



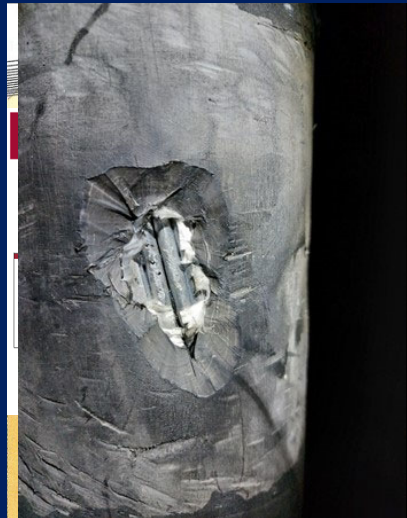
Manapouri 220kV Cable Fault & Repairs

Luke Reisima
Electrical Engineer



YARN SCHEDULE:

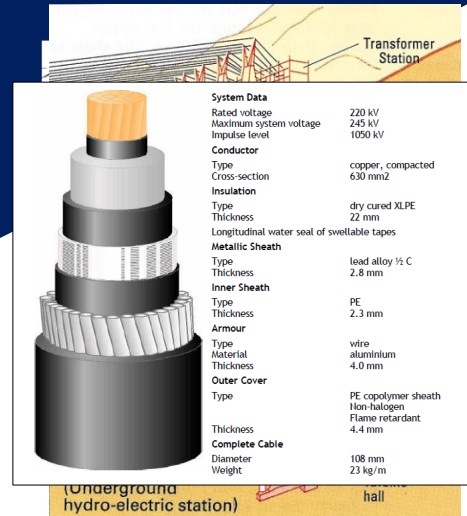
1. Background
2. Initiating fault
3. Cable damage
4. Fault locaiton
5. Repair



BACKGROUND:

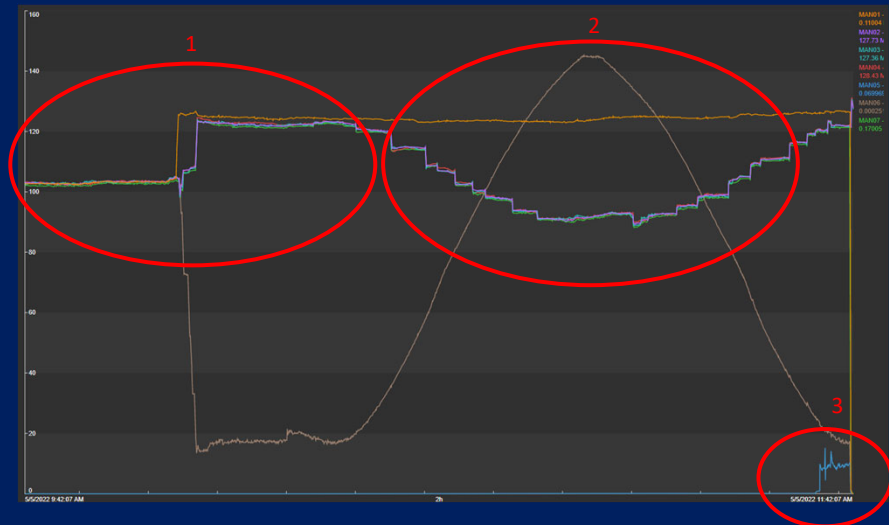
Manapouri power station

- 200m underground
- Seven generating units
- Each units GSU Tx located under ground
- Seven vertical cable shafts to AG ODS
- Single core 630mm² Cu XLPE SWA

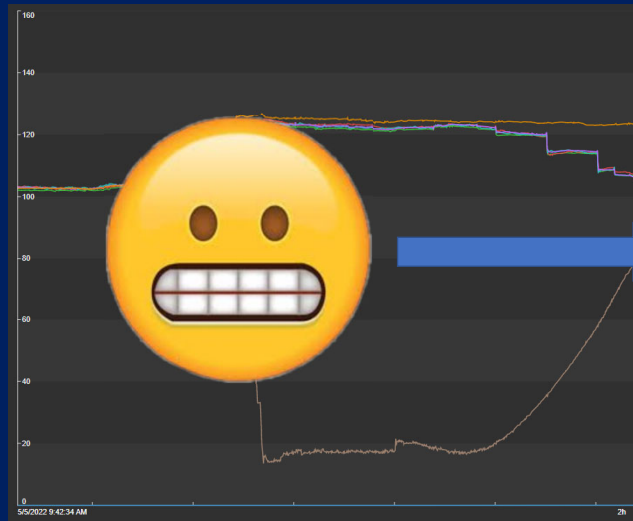


Initiating fault (Pre-Fault)



1. Units 1,2,3,4 & 7 at full load
2. Unit 6 on wicket gate ramp testing
3. Unit 5 returned to TWD



Initiating fault (Pre-Fault)



Initiating fault (Fault)

Excursion Notice

To: Excursion NZ Participants	From: The System Operator
Sent: 05-may-2022 12:01	Telephone: 0800 488 500
Ref: 4324388401	Email: NMDData@transpower.co.nz

Revision of:

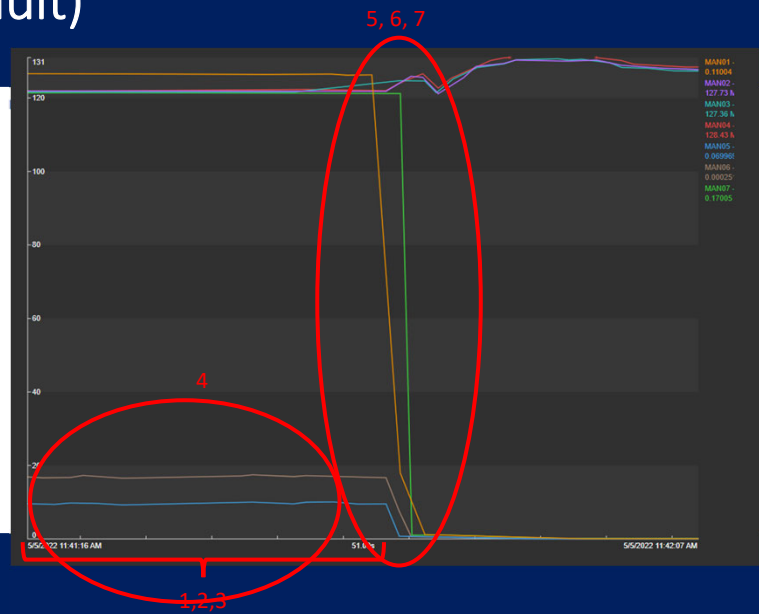
Excursion:	Frequency		
Time:	05-may-2022 11:41		
Location:	National		
Affected Plant:			
SI Hz Level:	48.97	NI Hz Level:	49.21
Comments:	Manapouri generation tripped.		

Frequency Excursion notices are only issued if the deviation is out side 49.5 and 50.5 Hz.



Initiating fault (Fault)

1. Units 1,2,3,4 & 7 at full load
2. Unit 6 on wicket gate ramp testing
3. Unit 5 returned to TWD
4. Unknowingly, unit 5 sheath voltage charges up
5. Sheath voltage breaks down insulation and shorts to earth
6. EGVR causes damage to Airpax speed relays
7. Units 1, 5, 6 & 7 trip
8. SI grid frequency drops to 48.5Hz



Initiating fault (Fault cause)

Isolations not returned for service:



Bolted earth
(shown test fitting new bolt for padlocks)



Sheath voltage limiters
(correctly in service position)



Initiating fault (damage)

		Test Conditions								
Weather Humidity		Unknown	Air Temperature				18 UNDERGROUND °C			
		40 %	Oil Temperature							
		Test Results								
No	Test ID	L Circ. C Desc.	kV	mA	Watts	Meas. %PF	Corr. Fctr	Corr. %PF	Cap./ Ind.	R T
1	Red Phase	B GAR-RB	10.00	133.223	0.545	0.041	1.00	0.041	42839.00 pF	
2	IR 1 MIN 49.8 g						1.00			
3	IR 10 MIN 53.8 g						1.00			
4	PI						1.00			
6	Yellow Phase	B GAR-RB	10.00	132.826	0.456	0.034	1.00	0.034	42712.70 pF	
7	IR 1 MIN 38.7g						1.00			
8	IR 10 MIN 63.7G						1.00			
9	PI 1.65						1.00			
11	Blue Phase	B GAR-RB	10.00	133.964	0.446	0.033	1.00	0.033	43075.95 pF	
12	IR 1 MIN 99.9G						1.00			
13	IR 10 MIN 62.2G						1.00			
14	PI 0.62						1.00			

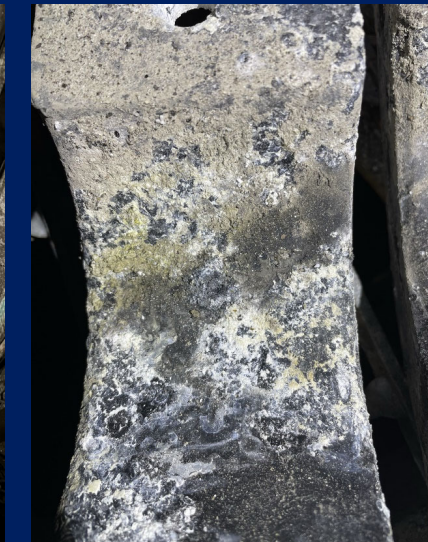
Sheath megger results ...

Red phase: 5V
 Yellow phase: 17V
 Blue: 23V

Core Doble results ✓




Yeah



Na

->

Cable Damage
 (Corrosion)



Cable Damage
(Pitting)



Absolutely nothing

Cable Damage
(Visual inspection)

Cable testing (AKA – doing it properly)

Fault location
(Pre location)

When Cable testing (This time we are actually doing it properly)

Fault location
(Pre location)

Murray method

*Murray balance circuit*²

*Murray fault location circuit*²

Murray test set up using Baur Shirla¹

Meridian.

¹ <https://hvtechnologies.com/cable-sheath-fault-location-using-bridge-methods/>
² Tobias Neier. (2013). BAUR Cable Fault Location in LV, MV & HV Underground cable networks (Practical Experience)

Wheatstone Bridge (Glasser method)

*Glasser balance circuit*²

*Glasser fault location circuit*²

Glasser test set up using Baur Shirla¹

¹ <https://hvtechnologies.com/cable-sheath-fault-location-using-bridge-methods/>
² Tobias Neier. (2013). BAUR Cable Fault Location in LV, MV & HV Underground cable networks (Practical Experience)

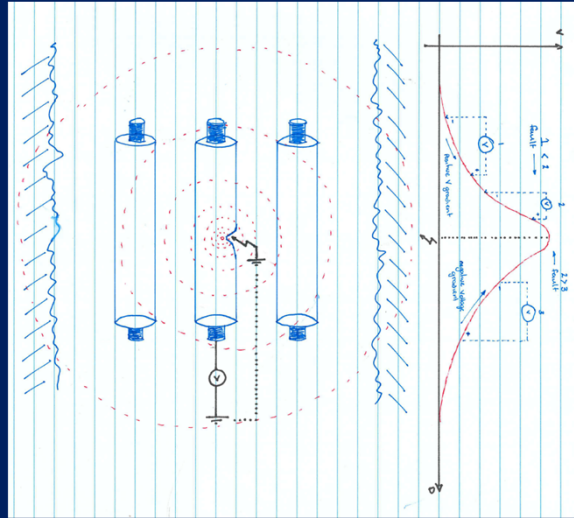
Time Domain Reflectometry (TDR)¹

Fault location (Precise location)

¹ Tobias Neier. (2013). BAUR Cable Fault Location in LV, MV & HV Underground cable networks (Practical Experience)

Step voltage

Fault location
(Precise location)



Cable Faults (Blue Phase)



Cable Faults (Red and White Phases)



Cable Repairs



Cable Repairs



Cable Repairs

Megger results ✓

- R: 9.3MΩ
- Y: 9.3MΩ
- B: 15.1MΩ

Doble results ✓

Test Results											
No	Test ID	L	Circ.				Meas.	Corr.	Corr.	Cap./	R
		C	Desc.	kV	mA	Watts	%PF	Fctr	%PF	Ind.	T
1	Red Phase	B	GAR-RB	10	133.208	0.388	0.029	1	0.029	42831.70	pF
2	IR 1 MIN 173 Gohms									1	
3	IR 10 MIN 229 Gohms									1	
4	PI 1.32									1	
6	Yellow Phase	B	GAR-RB	10	132.821	0.367	0.028	1	0.028	42706.00	pF
7	IR 1 MIN 231 Gohms									1	
8	IR 10 MIN 288 Gohms									1	
9	PI 1.25									1	
11	Blue Phase	B	GAR-RB	10	133.96	0.433	0.032	1	0.032	43075.40	pF
12	IR 1 MIN 219 Gohms									1	
13	IR 10 MIN 199 Gohms									1	
14	PI 0.91									1	



How do we not do this again?



Thank You!
Questions?

