

ID	Item Topic	Reference	Description
Standard 220 kV SC with bypass - Designer's Log			
Doc No. -			
Doc Rev A			
1	Purpose / Overview	General	The purpose of this document is to identify the key decisions and assumptions for a standard 220 kV single circuit with bypass substation design to be used as consenting and conceptual design input for all new Customer Connections to Transpower's 220 kV network.
2	Fault Scenarios	General	Four fault scenarios were explored at the beginning of the project which were different permutations of: 1) 1 or 2 transformer plus a future 3rd 2) 2 lines (1 diameter) plus a future line bay (half diameter) 3) solid bus or CB bus coupler or back-to-back DCBs bus coupler  It was eventually agreed to settle with 2 transformers and 2 lines (1 diameter) and CB bus coupler as the bare minimum to achieve the required substation bypass arrangement if the substation were to be offline.
3	Single Line Diagram (SLD)	General	The first SLD format was such that the two lines were coming from the left and right sides of the A3 sheet while the transformers from the bottom of the page to connect to the Bus 1 and Bus 2. The rationale was to follow the AECOM 220kV CC design where the customer side of both transformers come from the same end.  This was revised to the SLD we have now to align with the efficient use of the switchyard land area. This format also enabled the addition of a future 3rd transformer towards the bottom of the page.
4	Relay and Instrument Diagram (RID)	General	<b>Line and Bypass RIDs:</b> were based on Transpower's breaker-and-a-half RID standard design for a line's diameter (conventional SS) [TP114835 rev A, 30Jun2023.000.000], converted to the style of AECOMs new RID for digital SS. As instructed, we have not converted to the very recently issued RIDs for Digital SS standard design.  <b>Bus coupler RID:</b> is based on AECOMs new "Standard 220kV Customer Connection" RID for digital SS bus coupler, with the following important changes: Implemented crossover of CTs for number 2 Bus Zone protections Implemented sequential CT core order into the merging units (core 1 to F#2 merging unit 1, core 2 to F#2 merging unit 2, core 3 to E#2 merging unit 1, core 4 to E#2 merging unit 2) Implemented CB Fail initiation with crossover of signals. This is to prevent a total 2 bus shutdown for faults in the large blind-spots between the back-to-back DCBs Deleted TCS function blocks from all MUs (TCS = Trip Circuit Supervision; will be located in these MUs but is not normally shown on RID)  <b>Transformer RIDs:</b> were based on AECOMs new "Standard 220kV Customer Connection" RID for digital SS transformer, with the following important changes: Changed ac input of LVCB merging units from [A/Digital] to [A,V/Digital] to include the VT input signals present in both designs Implemented sequential NCTA and NCTB core order into the merging units (NCT core 1 to NCT merging unit 1 etc) Retained the non-standard "P1 away from CB" for compatibility with standard designs in this unusual SLD which has an additional outdoor 33kV DCB between the transformer and the customer's switchgear Deleted TCS function blocks from all MUs
5	RID (Issues carried forward)	General	A number of RID issues have been carried forward for future consideration:  - The Digital Substations team have recently issued TP207418 which is a set of RIDs with new more detailed line types see Appendix Tab to view these. The more detailed line types help newcomers to interpret the new technology described in the RID and relate this to past practice. The new line types should be considered and the new RIDs could be adopted or adapted in lieu of the ones produced under this project.  - The 33kV outdoor CT and CB for the case where the customer takes a single feeder to off-site switchgear has generated discussion because; - following the AECOM "Standard 220kV Customer Connection" design, the CT has been placed on the abnormal side of the LVCB, this moves the CB into the transformer differential zone. Keeping the normal polarity expected by standard protection designs this breaks the Transpower rule "P1 towards the CB". Option 1: off-site switchgear owned by the customer may be typical of GIPs, for this case Transpower has a 33kV outdoor switchyard with outdoor post CT, post CB, post arrester and dog-box CB. Option 2: on-site switchgear owned by Transpower or the customer, for this case the switchgear would be conventional indoor type.  Option 1 has messed with the placement of the CT and also messed with the "P1 towards the CB" rule. For Option 1 the RID and SLD apply directly, The CT is placed unconventionally such that faults in Transpower's LVCB are covered by the Transformer differential zone. The customer should be required to provide differential protection for the outgoing cables and Transpower's post CT as well as appropriate coverage of the blind-spot faults. The CT cores used provide overlapping differential zones, but tripping Transpower's CB will not isolate a fault in the CT or blind spot. The orientation of "P1 away from the CB" is non-standard to allow direct application of standard transformer protection designs. For Option 2 the CT should be moved to the opposite side of the LVCB as in conventional switchgear. Faults in Transpower's LVCB would then be covered by the Busbar differential zone, arc flash protection etc.  - The normal rule for RIDs is: "inputs at left of function box and outputs at right". This has for a long time (since circa PAK 220) been broken for breaker and a half due to the double header on the protection relay depiction. It has now been broken for the back-to-back DCB bus coupler depiction where the mirrored layout emphasises the symmetry of the functions, but breaks the RID rules when this could have been avoided.  - The best method should be determined for covering blind spots in the bus coupler, this was not explicit in the original AECOM design "Standard 220kV Customer Connection" and is explicit in TP207418. Another method "Option A" is more direct but may break the DC segregation rules under-pinning the Digital SS designs. See the more detailed discussion under the Appendix tab of this log.  - Several changes listed in row 4 above should be made also in the "Standard 220kV Customer Connection" RIDs.
6	Demarcation	General	The demarcation between Transpower and the Customer is to be agreed with Transpower on a connection-specific basis.  Alternative demarcation points are described below.  Grid Injection Points (GIP): 1) 220 kV Bus with the support post between the 220 kV ES and the HV bushing of the 220/33 kV power transformer. Transpower will own the 220 kV ES and the 220 kV Bus with the support post.  Grid Exit Points (GXP): 1) 33 kV cable termination within Customer-owned incomer switchgear panel. Transpower will own the 33 kV incomer cable. 2) 33 kV cable termination within Transpower-owned 33 kV bus. Customer will own 33 kV feeder cables connected to Transpower-owned 33 kV switchgear panel.  For this work, it was agreed to assume that the substation will be a Grid Exit Point.
7	220 kV Line Entry	General	The 220 kV standard line entry will be developed by Transpower and included in a separate design document.
8	220 kV Gantry Type	General	The 220 kV gantry type is a steel H frame sourced from an overseas supplier - note following: - The provided heights represent an expected worst case height - Project-specific design is required and will be completed in the detailed design stage.
9	220 kV Line Bays	General	The 220 kV Bus Arrangement is based on the standard drawing reference TP58393_3, 220 kV 1.5 CB (4000 A RATED) AIS SUBSTATION.  It was agreed to use DCB instead of a bus-side CB to align with Transpower's future strategy. The DCB has the following benefits over the conventional CB: 1) Less frequent maintenance period (every 15 years instead of every 4 years). 2) A higher Lightning Impulse Withstand Voltage.  The following items are: - 220kV line bay DCB - 220 kV line bay earth switch, origin from TP58393_3 - 220 kV line bay DIS/ES, origin from GE Three pole Disconnecter & Earthing Switch - 220 kV line bay CVT, origin from TP58393_3

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10	220kV Half Breaker	General	<p>The possibility of using back-to-back DCBs for the half breaker was explored to be match the line bays. However, it was agreed to revert to the conventional CB because the Digital Substation RID with a DCB half breaker does not exist and is outside the scope of this work. However, the switchyard layout was designed such that this bay will achieve the required electrical clearances if the CB were to be swapped with a DCB in the future.</p> <p>The following items are:</p> <ul style="list-style-type: none"> <li>- 220 kV line bay switchgear (Conventional CB/CT), origin from TP58393_3</li> <li>- 220 kV line bay DIS/ES, origin from GE Three pole Disconnecter &amp; Right side Earthing Switch</li> <li>- 220 kV line bay DIS/ES, origin from GE Three pole Disconnecter &amp; Left side Earthing Switch</li> </ul>
11	220 kV Transformer Bays	General	<p>The 220 kV Bus Arrangement is based on the standard drawing reference TP_Aecom.</p> <p>The following items are:</p> <ul style="list-style-type: none"> <li>- 220 kV line bay DCB/CT</li> <li>- 220 kV line bay ES</li> <li>- 220 kV line bay SA1</li> <li>- 220/33 kV Transformer</li> <li>- 220 kV line bay SA2</li> <li>- 220 kV NER</li> <li>- 33 kV NER</li> <li>- 33 kV / 415 V ET</li> <li>- 33 kV line bay ES1</li> <li>- 33 kV line bay DCB/CT</li> <li>- 33 kV line bay VT</li> <li>- 33 kV line bay ES2</li> </ul>
12	Transformer 1 Phasing	General	<p>To maximise the switchyard layout, the back-to-back DCB bus coupler bay was placed in between the two transformer bays. This enables the transformer diameter to take the same land area as the line diameter to maximise the space. However, this creates a clearance issue with the R and B phases of the 220kV overhead connection from the HV bushing across Bus 1 to the bus coupler. To solve this, it was agreed to swap the T1 R and B phases to 'mirror' the T2 'natural' phasing.</p>
13	220 kV Bus Coupler	General	<p>The 220 kV Bus Arrangement is based on the standard drawing reference TP_Aecom.</p> <p>The following items are:</p> <ul style="list-style-type: none"> <li>- 220 kV line bay CT</li> <li>- 220 kV line bay DCB/ES Back to Back</li> <li>- 220 kV line bay CVT</li> </ul>
14	220 kV Bus Arrangement	General	<p>The 220 kV Bus Arrangement is based on the standard drawing reference TP58393_3, 220 kV 1.5 CB (4000 A RATED) AIS SUBSTATION.</p> <p>The following items are:</p> <ul style="list-style-type: none"> <li>- 13.65 m long, 9.175 m height, 200mm OD Busbar {200mm OD x 6mm WT Tubular Bus Tube, Grage 6061 T6 (Span length &gt; 12m)}</li> <li>- 7.9 m long, 9.175 m height, 200mm OD Busbar {200mm OD x 6mm WT Tubular Bus Tube, Grage 6101 T6 (Span length &lt; 12m)}</li> <li>- 220 kV Bus Support 3ph 2col with Insulator, origin from TP58393_3</li> </ul>
15	220 kV Surge Arresters	General	<p>The layout includes 220 kV line surge arresters - these may be omitted if overhead line earth wires extend a minimum of 1 km out from the substation.</p>
16	Oil Containment	General	<p>The oil separator is mounted inside the transformer foundation and is Transpower's preferred position for the case where Transpower own the 220/33 kV power transformers.</p>
17	Fire Clearance	General	<p>The fire clearances are based on TP DS 61.06, Issue 6.</p> <p>The following basis has been applied to the layouts based on Table 1 of TP DS 61.06:</p> <p>a) The switchyard security fence is to be placed at the non-combustible building material limit (15m). The reasons for this approach are:</p> <ul style="list-style-type: none"> <li>- To control the type of items that are placed within the non-combustible building material extent</li> <li>- To minimise the risk of fire spread</li> <li>- To maintain the integrity of the switchyard security fence in the event of a transformer fire.</li> </ul> <p>b) The extent of the Setback Zone (refer item 15) is the greater of:</p> <ul style="list-style-type: none"> <li>- The combustibile building material limit for initial and future transformers (30m)</li> <li>- Allowance for a Transpower access corridor between the 220 kV ES and the barrier fence (refer to item 10)</li> </ul> <p>The layout sketches also include the Property Boundary limit as per TP DS 61.06 Issue 6, Table 1.</p> <p>Specifically, about the firewall, TP DS 61.06 does not prescribe a clearance in the vertical direction between a firewall and the adjacent gantry, only to a building as per section 7.3.3 Figure 9.</p> <p>The following basis has been applied to achieve fire protection</p> <ul style="list-style-type: none"> <li>c) 3500mm separation between the gantry and firewall for vehicle</li> <li>d) Firewall height set to 9m (&lt;12m max)</li> <li>e) Firewall height at least 600mm above the conservator tank</li> <li>f) Firewall protects the gantry insulators</li> </ul>
18	33 kV Switchroom Building	General	<p>The 33 kV switchroom and facilities buildings are located on the bottom of the page near the main substation entry point. This allows substation entrants to sign into the building (and access the toilet) without going to the switchyard first.</p>
19	Transpower and Customer Barrier Fence	General	<p>Where the Customer owns the 220/33 kV power transformers and installs this adjacent to the Transpower switchyard, a barrier fence shall be installed at the demarcation point between Transpower and the Customer.</p> <p>In this case, Transpower's equipment arrangement is modified to include a 7m space between the 220 kV ES and the barrier fence - this is to allow for a 5m vehicle access corridor, bus support posts and maintenance of the 220 kV ES (2m).</p> <p>The purpose of the barrier fence is to prevent inadvertent access to the other party's switchyard where personnel may not have the right competency. The barrier will be the same specification as Transpower's standard security fence but without the possum wire installed.</p>
20	220 kV Connected NER	General	<p>The 220 kV connected NER is required for some sites only. The customer is to seek clarification from Transpower.</p>
21	Vehicle Access	General	<p>Vehicle access is based on the requirements of TP DS 62.01 Issue 4.2. Where overall site access from the road does not align with the Transpower site access as shown, a 6m roadway is to be provided to Transpower's access point.</p>
22	Electrical Clearances	General	<p>Electrical clearances are based on the requirements of TP DS 62.01 Issue 4.2.</p>
23	Digital Substation	General	<p>Transpower's switchyard arrangement is based on a process bus solution (digital substation).</p>
24	Setback Zone	General	<p>The basis of the setback zone is to provide space for an access corridor between Transpower's 220 kV ES and the barrier fence (for the case where the Customer owns the 220/33 kV power transformers).</p>
25	Future Diameter	General	<p>The SLD and site layout were designed such that a future second diameter bay or 3rd transformer or reactive power bay can be built on the side of the existing diameter opposite from the power transformers.</p>