March 21, 2024

Mr. Jacob Diermann & Mr. Jack Thessen
LS Power Grid California

Re: Power Santa Clara Valley Transmission Project
Electromagnetic Effects of AC & DC High Voltage Circuit on Nearby Utilities
Santa Clara County, California

Dear Mr. Diermann and Mr. Thessen:

ARK Engineering was contracted by LS Power Grid California to investigate the electromagnetic effects of the proposed AC and DC high voltage circuits onto nearby utilities to support the comprehensive environmental evaluation associated with the California Environmental Quality Act (CEQA) process.

A proposed 320 kV underground DC circuit, which will be approximately 13 miles in length, and a proposed 500 kV underground AC circuit, which will be approximately 1.5 miles in length, will be installed in Santa Clara County, California.

Approximate utility locations within the area of the proposed electric circuits were obtained from the National Pipeline Mapping System (NPMS) database. The electromagnetic fields created by AC and DC circuits are fundamentally different from one another, which results in unique considerations for each with respect to induced current, shock hazard, and potential corrosion effects.

For the project's proposed AC circuit, ARK Engineering has identified one (1) gas pipeline crossing along Coyote Ranch Road at an approximate angle of 45° that will be susceptible to AC interference effects, and additional study is warranted to evaluate any AC interference mitigation measures that may be required.

For the project's proposed DC circuit, based on currently available information, shock hazards due to stray DC currents are not expected. However, there may be potential DC interference effects created during a short circuit fault of the DC line on one (1) natural gas pipeline identified in proximity to the Skyline HVDC terminal. This area will require further site and circuit details to fully evaluate the extent of potential impacts and mitigation.

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1. The following requirements relate to the CEQA guidelines: **Provide a description of potential shock hazards from the induced current caused by both the project's HVAC and HVDC segments, as applicable.**

When coated metallic pipelines are in shared rights-of-way with high voltage electric transmission circuits, the pipelines can incur high induced voltages and currents due to AC interference effects. This situation can cause many safety issues if not mitigated effectively. The possible effects of this AC interference can include personnel subject to electric shock up to a lethal level, accelerated corrosion, arcing through pipeline coating, arcing across insulators, disbondment or degradation of coating, or possible perforation of the pipeline.

AMPP/NACE Standard SP0177-2014 – Mitigation of Alternating Current and Lightning Effects on Metallic structures and Corrosion Control Systems, Section 5.2.1.1, states, "Safe limits must be determined by qualified personnel based on anticipated exposure conditions. For the purpose of this standard, a steady-state touch voltage of fifteen (15) V or more with respect to local earth at above-grade or exposed sections and appurtenances is considered to constitute a shock hazard."

The acceptable levels of DC interference are dependent on multiple factors including but not limited to pipeline coating, soil resistivity, type of pipeline cathodic protection system, existing pipeline potentials, and duration of ground faults.

For this project, based on the proposed location of the DC transmission circuit and the expected separation distance between the pipelines and the DC transmission circuit, any DC interference effects are not expected to affect the existing pipelines.

Step and Touch potential effects will be analyzed as part of this project work.

Step potential is the measurement of voltage that passes through the body, from one foot to the other.

Touch potential is the measurement of voltage that passes through the body, from one hand down through the foot.

Touch and step potential analysis will be completed at all above grade piping locations within proximity to the proposed AC and DC transmission circuits.

The step and touch potential limits to prevent defibrillation in humans is significantly lower for AC current than for DC current.

Both simulated AC and DC fault scenarios should be analyzed contingent on their distance to the pipeline and their fault current values.

2. **Provide a description of potential corrosion concerns from the induced current caused by both the project's HVAC and HVDC segments, as applicable.**

AC corrosion effects to a pipeline can occur when induced AC current caused by the proposed AC electromagnetic field leaves a metallic pipeline at a coating defect or holiday. AC density, associated with AC corrosion mechanisms, is calculated based on the induced AC potentials on the pipelines along with the soil resistivity in that area and the size of the coating holiday.

While DC electric circuits do not generate the same electromagnetic fields that are caused by AC circuits, DC interference effects to the pipeline can still promote corrosion through potentials passed through the earth or directly connected to the pipeline. These effects may increase or decrease the Cathodic Protection (CP) potentials along the pipeline or induce stray current corrosion on a pipeline. The existing pipeline CP system may have to be adjusted after energization of these electric circuits to account for any stray current effects.

Pipeline corrosion caused by the DC electric circuits can occur from consistently high DC interference effects to a pipeline. During monopolar conditions on a DC circuit, such as a fault condition or de-energizing the circuit for maintenance, etc. the grounding electrodes may fault in a negative or positive direction and producing a voltage gradient in the soil around the pipeline. This DC current discharge from the pipe may cause corrosion at the discharge areas, causing a positive DC potential shift on the pipeline.

3. Provide a description of potential mitigation measures for induction related issues which may occur.

If AC interference effects are determined to be an issue to the nearby coated pipelines, AC mitigation or monitoring measures would be recommended.

Pipeline AC mitigation is accomplished by installation of gradient control wires (zinc ribbon or equivalent) or AC ground wells along the pipeline in the areas of computed high AC interference values. This method also reduces AC interference and AC coating stress voltages during fault conditions on the electric transmission circuits. These gradient control wires or ground wells would be connected to the pipeline at various locations through a solid-state decoupling (SSD) device. The AC mitigation system would be designed to reduce the pipeline AC electrical interference effects to acceptable levels for personnel safety and pipeline integrity.

Touch and step potentials, at above ground pipeline locations, during a fault condition on the electric circuits are mitigated using gradient control mats and/or crushed stone.. These techniques reduce the AC or DC potential between a person and the pipeline infrastructure to acceptable levels for personnel safety. These mitigation measures are developed through the use of state-of-the-art interference modeling software and touch and step safety threshold calculations associated with the electric industry standard document IEEE Standard P80-2013.

4. Because comprehensive utility and routing data for this project is not yet available, ARK Engineering will use representative metallic utilities paralleling a representative project centerline and evaluate effects at varying distances until potential shock hazard or cathodic protection needs are below the level at which project-specific mitigation measures would be anticipated. As appropriate for utility crossings, perform a similar analysis.

Due to lack of available information provided for this initial analysis, assumptions were utilized to analyze the proposed gas pipeline crossing. This pipeline has been assumed as a 16" diameter pipeline with fusion bonded epoxy coating. This analysis includes the AC electric circuit conditions operating at steady state load conditions.

- The maximum induced AC pipeline potential for the pipeline crossing at approximately 45° to the proposed circuit, was computed to be less than one (0.8) Volt, with respect to remote earth.

Pipelines that cross the proposed AC electric circuit at less than 45° may require additional analysis for steady-state conditions depending on the soil resistivity at the crossing. Even if AC touch potentials are below their design limit, low soil resistivity can result in high AC density values.

There are additional water lines in the area of study, however additional data is needed to accurately analyze those lines.

The proposed AC circuit route may potentially parallel a 16" pipeline for approximately one thousand (1,000) feet at a separation distance of approximately thirty (30) feet. This scenario has been modeled during steady state load conditions.

- The maximum induced AC pipeline potential was computed to be approximately two (2) Volts, with respect to remote earth.

An example scenario has been modeled to include a pipeline parallel to the proposed AC electric circuit at the same thirty (30) foot separation distance but for a mile long parallelism. This modeled data can be utilized as a conservative result to determine approximately when a touch potential issue may occur during steady state conditions.

- The maximum induced AC pipeline potential was computed to be approximately twelve (12) Volts, with respect to remote earth.

Another example scenario completed involves a parallel metallic coated pipeline along the entire proposed AC route located approximately one hundred (100) feet from the proposed 500 kV AC electric circuit.

- The maximum induced AC pipeline potential was computed to be approximately two (2) Volts, with respect to remote earth.

The AC potentials for the modeled parallel pipeline scenarios were computed below the industry standard fifteen (15) Volt design limit as specified by AMPP/NACE Standard SP0177-2014.

These touch voltage values do not indicate if the pipelines will have AC corrosion issues related to AC density calculations. Industry standard NACE SP21424-2018, "Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation and monitoring" Section 6.6.2 states that AC corrosion may occur when pipeline AC density levels increase above a time-weighted average of thirty (30) A/m^2 if DC current density exceeds one (1) A/m^2.

Typical soil resistivity measurements would result in AC density levels less than this limit for pipelines with AC potentials less than two (2) Volts.

Any pipelines identified that parallel the 500 kV AC circuit for more than one thousand (1,000) feet at a separation distance of thirty (30) feet or less, should be modeled and analyzed as part of an AC interference study.

DC interference effects to a nearby metallic structure such as a pipeline may occur during a fault condition on the HVDC circuit. These interference effects are limited to the HVDC circuit grounding locations. HVDC transmission circuits are typically grounded at the beginning and ending converter substations of the circuit.

Previous studies conducted by ARK Engineering for a pipeline located approximately one (1) mile from the DC grounding system indicated a maximum DC pipeline potential effect from the circuit of less than 0.01 volts during the fault condition simulation.

Any DC interference concerns to the pipeline from the circuit would require sustained fault current drain from the circuit in an area near the pipeline. This is usually not the case as circuit designs restrict the fault current drain to ground to a short duration with sensing equipment and breakers, etc.

One (1) pipeline has been observed to be in proximity to the Skyline Terminal of the Santa Clara Valley DC circuit. This pipeline will be evaluated further when additional information is available to complete a DC fault analysis.

ARK Engineering's initial analysis indicates that AC and DC interference effects to existing infrastructure crossing the AC circuit at an angle of 45° or more, or parallel infrastructure located 100 feet away or more is negligible. Upon receipt of additional information of the proposed circuits, a complete AC and DC interference study will be completed to determine maximum AC and DC interference effects to the existing utilities.

To complete these studies, circuit fault current values are required to confirm that the effects from the proposed AC & DC electric transmission circuits will not exceed the industry standard design limits for the existing buried infrastructure.

Please call or email the author if you have questions or require additional information regarding this analysis.

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