Trade & Investment
Mine Safety

SAFETY ALERT

Fire in 33kV XLPE cable splice

BACKGROUND

An underground mine was evacuated after a fault occurred involving the three-phase and ground on the 33kV overhead line on the mine surface. While the initial fault cleared quickly, it appears to have led to a 'cross country fault' in the 33kV reticulation system.

Over the next six minutes a failure occurred on a 33kV pole-mounted circuit breaker and a 33kV cable splice underground.

Monitoring systems logged significant disturbances on the high voltage (HV) network throughout this period, leading to the HV protection system shutting down power to the site.

The failure of the underground splice caused a fire at the splice and after an unsuccessful attempt to extinguish the fire, the mine was evacuated.

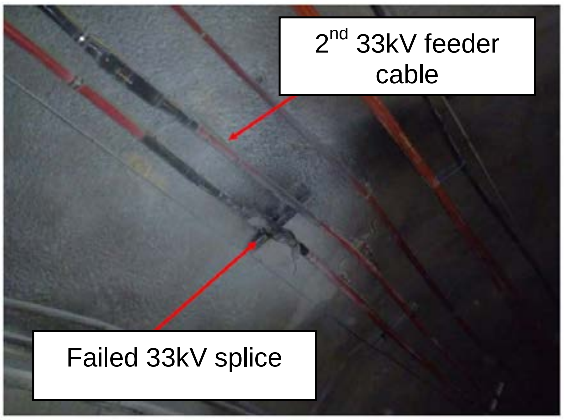

Figure 1: The burnt out cable splice as seen from the floor of the mine.

Figure 2: What remained inside the cable splice cage.

APPARENT CAUSES

The initial fault may have been caused by a fallen branch or wildlife coming into contact with the 33kV overhead line resulting in a phase-to-phase and a phase-to-ground fault that was cleared within 50milliseconds.

A series of short duration 'cross county faults' occurred involving two different 33kV feeders on the 100 Amp earth fault limited system. The earth leakage protection settings had a definite time delay of 1.5 seconds. The resulting series of short duration faults failed to cause tripping of the relevant earth leakage protection relays. Investigations following the power trip identified a flashover at a separate 33kV recloser on the surface and the insulation failure and subsequent fire on the underground 33kV feeder cable splice.

CONTRIBUTING FACTORS

- During commissioning of the 33kV XLPE cable, suboptimal insulation readings were observed but as they lay well within 'acceptable limits', no further action was considered necessary. The 'suboptimal readings' were resolved when the fire-damaged splice was replaced.
- Due to the reduced level of earth fault current in an IT network (as used in mines), high speed overcurrent protection will not provide fast clearance times during fault current limited earth faults. For low voltage circuits with fault currents limited to 5 amps and sensitive earth leakage detection, this may not represent a major issue. On HV distribution networks where the earth fault current may be limited to much higher levels, these 'higher energy' earth faults can potentially cause fires if not cleared quickly.
- The 33kV splice fire was not discovered until 36 minutes after the initial fault. The splice is believed to have burnt for about two hours, periodically dropping burning insulation material onto the roadway. The XLPE cable on either side of the splice did not burn. The situation was compounded when another electrician resetting power to the mine, failed to identify that the 33kV underground feeder involved had tripped on an earth fault, and reset power to the effected cable. This happened about 55 minutes after the initial failure and subsequent fire.
- The surface communications only had a limited back up power supply. Due to the loss of power to the mine site, communication was lost to the underground part of the mine and this delayed the fire team response.
- The cable splice was of a tape and heat shrink construction. Such joints do not fully preclude air from getting inside the completed splice. The manufacturer has confirmed that this may make such joints more vulnerable to fire.

ADDITIONAL COMMENTS

- The splice manufacturer confirmed that non-resin filled cable joins will contain some air voids and the use of resin or compound filled joins may be advantageous where optimum fire resistance is required.
- The splice manufacturer's specifications for this splice kit indicate its voltage ratings for phase-to-ground insulation coordination is suitable for this IT network application.
- The installation of splices on HV networks requires a high level of professionalism and quality control. Very small errors during installation may result in future joint failure.
- There is considerable diversity of opinion within industry as to the appropriate testing regime for 33 kV HV XLPE cable systems. While DC megger testing to 5 kV and VLF HiPot testing to about system voltage is widely used, the required duration of the test and actual test voltage levels remains controversial. Excessive test times and voltages may damage these HV XLPE installations, while shorter duration and lower test voltages may lead to false 'positive' results.

RECOMMENDATIONS

1. Underground HV networks should be isolated from surface HV overhead lines that have a higher risk of faults, due to factors such as lightning, fallen branches, wildlife, etc.
2. Provide effective surge diverters and associated earthing rated for:
   - the potential line voltage during an earth fault,
   - prospective short circuit current of the network, and
   - the short circuit fault clearing time

   This will help minimise transients transferring to underground cable networks.
3. The electrical protection on IT network HV supplies should be set with the fastest clearance time possible while still allowing for discrimination and reliable performance. To best achieve these goals, consideration should be given to the use of zone protection relays interconnected by high speed communications. The use of such relays can dramatically reduce the time required for fault clearance while still maintaining effective discrimination.
4. Set the fault current limitation on HV IT networks to the minimum level required for reliable system stability.
5. A risk assessment should be carried out to determine the suitability for use of the various types of HV splice kits available for use in an underground mine. Considerations should include, but not be limited to:
   - the availability of suitable testing equipment and regimes for these installations
   - the impact of a splice failure in an underground mine
   - whether epoxy-filled HV cable splices would be more appropriate in the underground portion of the mine - considerations should include initial installation issues and the life of the mine, including maintenance.
   - whether fire rated HV cable splices would be more appropriate in the underground portion of the mine
6. Mine emergency response plans need to consider:
   - the effect of power loss to the mine site, or parts thereof, on mine communication systems
   - the effect of external pressure on personnel making critical decisions regarding restoration of electrical power following system faults. Clear lines of authority within and across different mining disciplines should be developed for mining emergencies
7. Partial discharge testing should be carried out at commissioning of HV cable networks to assist in assessing the quality of the installation and to establish a baseline figure for future analysis.
8. Where HV transmission systems are utilised in mines, consideration should be given to the appropriate control of transient conditions caused by earth faults on cables and equipment within IT networks.

REFERENCES:

- AS1429.1-2009 *Electric cables—Polymeric insulated Part 1: For working voltages 1.9/3.3(3.6) kV up to and including 19/33 (36)kV*
- IEEE Std 400.2 2004 IEEE *Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)*
- Burgess R & Ahfock H, *Minimising the Risk of Cross-Country Faults in Systems Using Arc Suppression Coils,* University of Southern Queensland, 2011

NOTE: Please ensure all relevant people in your organisation receive a copy of this Safety Bulletin, and are informed of its content and recommendations. This Safety Bulletin should be processed in a systematic manner through the mine's information and communication process. It should also be placed on the mine's notice board.

Signed

Rob Regan
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MINE SAFETY OPERATIONS
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