



Penrose Circuit Overload Protection Scheme Overview

Purpose of the Document This document provides an overview of the Penrose Circuit Overload Protection Scheme (COPS).

System Need Penrose is supplied through three 220 kV circuits:

- Otahuhu–Penrose–5
- Otahuhu–Penrose–6
- Pakuranga–Penrose–3

Penrose can also be supplied through the 110 kV Otahuhu–Penrose–2 circuit, which is normally open at Penrose (i.e. carrying no load).

From Penrose, power is supplied to:

- the 33 kV grid exit point, through four 220/33 kV transformers
- Vector’s two 110 kV cables to Liverpool Street substation, through two 220/110 kV transformers
- Hobson Street and onto Wairau Road and Albany substations, through Transpower’s 220 kV cable from Penrose, Hobson Street and Wairau Road to Albany (the “NAaN” cable).

When one of the three 220 kV circuits that supply Penrose is out of service, the tripping of another circuit may overload either the Otahuhu–Penrose–5 or 6 circuit.

The overloading could be avoided by:

- constraining (limiting) the maximum load offtake at Penrose and substations in north Auckland and Northland pre-contingency, or
- splitting the system to prevent power from north from Penrose (opening the Penrose 220/110 kV transformers and 220 kV Penrose–Hobson Street cable circuit) and constraining (limiting) the maximum load offtake at substations in north Auckland and Northland).

Alternatively, the overloading can be avoided by splitting the system post-contingency, avoiding the need for pre-contingency load constraints.

Purpose of the Scheme To allow unconstrained pre-contingency load offtake when a 220 kV circuit supplying Penrose is out of service (Otahuhu–Penrose–5 or 6, or Pakuranga–Penrose–3) by managing post-contingency overloading on Otahuhu–Penrose–5 or 6.

When to Enable the Scheme

The Penrose COPS is enabled when one of the following 220 kV circuits is out of service:

- Otahuhu–Penrose–5
- Otahuhu–Penrose–6
- Pakuranga–Penrose–3

The following system configuration is also required in conjunction with enabling the Penrose COPS:

- Vector’s 110 kV CBD system is connected to both Penrose and Hobson Street or connected to both Penrose and Mount Roskill
- The 220 kV Penrose R862 series reactor (on the Hobson Street–Penrose circuit) is in service (NOT bypassed)
- The 110 kV Otahuhu–Penrose–2 circuit is out of service.

When to Disable the Scheme

The Penrose COPS is normally disabled when all three 220 kV circuits are in service (i.e. Otahuhu–Penrose–5 and 6, and Pakuranga–Penrose–3).

The scheme can also be disabled if one of the above 220 kV circuits is out of service, and the System Operator’s modelling tools indicate there is no risk of post-contingency overloading of the remaining 220 kV circuits.

Overview of the Scheme

When one of the two 220 kV Otahuhu–Penrose circuits and the 220 kV Pakuranga–Penrose circuits are out of service, the remaining in-service 220 kV Otahuhu–Penrose circuit supplies:

- the 33 kV grid exit point, through four 220/33 kV transformers
- Vector’s two 110 kV cables to Liverpool Street substation, through two 220/110 kV transformers
- Hobson Street to Wairau Road and Albany substations, through Transpower’s 220 kV cable from Penrose, Hobson Street and Wairau Road to Albany (the “NAaN” cable).

This may overload the remaining in-service 220 kV Otahuhu–Penrose circuit.

The Penrose COPS reduces the loading on the remaining in-service Otahuhu–Penrose circuit by:

- Opening the two 220/110 kV transformers (T6 and T10), disconnecting supply from Penrose to Vector’s 110 kV cables to Liverpool substation. Liverpool Street substation continues to be supplied from either Hobson Street or Mount Roskill.
- Opening the 220 kV Hobson Street–Penrose circuit, disconnecting supply from Penrose to Hobson Street, Wairau Road and Albany. Supply is maintained to these substations through the 220 kV Otahuhu–Henderson–Huapai–Albany transmission corridor.

The remaining in-service 220 kV Otahuhu–Penrose circuit then supplies only the Penrose 33 kV load through the Penrose 220/33 kV supply transformers.

Relay settings

The Penrose COPS has only summer and winter settings; no shoulder setting is available. The summer settings are used when the shoulder season applies.

Circuit	Season	COPS operate level (amps)	Recommended maximum pre-contingency loading (amps)	Line rating (Amps)
Otahuhu–Penrose–5 and 6	Summer	1224	1163	1231
	Winter	1284	1220	1292

Additional information

The Pakuranga–Penrose circuit is rated 2294/2294/2449 amps (874/874/933 MVA) summer/shoulder/winter. This is considerably higher than the Otahuhu–Penrose–5 and 6 circuits, rated at 1231/1262/1292 amps (469/481/492 MVA) summer/shoulder/winter. Therefore, the Pakuranga–Penrose (cable) circuit does not require a special protection scheme to manage its loading.

The 220 kV Penrose R862 series reactor (on the Hobson Street–Penrose circuit) is in service (NOT bypassed), to reduce power flow on the circuit out from Penrose. This in turn reduces the power flow on the three circuits into Penrose (Otahuhu–Penrose–5 and 6, Pakuranga–Penrose), and so reduces the probability the Penrose COPS will need to act.

Other supporting information

There are a number of special protection schemes involving Penrose:

- Penrose COPS (this overview)
- Penrose Reactor Bypass Scheme
- Penrose Transformer Overload Protection Scheme (220/33 kV supply transformers)

The Penrose COPS operates independently of the other schemes.