

Chapter 16—Corona and Induced Current Effects

16.1 Introduction

This chapter provides a discussion of corona and induced-current effects associated with operation of the proposed high-voltage transmission lines. These effects include: audible noise; radio, television, and computer-monitor interference; gaseous effluents; fuel ignition; and interference with cardiac pacemakers. Further background on electric and magnetic field effects are found in Appendix F, Corona and Induced Effects, although the CPUC has found that such effects cannot constitute impacts under CEQA.

16.1.1 Methodology

Because these effects are common to all transmission lines, they are discussed as generally applicable. These effects have been determined to be negligible or non-existent for the proposed Project; therefore, no significant impacts would result and mitigation measures are not required.

16.2 Existing Conditions

16.2.1 Corona

One of the phenomena associated with all energized electrical devices, including high-voltage transmission lines, is corona. The localized electric field near a conductor can be sufficiently concentrated to ionize air close to the conductors, resulting in a partial discharge of electrical energy called a corona discharge, or corona. Several factors (e.g., conductor voltage, shape, and diameter, and surface irregularities such as scratches, nicks, dust, or water drops) can affect a conductor's electrical-surface gradient and its corona performance. Corona is the physical manifestation of energy loss and can transform discharged energy into very small amounts of sound, radio noise, heat, and chemical reactions with air components. Because power loss is uneconomical and noise is undesirable, corona on transmission lines has been studied by engineers since the early part of this century. Many excellent references exist on the subject of transmission-line corona. Consequently, corona is well understood by engineers, and steps to minimize it are major factors in transmission-line design.

16.2.1.1 Audible Noise

During corona activity, transmission lines (primarily those rated at 345 kV and above) can generate a small amount of sound energy. This audible noise can increase during inclement weather conditions, when water drops may collect on the surface of the conductors and increase corona activity so that a crackling or humming sound may be heard near a transmission line. Transmission line audible noise is measured in decibels using a special weighting scale, the "A" scale, that responds to different sound characteristics similar to the response of the human ear.

16.2.1.2 Radio and Television Interference

Overhead transmission lines do not, as a general rule, interfere with radio or TV reception. There are two potential sources for interference: corona and gap discharges. As described above, corona discharges can sometimes generate unwanted electrical signals. Corona-generated electrical noise decreases with distance from a transmission line and also decreases with higher frequencies (when it is a problem, it is usually for AM radio and not the higher frequencies associated with TV signals).

Gap discharges are different from corona. Gap discharges can develop on power lines at any voltage. They can take place at tiny electrical separations (gaps) that can develop between mechanically connected metal parts. A small electric spark discharges across the gap and can create unwanted electrical noise. The severity of gap-discharge interference depends on the strength and quality of the transmitted radio or TV signal, the quality of the radio or TV set and antenna system, and the distance between the receiver and power line. The large majority of interference complaints are found to be attributable to sources other than power lines (e.g., poor signal quality, poor antenna, door bells, and appliances such as heating pads, sewing machines, freezers, ignition systems, aquarium thermostats, and fluorescent lights). Gap discharges can occur on broken or poorly-fitting line hardware (e.g., insulators, clamps, or brackets). In addition, tiny electrical arcs can develop on the surface of dirty or contaminated insulators, but this interference source is less significant than gap discharge.

16.2.1.3 Gaseous Effluents

Corona activity in the air can produce very tiny amounts of gaseous effluents (i.e., ozone and NO_x). Ozone is a naturally-occurring part of the air, with typical rural ambient levels ranging from about 10 to 30 parts per billion (ppb) at night and peaks at approximately 100 ppb. In urban areas, concentrations exceeding 100 ppb are common. After a thunderstorm, the air may contain 50 to 150 ppb of ozone, and levels of several hundred ppb have been recorded in large cities and commercial airliners. Ozone is also emitted by welding equipment, copy machines, air fresheners, and many household appliances.

16.2.2 Induced Currents

Small electric currents can be induced by electric fields in metallic objects close to transmission lines. Metallic roofs, vehicles, vineyard trellises, and fences are examples of objects that can develop a small electric charge in proximity to high-voltage transmission lines. Object characteristics, degree of grounding, and electric-field strength affect the amount of induced charge. An electric current can flow when an object has an induced charge and a path to ground is presented. The amount of current flow is determined by the impedance of the object to ground and the voltage induced between the object and ground. The amount of induced current that can flow is important to evaluate because of the potential for nuisance shocks to people and the possibility of other effects, such as fuel ignition.

16.2.2.1 Fuel Ignition

If a vehicle were to be refueled under a high-voltage transmission line, a possible safety concern could be the potential for accidental fuel ignition. The source of fuel ignition could be a spark discharge into fuel vapors collected in the filling tube near the top of the gas tank. The spark discharge would be due to current induced in a vehicle (insulated from ground) by

the electric field of the transmission line and discharged to ground through a metallic refueling container held by a well-grounded person. Theoretical calculations show that if a number of unlikely conditions exist simultaneously, a spark could release enough energy to ignite gasoline vapors. This could not occur if a vehicle were simply driven or parked under a transmission line. Rather, several specific conditions would need to be satisfied: A large gasoline-powered vehicle would have to be parked in an electric field of about 5 kV/m or greater. A person would have to be refueling the vehicle while standing on damp earth and while the vehicle is on dry asphalt or gravel. The fuel vapors and air would have to mix in an optimum proportion, and finally, the pouring spout would have to be metallic.

16.2.2.2 Cardiac Pacemakers

One area of concern related to the electric and magnetic fields of transmission lines has been the possibility of interference with cardiac pacemakers. There are two general types of pacemakers: asynchronous and synchronous. The asynchronous pacemaker pulses at a predetermined rate and is practically immune to interference because it has no sensing circuitry and is not exceptionally complex. The synchronous pacemaker, on the other hand, pulses only when its sensing circuitry determines that pacing is necessary.

16.2.3 Computer Interference

Personal-computer monitors can be susceptible to 60-Hz magnetic-field interference.

16.3 Potential Impacts

16.3.1 Corona

Corona is usually not a design problem for lines rated at 230 kV and lower. The conductor size selected for the proposed 230 kV transmission lines is of sufficient diameter to lower the localized electrical stress on the air at the conductor surface, and would further reduce already low conductor surface gradients so that little or no corona activity would exist under most operating conditions.

16.3.1.1 Audible Noise

Audible noise levels on typical 230 kV lines are very low and are usually not noticeable. For example, the calculated rainy-weather audible noise for a 230 kV transmission line at the ROW edge is about 25 dBA, which is less than ambient levels in a library and much less than background noise for wind and rain.

16.3.1.2 Radio and Television Interference

Corona interference with radio and television reception is usually not a design problem for transmission lines rated at 230 kV and lower. Calculated radio- and TV-interference levels in fair weather and rain are extremely low at the edge of the ROW for a 230 kV transmission line. The resulting signal-to-noise ratio will easily meet the reception guidelines of the Federal Communications Commission.

Hardware is designed to be problem-free, but corrosion, wind motion, gunshot damage, and insufficient maintenance contribute to gap formation. Generally, interference due to gap

discharges is less frequent for high-voltage transmission lines than lower-voltage lines. The reasons that transmission lines have fewer problems include: predominate use of steel structures, fewer structures, greater mechanical load on hardware, and different design and maintenance standards. Gap-discharge interference can be avoided or minimized by proper design of the transmission-line hardware parts, use of electrical bonding where necessary, and by careful tightening of fastenings during construction. Individual sources of gap-discharge noise can be readily located and corrected. Arcing on contaminated insulators can be prevented by increasing the insulation in high-contamination areas and with periodic washing of insulator strings.

16.3.1.3 Gaseous Effluents

The National Ambient Air Quality Standard for Oxidants (ozone is usually 90 to 95 percent of the oxidants in the air) is 120 ppb, not to be exceeded as a peak concentration on more than one day a year. In general, the most sensitive ozone-measurement instrumentation can measure about 1 ppb. Typical calculated maximum concentrations of ozone at ground level for 230 kV transmission lines during heavy rain are far below levels that the most sensitive instruments can measure and thousands of times less than ambient levels. Therefore, the proposed transmission lines would not create any significant adverse effects in the ambient air quality of the Project Area.

16.3.2 Induced Currents

The amount of induced current can be used to evaluate the potential for harmful or other effects. As an example, when an average woman or man grips an energized conductor, the threshold for perception of an electric current is 0.73 milliampere (mA) and 1.1 mA, respectively. If the current is gradually increased beyond a person's perception threshold, it becomes bothersome and possibly startling. With sufficiently large currents, the muscles of the hand and arm involuntarily contract and a person cannot release the gripped object. For men, women, and children, the value at which 99.5 percent can let go (that is, 0.5 percent cannot) is 9.0, 6.0, and 4.5 mA, respectively. However, before the current flows in a shock situation, contact must be made, and in the process of establishing contact, a small arc occurs. This causes a withdrawal reaction that, in some cases, may be a hazard if the involuntary nature of the reaction causes a fall or other accident.

The proposed 230 kV transmission line will have the highest electric field within the ROW, approximately 0.2 to 1.5 kV per meter (kV/m), and approximately 0.1 to 0.9 kV/m at the edge of the ROW. Induced currents have been calculated for common objects for a set of worst-case theoretical assumptions: the object is perfectly insulated from ground, located in the highest field, and touched by a perfectly grounded person. Even though the maximum electric field only occurs on a small portion of the ROW, and perfect insulation and grounding states are not always common, the calculated induced-current values are very low: sedan—0.16 mA; farm tractor pulling crop wagon—0.45 mA; large school bus—0.59 mA; and large tractor-trailer—0.96 mA. Therefore, in most situations, even in the highest field location, induced currents are below the threshold of perception and are far below hazardous levels.

Agricultural operations can occur on or near a transmission line ROW. Irrigation systems often incorporate long runs of metallic pipes that can be subject to magnetic-field induction when located parallel and close to transmission lines. Because the irrigation pipes contact

moist soil, electric field induction is generally negligible, but annoying currents could still be experienced from magnetic-field coupling to the pipe. Pipe runs laid at right angles to the transmission line will minimize magnetically-induced currents, although such a layout may not always be feasible. If there are induction problems, they can be mitigated by grounding and/or insulating the pipe runs. Operation of irrigation systems beneath transmission lines presents another safety concern. If the system uses a high-pressure nozzle to project a stream of water, the water may make contact with the energized transmission-line conductor. Generally, the water stream consists of solid and broken portions. If the solid stream contacts an energized conductor, an electric current could flow down the water stream to someone contacting the high-pressure nozzle. Transmission-line contact by the broken-up part of the water stream is unlikely to present any hazard.

16.3.2.1 Fuel Ignition

The chances of having all the conditions necessary for fuel ignition present at the same time are extremely small. Very large vehicles (necessary to collect larger amounts of electric charge) are often diesel-powered, and diesel fuel is less volatile and more difficult to ignite. The proposed 230 kV transmission line electric-field levels are too low (about 0.2-1.5 kV/m on the ROW) for the minimum energy necessary for fuel ignition under any practical circumstances.

One additional consideration is the presence of gasoline stations located near the ROW edge. The low electric fields of the proposed transmission line would be further reduced to almost zero because of shielding by typical metallic coverings over the refueling area and by the presence of any nearby light poles or trees. A typical tractor-trailer gasoline truck used to replenish the underground fuel-storage tanks is commonly grounded during fuel-handling operations, and this is done to eliminate electric discharges; therefore, fuel ignition does not pose a significant hazard.

16.3.2.2 Cardiac Pacemakers

Interference resulting from the transmission-line electric or magnetic field can cause a spurious signal in the pacemaker's sensing circuitry. However, when these pacemakers detect a spurious signal, such as a 60 hertz (Hz) signal, they are programmed to revert to an asynchronous or fixed-pacing mode of operation and return to synchronous operation within a specified time after the signal is no longer detected. The potential for pacemaker interference depends on the manufacturer, model, and implantation method, among other factors. Studies have determined thresholds for interference of the most sensitive units to be about 2,000 to 12,000 milligauss (mG) for magnetic fields and about 1.5 to 2.0 kV/m for electric fields. The electric and magnetic fields at the ROW edge are below these values, and on the ROW, only the lower-bound electric field value of 1.5 kV/m is reached. Therefore, the potential impact would not be significant.

16.3.3 Computer Interference

Magnetic field interference results in disturbances to the image displayed on the monitor, often described as screen distortion, "jitter," or other visual defects. In most cases, it is annoying, and at its worst, it can prevent use of the monitor. Magnetic fields occur in the normal operation of the electric-power system.

This type of interference is a recognized problem by the video-monitor industry. As a result, there are manufacturers who specialize in monitor-interference solutions and shielding equipment. Possible solutions to this problem include: relocation of the monitor, use of magnetic-shield enclosures, software programs, and replacement of cathode-ray-tube monitors with liquid-crystal displays that are not susceptible to 60 Hz magnetic-field interference. Because these solutions are widely available to computer users, potential impacts would be less than significant.

16.4 Mitigation Measures

Because corona and induced-current effects associated with the proposed Project are less than significant, mitigation measures are not required.

16.5 References

Deno, D. W., and J. M. Silva. 1985. "Probability and Consequence of Gasoline Ignition Under HVAC Transmission Lines." *IEEE Transactions on Power Apparatus and Systems*. Vol. PAS-104, No. 11. November.

_____. 1987. "Transmission Line Electric Field Shielding by Objects." *IEEE Transactions on Power Delivery*. Vol. PWRD-2, No. 1. January.

Electric Power Research Institute. 1982. *Transmission Line Reference Book: 345 kV and Above*. Second Edition.

_____. 1997. *Susceptibility of Implanted Pacemakers and Defibrillators to Interference by Power-Frequency Electric and Magnetic Fields*. August.

Institute of Electrical and Electronics Engineers. 1976. *The Location, Correction, and Prevention of RI and TVI Sources from Overhead Power Lines*. IEEE Tutorial Document. No. 76-CH1163-5-PWR.

_____. 1980. "Review of Technical Considerations on Limits to Interference from Power Lines and Stations." *IEEE Transactions on Power Apparatus and Systems*. Vol. PAS-99, No. 1. January/February.

Miller, L. N. 1978. "Sound Levels of Rain and Wind in the Trees." *Noise Control Engineering*. Vol. 11, No. 3. November.