# Design of Tap Connections on Overhead Transmission Lines

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- What is a tap connection?
- Why a tap connection?
- How to design a tap connection?
- Stake holder engagement
- Engineering considerations
- Focus on 69kV and 138kV tap design

# Tap Connection

- T-connection between a tap line and the main line.
- Commonly used to either deliver power to load customers or receive power from independent power producers (IPP).
- Often, tap lines would be owned by customers, and the main lines are owned by BC Hydro.
- Often serves as the point of interconnection (POI).
- Popular in BC Hydro transmission line system for 69kV and 138kV due to the cost effectiveness, rare for 230kV.


# Stake Holder Engagement

- To ensure the success of the project delivery, it is critical to engage all the stake holders from very beginning to the end of the project.
- Stake holders may include customer, property, environmental impact, indigenous relations, field operations, system operations, construction, system planning, etc.

# Stake Holder Engagement: Customer

- A tap connection is typically driven by a customer (either a load or IPP customer) so that the customer need is always of the utmost importance.
- Usually, it will dictate the location of the tap as well as majority of the tap line parameters.
- Naturally, a tap connection closet to the customer's substation is always preferred if feasible.
- Those key line parameters such as voltage level, conductor type, structure type, electrical capacity, are determined mostly by the customer depending on the particular needs of the customer.

# Stake Holder Engagement: Property

- Nowadays, property is likely the most important factor in considering tap location.
- Basically, right of way (ROW) is required to accommodate both the tap line and the tap connection point.
- Acquiring ROW is usually not only costly but also time consuming.
- Thus, it is always preferred that the line route is selected so that it is fast and easy to acquire and less costly.

# Stake Holder Engagement: Environmental

- A severe environmental issue could be a show stopper for the project.
- In principle, the tap line and the tap connection point shall meet all the requirements imposed by all relevant laws, regulations, and bylaws at federal, provincial and municipal levels.
- It is important to have environmental professionals/specialists to conduct environmental impact assessments on as need basis throughout the project.
- Environmental concerns may include wetlands, rivers, streams, wildlife habitations, bird nesting, archaeology, vegetation, danger species of plants and wildlife, wildfire, etc.

# Stake Holder Engagement: Field Operations

- It is a good practice to seek feedback from local transmission line field operation (FO) team to ensure the tap line and the tap connection is maintainable.
- Usually the need for disconnect switches (the number, type and locations) is dictated by FO for the ease of maintenance.
- FO may also help to decide some key line parameters, such as type of structures, need for access roads, and ROW width to ensure maintainability (lively or with minimal outage).

# Stake Holder Engagement: System Operations

- Transmission system operations (TSO) is a key stake holder to consult for any issues related to outages required for both construction and maintenance.
- The intention is to minimize or even eliminate the need for outage during construction work and any future maintenance work.
- Thus, the TSO's input is important for identifying the need for disconnect switches.

# Stake Holder Engagement: System Planning

- Normally System Planning will dictate whether or not a specific tap connection is acceptable to the utility company on a high level.
- The tap connection designer shall consult System Planning for any question or confusion, particularly in the very beginning of the project.

# Stake Holder Engagement: Construction

- Constructability is another important factor to be considered in designing the tap connection in order to achieve a cost effective design with minimal demand or no need at all for outage during construction.

# Stake Holder Engagement: Indigenous Relations

- It is important to consult indigenous relations specialist for the project whenever the local indigenous community may likely have interests in the project area (even without owning the land). Proper procedure shall be followed for the engagement.

# Engineering Considerations

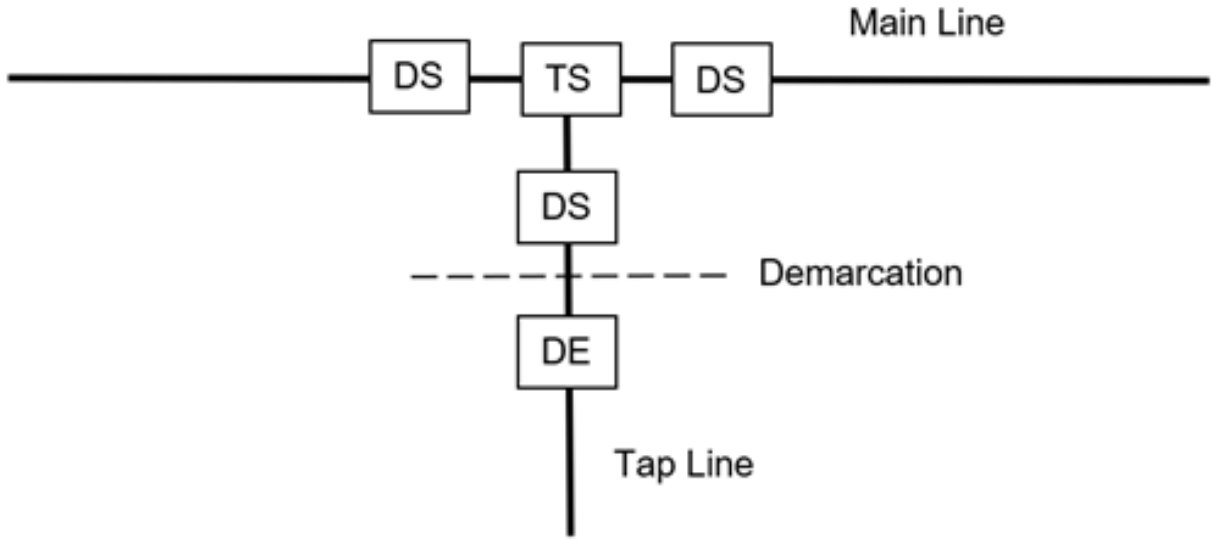
- Prepare design basis based on the feedbacks from all the stake holders. The design basis shall include user requirements, high-level scope of work, detailed design criteria, etc.
- Conduct Conceptual, preliminary and detailed designs successively.
- For each design stage, following engineering considerations shall be made in various details.

# Performance Criteria

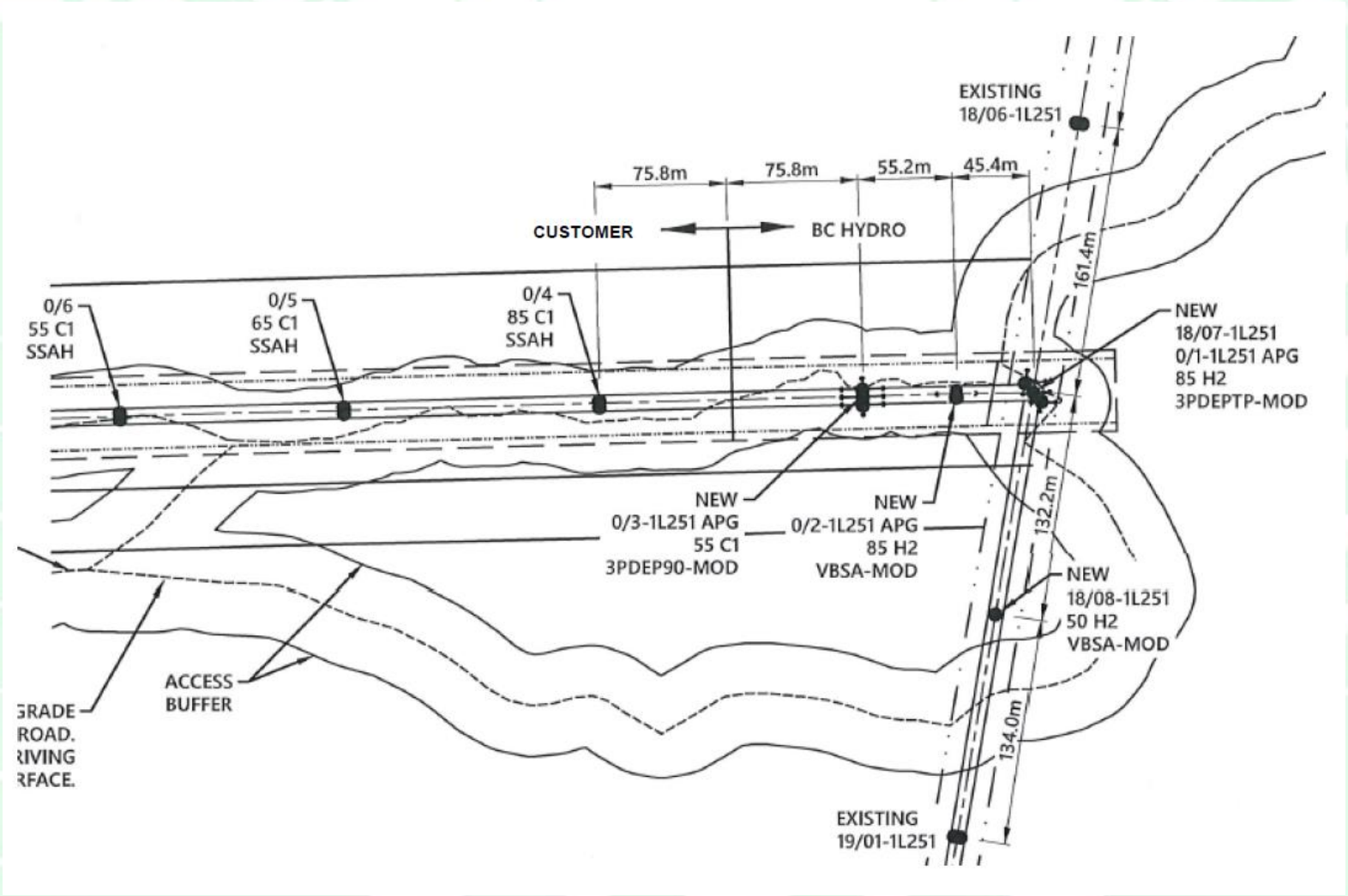
- A tap connection is essentially a special portion of its main transmission line. Accordingly, the performance criteria shall match those of the main line.

# Layout

- A tap structure “TS”;
- Up to three disconnect switch structures “DS”;
- A deadend structure may be installed as a demarcation point between the two owners: the utility owned tap connection and the customer owned tap line.
- The deadend structure can be owned either by the customer or the utility company depending on the mutual agreement.



# Layout: 138kV Example



# Conductor Selection

- Usually, the tap line will use the same conductor as the main line. However, a different conductor can be used with proper justification.

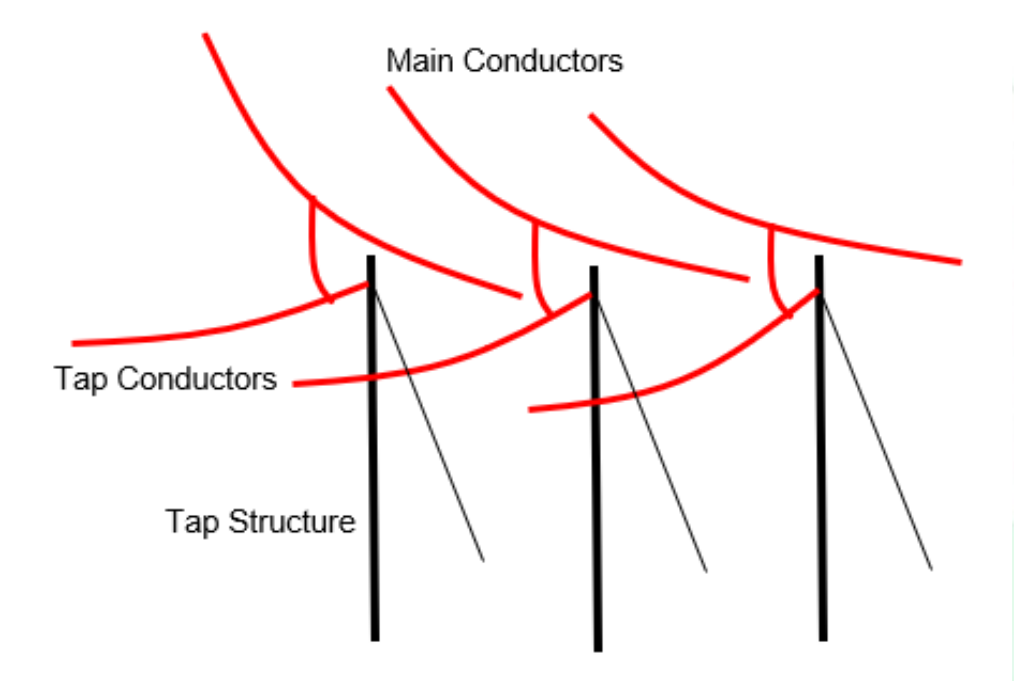
# Design Tension

- Usually, the main line portion of the tap connection shall be designed to maintain the same tension after inserting the new tap structure and new switch structures (if any).
- On the other hand, the tap line portion of the connection shall be designed to match the conductor tension of the customer side of the tap line if there is no deadend structure as a demarcation point.
- Otherwise, if there is a deadend structure as the demarcation, it is desirable to design the section between this deadend structure and the tap structure with slack tensions so that the structures involved are less stressed.

# Tap Structure

- Tap structure is essential as it is where the T-connection is made.
- Wood pole structures are usually used as the tap structure in BC Hydro for transmission lines up to 230kV due to cost effectiveness. Steel poles or even steel latticed towers could be used if necessary.
- Three-pole dead end (3PDE) structure is preferred type for tap structure for the enhanced security.
- However, single pole tap structure is commonly used for 69kV lines for areas with limited right of way.
- For

# Tap Structure: Flying Tap



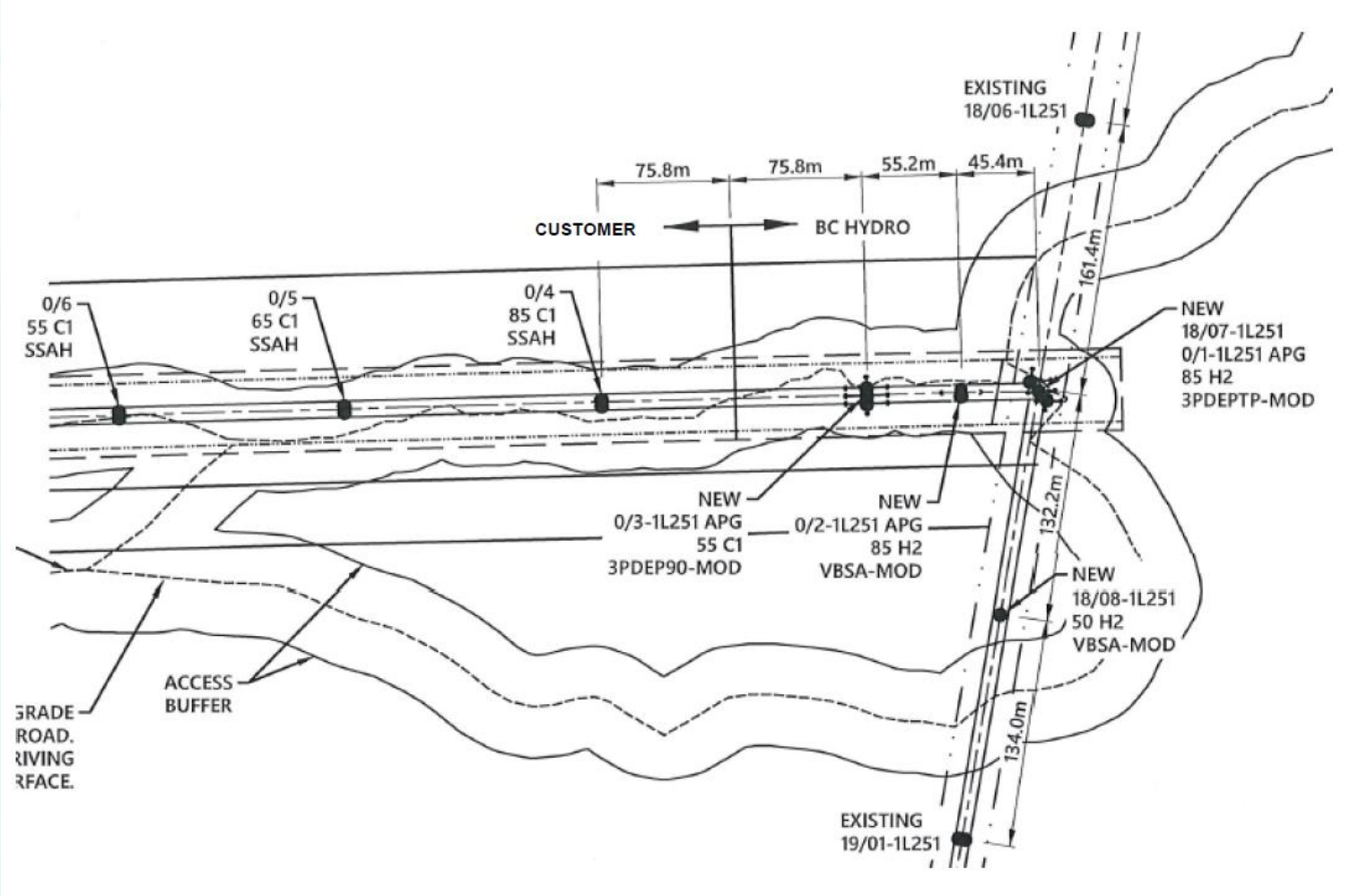

# Disconnect Switch

- Up to three disconnect switches are usually required
- The disconnect switch on the tap side is required almost always.
- If power flows one way on the main line, a disconnect switch may be installed on the down stream side of the tap structure
- If power can flow either way, two disconnect switches may be installed, one per side of the tap structure.
- Different Type of Disconnect Switch shall be selected based on the line length and purpose.
- To operate and maintain a disconnect switch, proper grounding shall be designed and installed.
- Proper access road may also be required (as shown in Figure 3 as an example)..

# Disconnect Switch: Example

# Deadend Structure

- For a relatively long tap line (say >1km), it is desirable to have a deadend structure as demarcation between the utility owned tap connection and the customer owned tap line.



# Conclusion

- To deliver a tap connection design project successfully, it is important to identify all the relevant stake holders and try to engage them from the very beginning.
- It is critical to ensure that the tap connection is located at the area where it is ease to meet those key requirements from property, environmental, and field operations, etc.
- It is important to ensure the number, type and location of the disconnect switches are determined properly by consulting with relevant stake holders.
- It is equally important to ensure that the entire tap connection (including structures, foundations, conductors, insulators, hardware etc.) is designed to meet all the engineering requirements while considering the feedback from all the relevant stake holders.

# Questions?