and manual arming the load shedding for the 5L29/31 OL RAS. The arming blocks start significantly large due to the non-linear nature of the MW/Amp relationship for the cable transfers. The amount of forecast load for each timing block and the accumulated load shedding is listed in the table (see Note 1 & 2).

Timing Block	Substation Load Block to be armed:	Block Load MW Value	Cumulative Load Shed Note 1
0s	CFT-A	373.0	373.0
	KTG-A		
	ESQ-A		
	GOW-A&C		
	GTP-A		
2s	GTP-B	293.1	666.1
	HSY-A		
	HSY-B&C		
4s	PAL-B	275.3	941.4
	NFD		
	SNY		
	KSH		
6s	CLD	204.2	1145.6
	LTZ		
8s	SHA	182.7	1328.3
	CMX		
	HWD		
10s	KTG-B Note 2	165.5	1493.8
	PVO-B		
	PVO-A		
	QLC		
	LDY		

Note 1: Based on forecasted Winter Load from Table 3.1.
Note 2: KTG-B load excludes loads previously shed at SNY.

Figure 3.3 EMS RAS Display

The figure below is an example of the layout for the 7T-40 5L29/31 OVERLOAD RAS display. This sample display is for information only. The display does not prescribe the actual settings for real time use.