DECAGON DEVICES

Application Note

Thermal Runaway

Matthew Brocket

Date: March 3, 1998

Testing thermal resistivity - a measure of the soil's ability to carry heat away from cables

From Reuters/ Variety

Wellington, March 3 (Reuters) - Irish rock band U2 came to the aid of power-hungry Auckland as a giant cargo plane for concert equipment was diverted to fly in generators to relieve a 12-day power outage in February 1998.

The use of the band's plane was one of very few victories for Mercury during 12 days which it has described as "the weeks from hell."

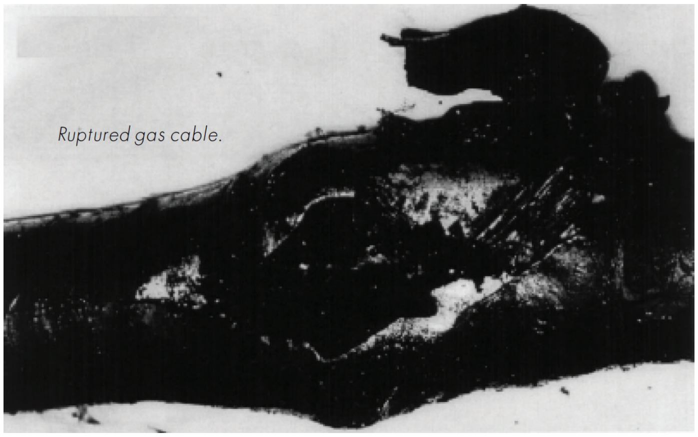
Central Auckland was plunged into darkness on February 20 when the last of Mercury's four main power cables into the city failed. The II0,000-volt cables started to collapse in January.

The source of the failure was thermal runaway in the buried cables carrying power to Auckland. Thermal runaway is becoming increasingly common throughout the world, as public power companies are privatized and infrastructure is pushed to the limits of its capacity in order to maximize profits. The results of miscalculations are disastrous. While Decagon can't stop thermal runaway problems, we can help.

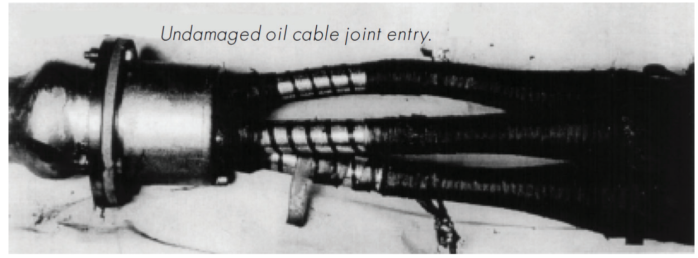
Thermal runaway can occur in underground power cables. Because the cables carry current, they generate heat. The heat is dissipated to the soil surrounding the cable. The soil/cable system is designed so that, for the current normally carried by the cable and the thermal properties of the soil in which it is placed, the temperature of the cable will remain within safe limits. Thermal runaway results when the design conditions are exceeded, either by passing too much current through the cable, or allowing the soil to dry around the cable, thus decreasing its thermal conductivity. Once the cable starts to heat, a positive feedback condition starts (similar to a microphone and amplifier in a public address system feeding back on itself). When a temperature gradient exists in soil, water tends to move from regions of high temperature to regions of low temperature. As the cable heats, the moisture around the cable is driven away, leaving the cable in dry soil. The thermal conductivity of dry soil is only about 1/5 that of wet soil, so the cable temperature has to rise substantially in order to dissipate the heat it is producing. This increased temperature dries an even thicker layer of soil around the cable, which results in even more temperature rise at the cable. The positive feedback produces a runaway condition where the cable temperatures become high enough to cause catastrophic cable failure, as is shown in the pictures.

How can Decagon help?

We can't control the current that power companies chose to send through a cable, but we can supply engineers with measurements of soil thermal properties. This will allow the engineers to compute safe limits for power dissipation in the cables. The Thermolink, with the thermal properties probe, measures thermal conductivity, thermal diffusivity, and specific heat of a soil in less than two minutes. Thermal resistivity, which is often used in these calculations in place of thermal conductivity, is just the reciprocal of the conductivity. It is probably too late to start these measurements and calculations after the lights go out, but we hope future disasters like the power outage in Auckland can be averted by better measurements of soil thermal properties and more careful design of soil/ cable systems which take these properties into account.



Ruptured gas cable.



Undamaged oil cable joint entry.

Oil cable joint entry ruptured due to thermomechanical failure.