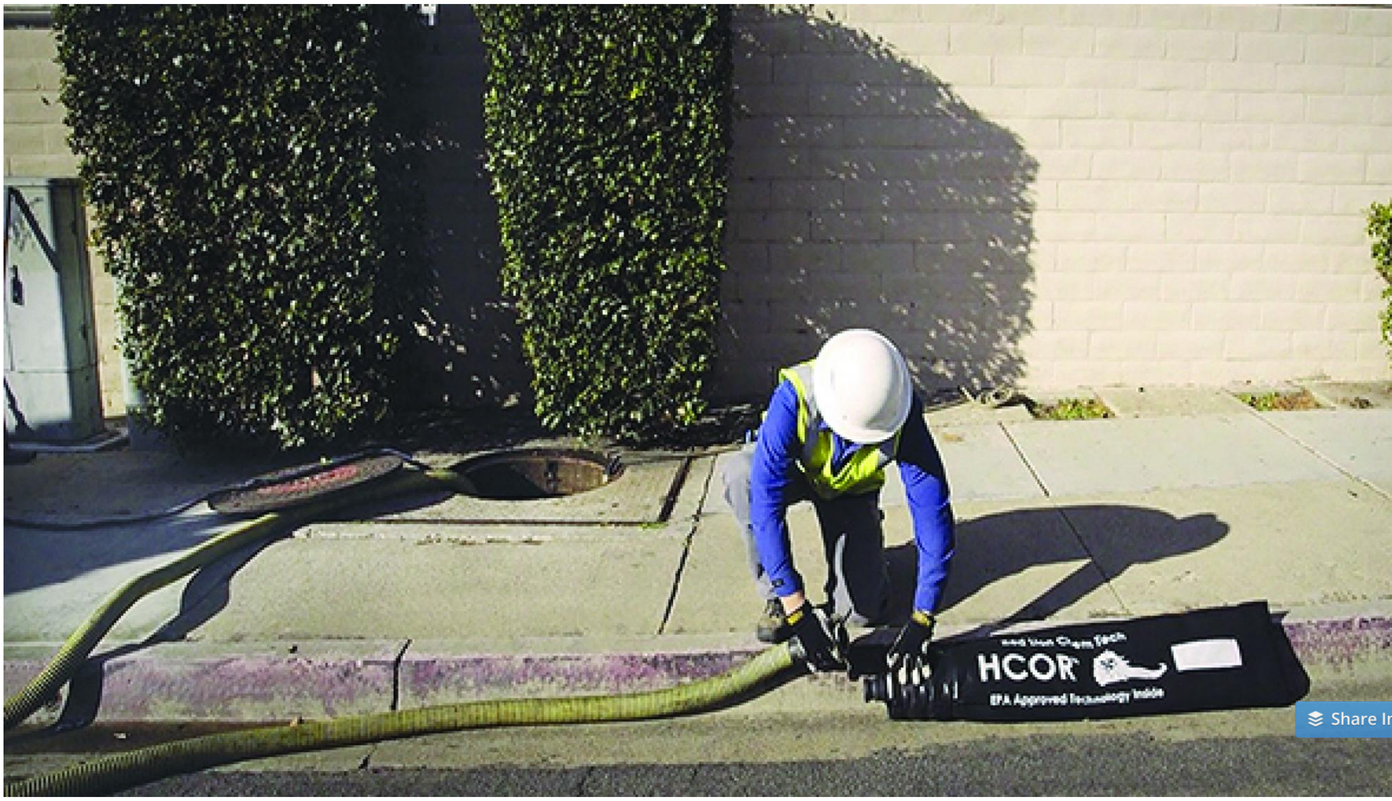
T&DWorld



<p>A water filtration sleeve is attached to the hose from the crew’s pump, so water can be released into a gutter and then into the storm drain.</p>

INTELLIGENT UNDERGROUNDING

Intelligent Undergrounding

SDG&E shares its philosophy and background for an extensive underground distribution system expansion.

Jon Erickson, San Diego Gas & Electric | Oct 24, 2016

San Diego Gas & Electric (SDG&E) serves approximately 1.4 million electric customers in San Diego County and southern Orange County, California, U.S. The utility's extensive underground electric system is a key element for serving these customers reliably and safely. Undergrounding protects electric infrastructure from high winds, inclement weather and other factors, thus reducing the number of outages for the system and benefiting customers.

SDG&E has the highest percentage of underground cable for any investor-owned utility in California. The underground medium-voltage distribution system began to grow in the 1960s and 1970s, with rapid expansion occurring in the 1980s. Today, more than 60% of the distribution system is underground. SDG&E has more than 10,000 circuit miles (16,093 circuit km) of underground distribution cable and 150 circuit miles (241 circuit km) of underground transmission lines. The transmission underground system (69 kV, 138 kV and 230 kV) also has grown over the years, as the difficulty of building overhead lines has increased along with the need to increase reliability in the downtown San Diego area.

SDG&E has developed several innovative techniques to maintain this extensive underground infrastructure, creating what the utility calls an intelligent undergrounding approach.

Cable System Expansion

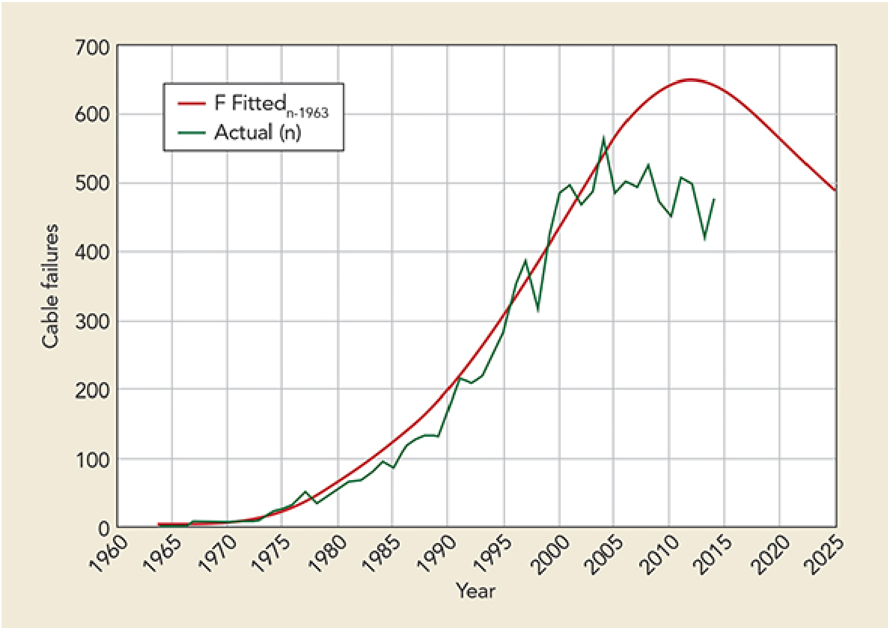
There are several reasons why the underground distribution cable system has expanded in San Diego. Many years ago, the city of San Diego and the other cities in the urban areas of the service territory began to require any new development — whether subdivision or commercial — be served by an underground distribution system. This requirement continues today.

In 1969, the California Public Utilities Commission (CPUC) developed a program to convert the overhead electric system to an underground system. This underground conversion program is called Rule 20, and there are three different rules of influence: 20A, 20B and 20C.

CPUC Rule 20A undergrounding projects are funded by all utility customers. The cities and county are allotted a certain amount of money each year based on the number of meters served from the overhead electric system in their jurisdiction. They decide what areas to convert. Areas converted must provide a benefit to the general public. SDG&E budgets about US$23 million per year for this Rule 20 conversion work.

CPUC Rule 20B concerns smaller projects covered by rate funds or private funds. Areas converted must be along public streets. CPUC Rule 20C concerns smaller conversion projects funded by property owners who usually want to convert a small number of poles.

In 2003, the city of San Diego decided all overhead lines within the city would be converted to underground within about 40 to 45 years and began to collect a surcharge to fund this work. The utility collects this surcharge through the customer's bill. The city currently spends an average of $35 million per year to convert about 12 circuit miles (19 circuit km) of overhead distribution lines.



The graph shows the actual number of cable failures per year as well as a prediction of projected cable failures that would have occurred had the cable system not been the subject of a proactive cable replacement program starting in 1994.

Aging Cable System

SDG&E installed unjacketed polyethylene-insulated medium-voltage cable (15 kV) beginning in 1963 until the mid-1980s. More than 99% of this cable is installed in conduit. In the early 1990s, SDG&E started experiencing failures of this cable, which began to impact the system average interruption duration index (SAIDI). A proactive cable replacement program and capital budget were established in 1994 to address this issue.

Many years ago, SDG&E developed an extensive cable failure database that included cable vintages and insulation material along with the length of cable that failed during each failure. Purchasing records were reviewed to determine the quantity of unjacketed cable purchased in a particular year. This database continues to be populated with cable failure information. All this information enabled SDG&E to develop specific vintage cable failure rates that are used to determine which vintages were performing poorly. SDG&E found cable installed in the 1960s and early 1970s with high-molecular-weight polyethylene was not the worst performing. Instead, cross-linked polyethylene cable produced between 1977 and 1983 was the worst performing.

With the availability of this cable failure rate and poor-performing vintage information, SDG&E was able to prioritize its proactive cable replacement work. Areas with multiple cable failures also were identified and included as part of the proactive work. Between 1994 and 2014, SDG&E proactively replaced an average of 13.5 circuit miles (21.7 circuit km) of feeder cable and 35.2 circuit miles (56.6 circuit km) of primarily underground residential distribution cable each year. This proactive cable replacement program continues today.

A few years ago, SDG&E wanted to determine what impact the proactive replacement work had on the number of cable failures. An analysis of the number of failures that occurred with proactive replacement was compared with the expected number of failures if no proactive cable replacement work had been done. The result was there could have been an additional 100 to 150 failures per year at the peak. The analysis also showed a substantial drop in failures in future years as the poor-performing cable was removed from the system. The reduction in underground cable failures has enhanced SAIDI scores, which currently are in the 60-minute range.

Water Filtration Sleeve

In the past several years, SDG&E has employed pumper trucks during outages on the underground cable system. These trucks are required because water is not allowed to be pumped out of manholes into storm drains unless it has been determined to be clean. This extended the outage duration and added operating cost to SDG&E and its customers.

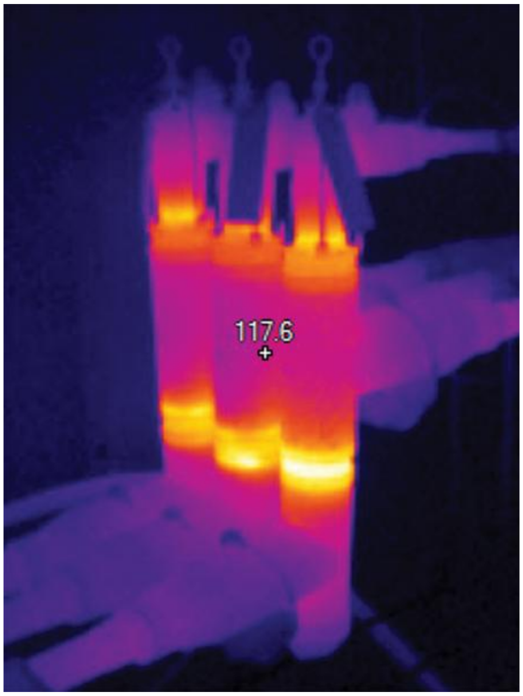
Last year, SDG&E collaborated in the development of an innovative water filtration sleeve that could be attached to the hose from the crew's pump, so water could be released into a gutter and then into the storm drain. The sleeve is designed to remove almost all dangerous chemicals from the water, including hydrocarbons, polychlorinated biphenyls and toxic heavy metals. The sleeve is currently being tested and is planned to be rolled out companywide in the near future. This sleeve will speed up the utility's pumping efforts, enhance reliability and help to keep the local environment clean.

Infrared Inspection

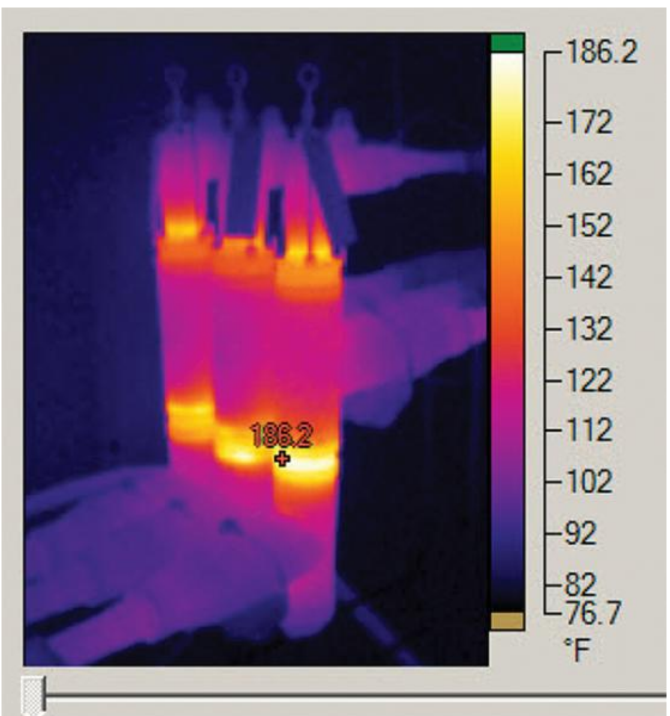
A major safety concern for any personnel who enter manholes or other subsurface structures with energized electric cable and connections is the integrity of the connections. Using an infrared camera is the best way to check all connections prior to entry into the substructure and enhance safety for crews. Several years ago, SDG&E implemented an operating standard practice to use an infrared camera to check all cable connections in a substructure prior to entering. This process was performed after properly venting the substructure.

If water is in the substructure, the water is pumped below the connector and infrared readings are recorded. Subsequent reads are taken every 5 minutes for 15 minutes to see if there is a substantial temperature rise. SDG&E has seen cases where 600-A tees have failed a few hours after water was removed from a substructure, so this shows the importance of waiting a period of time after water is removed from the connection and checking the temperature at subsequent time intervals.

There have been several times where the infrared inspection has found 600-A tees with elevated temperatures, and these connections were replaced to prevent a failure. SDG&E has established an operating practice for the response time to correct a problem based on the temperature of the connector compared to how much that temperature is above the cable temperature. Normally, the connector temperature should be below the cable temperature.



Infrared camera image of a 600-A tee showing a reference temperature that is used for comparing temperatures measured on neighboring components to determine if a hot spot exists.



Infrared camera image showing a significantly elevated temperature in the connecting plug part of a 600-A tee.

System Control and Data Acquisition

Over the last 30 years, SDG&E has greatly expanded the use of the supervisory control and data acquisition (SCADA) system throughout the overhead and underground electric distribution system. This includes SCADA in substations as well as automated overhead and underground distribution switches. This deployment has enabled system operators to control these switches remotely to restore service much faster during outages than in the past when line personnel were sent to operate these switches manually. SDG&E currently has SCADA on approximately 80% of distribution lines and on all transmission lines.

SCADA also has been deployed with line reclosers and is now being incorporated with distribution line capacitors and line regulators. Implementation of SCADA also has provided much more basic electrical information — such as voltage, current and power factor — about substations and distribution circuits to enable more efficient operation of the electric distribution system.

Result: Most Reliable

All these efforts have been aimed at transforming older infrastructure into a new, more versatile and resilient smart grid that is more reliable and sustainable for customers. SDG&E's focus on this area is producing stellar results, as evidenced by the utility being named the most reliable utility in the western United States for 10 years in a row. SDG&E will continue to modernize the electric grid with innovative technology and enhanced equipment, providing reliable and safe power for customers and empowering a prosperous future for the entire region.

Jon Erickson is a principal engineer with more than 38 years of experience with San Diego Gas & Electric, including eight years in field operations and 22 years in electric distribution engineering. He is responsible for medium-voltage and low-voltage underground cable and connectors, overhead conductor and connectors, and the design criteria for distribution transformer loading, distribution protection and circuit sectionalizing. He is also responsible for tracking medium-voltage underground cable failures and maintaining a cable failure database used for cable failure rate projections and to help prioritize proactive cable replacement.
