IMPROVING DISTRIBUTION SYSTEM RELIABILITY

Donald **BAINBRIDGE**, Victorian Electrical Supply Industry, (Australia), d.j.bainbridge@bigpond.com

ABSTRACT

Due to load growth and age a mainly xlpe insulated 22 kV cable system had become unreliable resulting in extended outages. The causes of the outages were identified and actions taken to improve reliability. Actions included installing additional circuits into the area, rejuvenation or replacement of aged cable, removal of Tee joints, replacement of aged straight joints. Lessons learned have been applied to existing and new cable systems across the whole network. The relationship between distribution voltage, circuit length and reliability is also observed.

Community expectation

In the last quarter of a century, society has become dependent upon digital electronics for almost everything we do. Loss of electric supply for more than a fraction of a second disrupts electronic equipment causing, economic loss, annoyance and the inconvenience of resetting electronic equipment. People expect reliable electricity supply.

In Victoria, Australia, the government has financial incentives and penalties for the electricity supply utilities to promote reliable supply. A high supply reliability factor allows the utility to charge customers a higher service fee. Electric supply companies want to be seen as reliable suppliers and good corporate citizens with satisfied customers.

Problem

Unlike overhead electrical systems, faults in underground cable systems can neither be seen nor quickly located and repaired. Underground cable system faults in a medium voltage system disrupt supply to large numbers of customers. An 11 kV fault typically affects an average of approximately 1,000 customers while a 22 kV fault typically affects an average of approximately 2,000 customers for about 40 minutes until the fault is isolated.

Unlike overhead systems, underground systems are invisible “out of sight and out of mind”. People are not as conscious of underground cable systems, their maintenance and improvement as they are for visible and vulnerable overhead systems.

In Victoria about 10 years ago it was found that early xlpe insulated MV cable systems were starting to have increasing rate of faults.

In the summer of 2002-3, a series of faults occurred in an aged 22 kV xlpe cable system in an outer Melbourne suburb. This area has since been carefully studied and many reliability improvements made.

The supply failures started in the study area when a high current fault caused failures elsewhere in the same circuit due to the high fault current and associated voltage transients causing breakdown of cable insulation, straight joints and a Tee joint.

Four kiosk substations were without any MV supply. Mobile generators, where available were hired in. Customers’ LV circuits were switched to other nearby kiosk substations on different MV circuits which then failed later in the day as the load increased when people came home, turning on air-conditioners, televisions and electric cookers.

Increase in Loading

The critical loading in Australia is in summer. The peak in load is due to the almost universal installation of air conditioning in new and existing homes. The average floor area of new homes built in Australia has increased 10% in the last 10 years to 215 sq m to be the largest in the world (USA 202 sq m) since the under grounding of cables in new suburban areas became compulsory over 20 years ago.

Climate Change

In Victoria, hotter summers have increased air-conditioner installation rate and usage resulting in increased hot weather loading on the electrical system. Soil temperature maximum was 20℃ when the cable system was designed in the 1970s. In recent years soil temperature at cable depth has been measured at over 25℃ in southern Victoria.

Rainfall average has decreased and water evaporation from the soil has increased since the1990s. The clay soil has dried and contracted causing cracks in the soil thus increasing the thermal resistance of the soil.

The cables are running hotter due to:

- increased current loading of air-conditioners,
- increased soil temperature and
- increased soil thermal resistance of dry, cracked soil which traps in heat from cables.

The contraction in the dry clay is visible as cracks in the surface and as undulations in the roadways.

The undulation in the roadways, cracking and mal-alignment of concrete footpaths driveways and gutters also suggests that there is soil movement around the cables and joints inducing mechanical forces into joints.

Types of faults

Cable faults

The cable faults include:

- Lead sheath corrosion on old paper insulated cable.
- Water tree failure in xlpe insulation.
- Accidental damage by people excavating without properly locating cables.
- Failure under high voltage VLF test.
- Termite attack of cable and joints.
- Damage due to fault current where screen wires are not correctly connected.
- Overheating of screen wires due to multiple application of fault current within a short time span.