Safe Work and Return to Work Awards 2019

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Safe Work and Return to Work Awards example entry Category three – Best solution to an identified electrical issue

1. Describe the electrical safety issue you identified while performing electrical work.
During the past few years, there has been a significant growth in coal traffic in Central Queensland, requiring a number of investments to increase electrification network capacity and reliability. The investments include the design, supply and construction of a number of new feeder stations and track sectioning cabins in the Goonyella and Blackwater systems.

As part of the power systems upgrading project, the gas insulated switchgear (GIS) has been adopted for the new switching buildings and the high voltage XLPE cabling has been used to connect the supply transformers and the overhead wiring along railway track to the switchgear.

Testing a switching station (a feeder station or a track sectioning cabin in railway electrification term) and its associated connections and cabling is required under:

- The Electrical Safety Regulation 2002 Clause 14 "Testing of electrical equipment after electrical work".
- Recommendation from cable supplier and AS60840: a cable soak test must be undertaken for a period of 24 hours at 27.5kV (derived from the nominal line voltage is 25kV plus 10%).

QR National identified that a connection of the switching station to the network for the testing introduces operational risk to the network and safety risk to the personnel.

The above requirements and issues prompted investigating the development of alternative and independent soak testing arrangements. Enquiries were made as to the availability of existing soak testing equipment that is suitable for 25kV AC rail electrification but were fruitless, so it was decided to develop and design suitable testing equipment.

The precepts of the high voltage cable test rig were:

- be powerful enough to test at 27.5kV for 24 hours up 900m of high voltage cable which is the maximum length of cable installed in
- a standard switching station in the electrified traction power system
- be self-contained with regard to power generation and testing capability thus being able to operate without dependency on any local services
- be transportable to facilitate relocating from site to site
- be easy to set up for testing at any site
- be simple and safe in operation
- provide a simple design to facilitate construction utilising standard off-the-shelf materials and equipment items.

One option which was considered was to connect the switching station to the adjacent traction power system through an overhead drop out fuse for sectioning testing of the switching station and 24 hour cable soak. But this option was not accepted due to:

- potential non-compliance with the Electrical Safety Regulation
- any electrical fault which occurs at the switching station during the testing can disturb the operation of the existing traction power network
- any electrical fault which occurs in the adjacent existing traction power system during the testing can make testing officers exposed to the electrical safety risk due to high fault level
- the installation of the drop out fuse and the direct connection to the existing traction power system requires traffic closure, lift platform, working at height, additional safety procedures associated with placing fuse in high voltage connection.

To manage the risks of connecting the switching station to the network during test, QR National developed a high voltage test rig consisting of a 20 foot shipping container equipped to provide a test voltage of 27.5kV.

It enabled the underground cable soak test to be undertaken for a period of 24 hours without curtailing the normal operations of the existing adjacent traction power network. It also facilitated positive testing of the correct connections of the installed high voltage cables and the associated switchgear.

2. Explain in detail the solution that was developed to address this issue.
The test rig was constructed and commissioned at an assembly factory in Brisbane at the end of October 2010. The commissioning was used as an opportunity to train the first two technicians as operators of the rig.

Subsequently, the test rig has been used to perform successfully the testing on fifteen switching stations (including a private station owned by Pacific National) between February 2011 and July 2012.

The design centred on accommodating the test equipment in a modified 20 foot international standard shipping container. A container would provide for transportability as well as securing the equipment against weather and theft. The concept was to modify the container to create three compartments. The end compartment with the standard container cam lock doors would serve as the high voltage equipment end. The centre compartment housed the generating set. The third compartment at the opposite end accommodated the control equipment. The latter two compartments are provided with access doors cut into the side of the container. The internal walls between compartments are fabricated from sound absorbing material to attenuate the noise of the diesel set.

The kVA demand to test 900m of high voltage cable at 25.7kV is approximately 50kVA or 1.8 amperes. This demand is based upon the capacitive characteristic of such a length of cable. This would govern the size of the diesel generator.

Initially, the design was directed to a 50kVA 240V single phase diesel generating set and a 50kVA 240V/27.5kV single phase transformer. However the load demand to energise the cable is almost entirely capacitive. Thus an equivalent inductive reactor was introduced into the testing circuit to reduce the load demand on the generator to virtually nothing. Such a reactor would have to be variable in size to provide for testing a wide range of cable lengths. This proposal proved to be economically feasible using a set of 10 x 5.0kVAr plus 1 x 2.5kVAr inductive reactors. The latter reactor is used to trim the total reactive load to plus/minus 2.5kVAr. Each of these reactors is provided with a switch for individually switching into circuit to suit the length of cable being tested. This resulted in a significant cost saving by reducing the size of the generator.

One of the necessary features for the operation of the rig is to provide control over the voltage applied to the cable being tested. With the reactors compensating for the capacitive load of the cable, the actual demand on the test circuit is comparatively low, probably less than 2.5kVAr. This may be higher in order to maintain a lagging power factor on the generator to enable stable operation. A 5.0kVA rated Variac was therefore selected to control the test circuit. Apart from being able to trim the test voltage to the desired value, the Variac allowed the application of the test voltage to be increased from zero to full voltage. Thus in the event of a fault in the cable, the operators would have early indication of any problems by slowly raising the test circuit voltage.

This feature enables the operators to isolate the test circuit without delay and to investigate accordingly. In addition, the provision of a Variac also by-passes the problem of magnetising inrush current to the 50kVA transformer. Inrush current at full voltage would normally trip the comparatively low power capacity test circuit.

The diesel generator is a 2-cylinder air cooled diesel generator rated 10kVA. A single cylinder same type of engine would have been too small. The 10kVA set required the provision of dummy loads to ensure the set would be loaded to a minimum of 75% of its full rating to optimise the performance of the engine.

The control compartment includes the following equipment items:

- the test circuit Variac
- remote controls for the diesel generator
- the control panel with selector switches for each of the reactors, meters for test circuit volts, amperes and power factor, control switches for the dummy loads as well as circuit breakers for lighting and power outlets.

The container includes a voltage transformer to measure the voltage applied to the cable being tested. The voltage transformer is located in the high voltage compartment adjacent to the 50kVA transformer. The test voltage value is displayed on the control panel to enable the operators to ensure the correct voltage value is applied to the cable being tested. The same circuit has an outlet for digital recording so that a test certificate may be provided to the end user of the cable.

The high voltage compartment is located at the end of the container with the cam-lock doors. This compartment houses the 50kVA, 240V/27.5kV, ONAN transformer and the voltage transformer. It also includes a test capacitor rated 45kVAr to enable the rig to be self-tested. This particular feature was deemed necessary so that a full operational check can be undertaken every time the rig is relocated from site to site to meet the safety and reliability requirements of QR National.

The high voltage connections between equipment items in the compartment are all air insulated with clearances arranged to meet those defined in the relevant Australian standards. The final connection from the high voltage terminal of the transformer to the end of the cable being tested is supported on an insulator installed on the end of an extensible arm.

The aspect of safety is a significant feature of the design of the rig. Engineering and administrative controls were introduced. This is of particular importance to QR National, which has a very strong emphasis on safety in all of its operations. Electrical safety is very closely associated with the earthing of electrical equipment. Thus the procedure of correctly earthing the rig from the time it is set up for a test until it is de-energised at the end of a test is an important part of its use. One of the benefits of using the rig to test cables is the independence from the adjacent energised electrical traction system. The maximum earth fault current of the power system in the rig is approximately 2500 Amperes. The touch potential rise under the worst fault conditions will be well within the limits defined in AS 3000.

The exposed high voltage connections are contained in a fenced area from the open doors of the container to the base of the mast supporting the cable. This area is created by panels of temporary fencing each of which is earthed with bolted copper cable connection to the adjacent panels and padlocked into position at each end to the doors of the container.

The earthing of the container, the fence panels and the interior equipment items represent an important safety feature of the rig. Flexible leads are provided to extend the connection of earthing system of the container to the earthing system of the compound in which the rig is operating.

The operation of the rig must be undertaken by a minimum of two technicians who have been trained to follow all operating procedures. One of the requirements is that two operators must be available during its set up and checking prior to testing. The procedure documentation includes a list of pre-start activities. These activities are directed towards general safety. One of the operators will undertake the activities and the other operator will check the activity has been satisfactorily completed.

A team of QR National Electrical Program staff were directly involved in the development of the test rig, including designers, design reviewers, project coordinators and commissioning coordinators.

3. Outline how successful the solution was and how it improved electrical safety.
The first 24 hour test application was successfully conducted at the Westwood Track Sectioning Cabin (TSC) in February 2011.

Following the successful testing at Westwood TSC, the test rig has been used for testing thirteen other new switching stations in the Blackwater area between March 2011 and April 2012, including Mt. Larcom TSC, Raglan Connection Station, Raglan Feeder Station (FS), Bajool TSC, Kabra TSC, Wycarbah FS, Edungalba TSC, Duaringa FS, Wallaroo TSC, Umolo TSC, Bluff FS, Blackwater TSC.

Some faults and defects have been identified during the test and due to the independence of the test application, the rig operator safely and easily stopped the test to rectify the fault before conducting another test. This is much safer than if the switching station is connected to the live network for testing.

In July 2012, the test rig was transported to Nebo to undertake the 24 hour testing of the Track Coupling Unit which belongs to Pacific National (a third party private rail operator).

The testing staff and electrical operational staff in QR National have found the test rig is very useful and safe to use. It also assists the project delivery in meeting the project programming since the testing is not dependent on the network operation.

This solution will be introduced to other areas of QR National operations. External interest is welcome. This solution is considered unique to the rail industry and will provide a safer efficient means for testing cables.