GROUNDLINE

Memo – Transpower Standard 220kV GIP

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Company:	Transpower	**Company:**	Groundline Engineering		
Subject:	**220kV Grid Injection Point Development**				

1. Background

Transpower engaged Groundline to carry out a study to standardise 220 kV Grid Injection Point (GIP) which includes support and input for the line's component of this design. The substation component is not in scope for this study.

This study is to standardise the below options:

- Grid Injection Point of a single circuit from a double circuit (DC) 220kV line.
- Grid Injection Point of a single circuit from a single circuit (SC) 220kV line.

2. Design Criteria

To maximise the vertical loads and conductor swings of GIP, the line will be designed with the following input:

Table 1: Design Parameters

Design Parameter	Description and/or Minimum Requirement
Altitude Assumed for Design Criteria	Structure groups will be defined as follows: 0-800m (S Zone – Snow and Ice Zone)
Maximum Wind	Wind Region - A7 -46m/s 300-year return period to tower line 300-year return period to pole
Snow and Ice Zone	S - NA
Snow and Ice	S – Extreme Snow 3cm S – Extreme Ice 5.5cm
Minimum Temp	-14 degrees
Maximum Operation Temperature (MOT)	120 degrees
GIP Cable	Duplex Zebra - 460mm Spacing
Tensions	VDC %2.5 – 3.3kN
Span	80m – Between Gantry Centre to Tower Centre
External Clearances	TP12.02 – To Ground - 7.5m+0.5m=8.0m TP12.02 - To Substation Building – 6.0m+0.5m =6.5m
Outages	Only single circuit outages are possible on this line.

- Loads were generated from Transpower's "*WC & LC Generator Master Rev H"* which is part of this document *"NZ-6485_GIP_Standard_GIP-PLS-CADD WC & LC Generator Master Rev H_rev0a."*

3. GIP Layout

The substation and gantry structures are placed based on a preliminary substation layout from Transpower. The GIP structures are placed 80m from 220 kV substation gantries in both the single circuit (SC) and the double circuit (DC) configurations. The distance between the gantries is 40 m as shown in **Figure 1**.

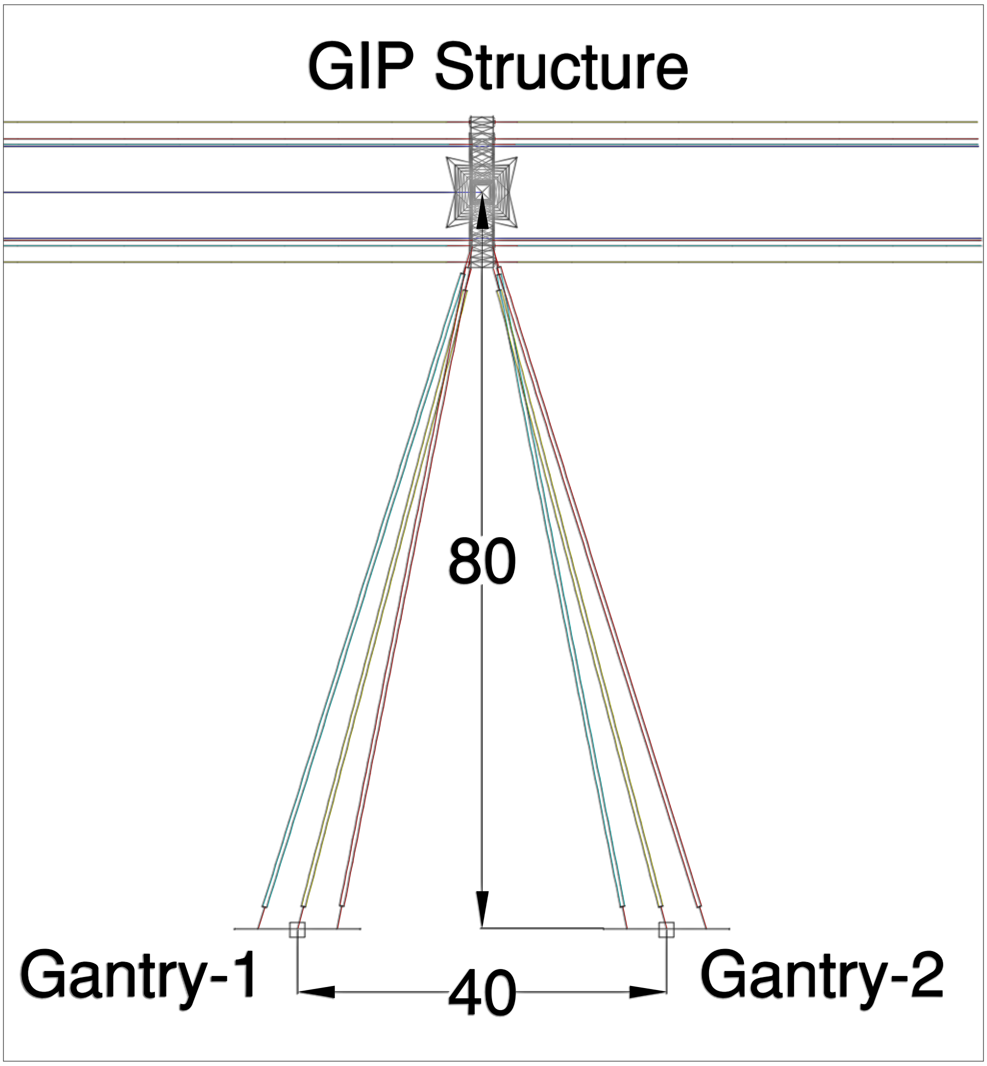

Figure 1: GIP General Layout

A general layout drawing is attached to this report for all investigated options.

4. Structure Information

A 2DD-HST structure is selected for this study with following configurations:

- Six crossarms configuration for double circuit GIPs.
- Nine crossarms configuration for (Jockey arm) for single circuit GIPs.

This structure incl. configurations have been used in previous projects.

A pole can be used as an alternative on a single circuit GIP, and by investigating clearances, a model is created for future use. Compared to a 2DD-HST structure, a pole has a smaller footprint and shorter construction time.

The upper structure's clearances were initially prioritised. Given the expected differences in the heights of the forward and back span structures, detailed investigation of the body and leg extensions was deemed unnecessary at this stage and will be part of future GIP projects.

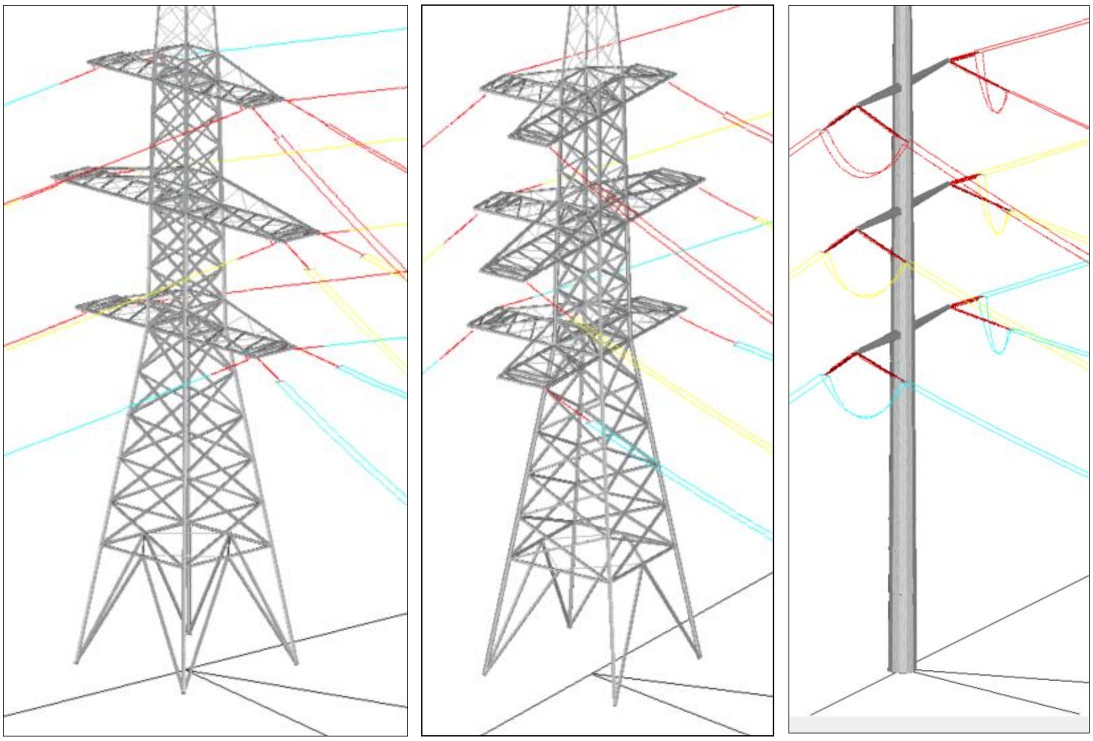

Figure 2: Considered Structure Types (Respectively: DC, SC, SC)

5. Hardware Information

Standardising hardware and insulator sets in GIP projects simplifies procurement and aligns with Transpower standards in any future application.

Transpower utilises two types of insulator sets for terminal spans, called Line End Sets and Gantry End Sets. The suggested standard insulator set numbers used in the design are tabulated below in **Table 2**. All insulator sets are to be confirmed by TP.

Table 2: Standard Insulator Sets

Location	Proposed Set	Description
Gantry - Line Side	865D	Duplex ACSR, Terminal Span - Gantry End, Zebra
GIP Tower/ Pole Strain -Downlead	866B	Duplex ACSR, Terminal Span - Line End, Zebra

6. Standardising Design

6.1. Attachment Elevation Difference Adjustment

Assumption: Flat ground between Gantry and GIP structure, and substation ground level is 0.5 m higher than GIP tower centre.

The attachment height difference is initially set at 1m for the concept design but can be changed to accommodate site constraints. As a result, the difference in the insulator attachment points was used instead of ground level to determine the minimum elevation difference between the Gantry and GIP Tower bottom crossarm attachment heights, as illustrated in **Figure 3** below.

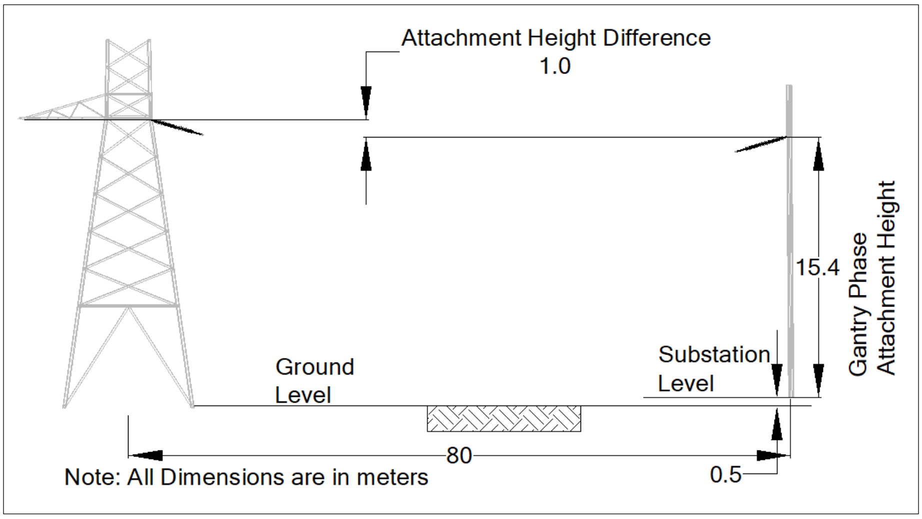

Figure 3: Attachment Height Difference

6.2. External Clearances

The minimum external clearance requirement can be achieved by setting the following:

- Minimum attachment height difference,
- Distance between gantry and GIP structure
- Tension on conductors (VDC %2.5 -Refer **Table 1**)

Table 3 lists the detailed minimum external clearance requirement of TP.DL 12.02, Issue 2.1:

Table 3: External Clearances

	To Building (m)	To Ground (m)					
	MOT	MOT	EDD	HWD	SDS	TIS	EIS
Required Clearance (m)	**6.5**(1)	**8.0**(1)					
Achieved Clearance (m)	**8.9**	**11.5**	**12.3**	**12.8**	**12.4**	**12.5**	**12.4**

(1) The 0.5m design margin has been taken into consideration in the achieved values.

Figure 4 visualises the Maximum Operating Temperature (MOT120):

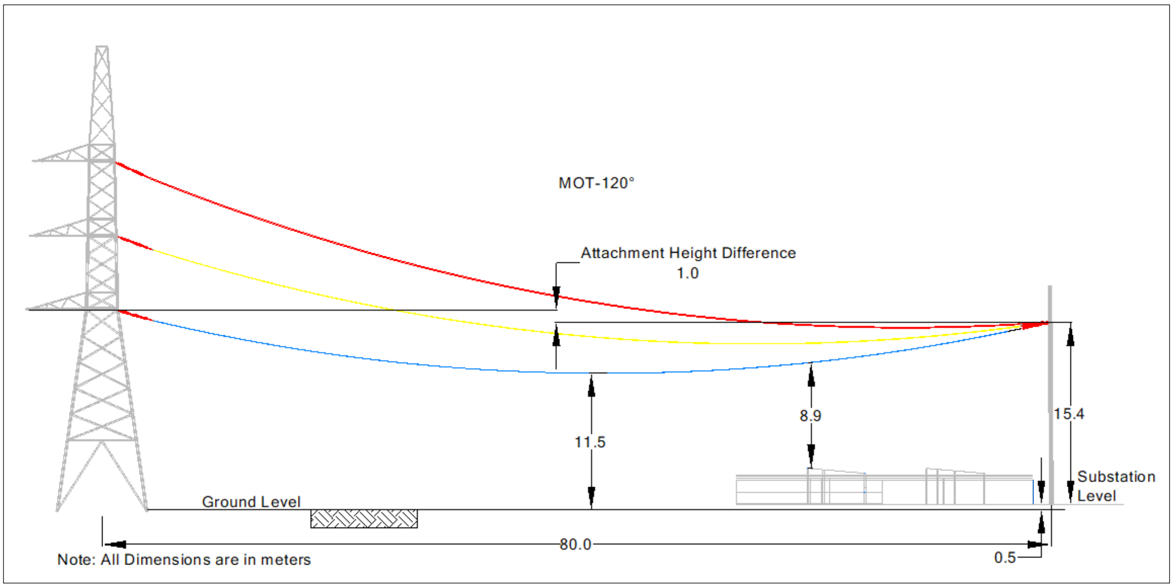

Figure 4: MOT120 External Clearances

7. Internal Clearances

The internal clearance between phases in terminal towers to gantries is essential for maintaining electrical safety, as it prevents short circuits by ensuring proper insulation and avoiding electrical arcs.

7.1. Span Effect

Based on Groundline's technical expertise, positioning the tower closer to the gantry tends to reduce internal clearances, subsequently elevating associated risks. Wider spans have a higher risk, particularly in scenarios of differential swing. To thoroughly examine this phenomenon, two distinct models with spans of 50 meters and 110 meters were developed (double circuit line with a 2DD-HST tower). The reason for choosing a double circuit is that phases are closer to each other compared to single circuit. The corresponding data shown in below **Table 4**.

Table 4: Internal Clearance changes for different spans under 2.5% VCD Tension

GIP Span	Conductor	EDS-EDS 1.9m	EDD-EDD 1.9m	EDS-EDD 1.9m	HWD-HWD 0.75m
50 meters	Phase to Phase	2.418	2.426	2.126	2.415
110 meters	Phase to Phase	2.575	2.574	1.764	2.578
80 meters	Phase to Phase	2.682	2.663	2.133	2.644

As shown in the table above, the most appropriate of the three different span values is 80m. More detailed work can be done to improve this value.

7.2. Phase Elevation Effect

There will always be an elevation difference between the conductor phase connection points, depending on the ground elevation difference between the gantry and the tower. In this standardising study, although a flat ground and a 1 m difference between the attachment points is assumed, two additional models were created and examined to confirm the decision. The same 2DD-HST tower is selected as the phases are closer to each other when comparing single circuit options.

The internal clearance results from modelling an elevation difference of 0m to 5m are as shown in **Table 5**.

Table 5: Internal Clearance changes for different phase elevations under 2.5% VCD Tension

GIP Span	Phase Elevation Difference	Conductor	EDS-EDS 1.9m	EDD-EDD 1.9m	EDS-EDD 1.9m	HWD-HWD 0.75m
80 meters	**0 meter**	Phase to Phase	2.703	2.686	2.157	2.665
	5 meters	Phase to Phase	2.594	2.572	2.030	2.553
	1 meter	Phase to Phase	2.682	2.663	2.133	2.644

EDS-EDD becomes more critical as the elevation difference between the phases increases in the 80m span. The design parameter outlined in **Table 1** will influence result. The most significant height difference is **8m**. Based on the 1.9-meter clearance limit, the internal clearance in this case is **1.948m**.

A span of 80m and an elevation difference of 1m seems appropriate from the internal clearance perspective to standardise the design under the assumed weather conditions (extreme conditions).

8. Gantry Loads

Design gantry loads are required to assess the gantry and insulator connection points. In the scenario where a 2.5% VDC tension is applied with an 80m span and 1m elevation difference, the conductor will exert the following maximum loads on the phase attachment points:

Table 6: Maximum Gantry Phase Loading (Reference: DC 2DDHST connection)

Load Case	Weather Case	Vertical (N)	Transverse (N)	Longitudinal (N)
Max. Vertical	EI0050_8 (Extreme Ice)	**4563**	8152	25252
Max. Transverse Wind (Ice Conditions Excluded)	MW2500_A8 (Max. Wind)	1057	**4979**	10171
Max. Longitudinal	EI0050_8 (Extreme Ice)	4563	7693	**25395**

Also given below gantry attachment loads for main weather cases:

Table 7: Gantry Phase Loading under Main Weather Conditions (Reference: DC 2DDHST connection)

Weather Case	Vertical (N)	Transverse (N)	Longitudinal (N)
EDS (Everyday Still Air)	1117	1931	6173
EDW (Everyday Wind	1116	2156	6198
HWD (High Wind Deflection)	1109	2767	6576
MW2500 (Maximum Wind Deflection)	1057	4979	10171

9. Construction

To facilitate the construction of a double circuit GIP tower, tong guys are proposed to enable the construction with both circuits live. A tong guy can be installed under single circuit outages.

The tong guys were used in previous Transpower projects and same setup can be utilised. Please refer to RedEye drawing TP103872.

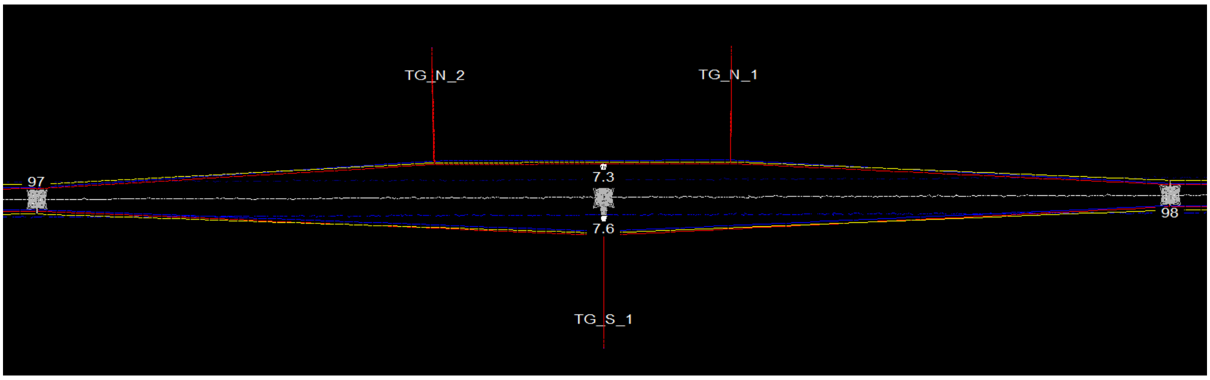

Figure 5: Construction Window by Using Tong Guys

The substation goes in the space between TG_N_1 and TG_N_2. This way, the work of the substation can continue.

10. Conclusion

The objective of this study was to create a standardised design for 220kV GIP, encompassing both single and double circuits. This design considers crucial factors such as phase elevation optimisation, clearance requirements, and environmental obstacles.

In summary, the study indicates that implementing a 2.5% Vibration Damage Condition (VDC) tension on duplex Zebra conductors and strategically placing GIP structures at an 80m span can effectively meet both external and internal clearance criteria under extreme weather conditions as shown in **Table 1.** This remains the case even if the elevation of the bottom arm tower attachment point is 0m to 5m higher than the gantry attachment point.

The elevation of the attachment point can be adjusted based on the chosen combination of GIP structure body and leg, considering the external clearances for both the back and ahead spans.

As the gantry design loads were not available for this study, it is crucial to verify that the gantry loads do not surpass the specified limits after the project layout has been finalised. If the design of the gantries has not been finalised yet, the report providing the maximum phase attachment loads can be taken into consideration during the gantries' design process.

Appendices

- **Appendix A:** Load Case Generator
- **Appendix B:** Site Specific Wind Speeds
- **Appendix C:** GIP Connection Layouts