Fire safety is serious business. No matter your industry the damage caused by a fire could be catastrophic for your business. But how do you mitigate the risk?

A risk assessment approach to substation fire protection

The Fire Protection Association of Southern Africa recommends that a fire risk assessment be conducted “whenever meaningful changes occur” at a site. These can include any changes to the building structure, changes in the processes in the building or changes to the employee contingent.

Substations are unique in that they offer particular fire risks and must be analysed separately from the general business model.

Alien Systems and Technologies has developed a risk assessment and reduction approach to substation fire protection using an understanding of substation fires. It uses the Workplace Risk Assessment Control (WRAC) Chart and Qualitative Guide (see Fig. 1).

Points of possible fire risks in substations include HT cabinet enclosures, MCC cabinet enclosures, VSD cabinet enclosures and bunched electrical power cables. The listed equipment, if damaged or destroyed in the event of fire, would affect the electrical power reticulation system of a mine, plant or building. These substations are designed to provide electrical power continually to maximise production and revenue income. Should they suffer a disruption or catastrophic event, recapitalisation costs would be high and losses in production severe.

Given the electrical energy present in substations, there is always the potential for fire in spite of every care to prevent faults leading to ignition. High levels of energy sufficient to increase temperature of materials to a point of fire ignition are the primary cause of fire.

This generally occurs in cable termination compartments leading out to motors and other equipment where cable is terminated within cabinets and the crimp on the lug occasionally overloads and increases in temperature to a point where fire occurs.

Another common source of fire is at the spring-loaded connection point between the breaker compartment and spouts leading to the bus bars. Occasionally, the spring loaded connection mechanism is weakened or damaged by workers “ramming” or misaligning the breaker to the spouts. The weakened or damaged spring leads to a faulty connection that causes overheating, leading to fire.

There are, however, other sources of fire within substations. Sometimes, rodents get inside electrical cabinets that result in arc flashing with enough energy to cause other materials to ignite.

Fire would ultimately destroy the substation, should such a fire event occur without any intervention. Fire from the substation can also travel along the routed cables to motors and other equipment. Transformers are usually situated near substations and can also form a secondary fire.

Using the WRAC Chart, fires within substations happen “occasionally” given the high energy present. Should
This is important, given that fires can escalate rapidly before any manned response occurs, should there be no rapid fire escalation. Using a point type optical smoke detector arrangement will confirm the presence of fire.

Where no ceiling is present and the substation is covered by a sheet metal roof a system such as Pyrogen could be used inside the electrical cabinets. Fire detection must be in the room and all cable trenches. It must be included should a cable room form part of the risk area. All detection systems must be designed and installed to conform to a recognised international engineering standard such as SANS/ISO 10139 and SANS 369 parts 1 and 2.

### Extinguishing

To extinguish a fire as quickly as possible and to minimise damage, an automatic system, operated from a fire detection system should detect a fire at its true incipient stage before the advent of smoke. This detector is ideal for dusty mining and plant environments as it is impervious to false alarms caused by dust particles. The key benefit of this is a very early warning of fire before the advent of smoke. This means that preventative action can be taken before any catastrophic event occurs.

#### Method of fire protection

The method of fire protection best suited to protecting switchgear operations works as follows:

#### Detection

The fire detection system should detect a fire at its true incipient stage before the advent of smoke to confirm the presence of combustion as early as possible to facilitate a fire extinguishing system and a manual means of alerting for fire. The fire detection system should alert a control and alarm signalling system and should also have a monitored detection system for fault and fire. The detection system should conform fully to an internationally-accepted engineering standard.

To detect fire combustion at its true incipient stage, a Cirrus Pro Aspirating detection system could be used. It employs a sub-micron combustion particle detection “cloud chamber”. It detects combustion particles that occur before smoke does.

### Table 1: Qualitative probability.

<table>
<thead>
<tr>
<th>Probability</th>
<th>Description</th>
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<tbody>
<tr>
<td>Frequent</td>
<td>Likely to occur often during the life of an individual item or system, or very often in operation of a large number of similar items.</td>
</tr>
<tr>
<td>Probable</td>
<td>Likely to occur several times in the life of an individual item or system, or often in operation of a large number of similar items.</td>
</tr>
<tr>
<td>Occasional</td>
<td>Likely to occur sometimes in the life of an individual item or system, or several times in operation of a large number of similar items.</td>
</tr>
<tr>
<td>Remote</td>
<td>Unlikely but possible to occur sometimes in the life of an individual item or system, or can be reasonably expected to occur in the life of a large number of similar components.</td>
</tr>
<tr>
<td>Improbable</td>
<td>So unlikely to occur in the individual item or system that it may be assumed not to be experienced, or it may be possible, but unlikely to occur in the life of a large number of similar components.</td>
</tr>
</tbody>
</table>

### Table 2: Qualitative consequence.

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Catastrophic</td>
<td>Death, loss of system or plant, release to the environment, such that significant public interest or regulatory intervention occurs or reasonably could occur.</td>
</tr>
<tr>
<td>Critical</td>
<td>Severe injury, major system damage or other event which causes some loss of production, unplanned localised damage to the environment, affect other areas or could have resulted in catastrophic consequences in different circumstances.</td>
</tr>
<tr>
<td>Marginal</td>
<td>Minor injury, minor system damage, minor, confined and non-damaging environment exposure or other event.</td>
</tr>
<tr>
<td>Negligible</td>
<td>Less than the above.</td>
</tr>
</tbody>
</table>

If the probability is occasional and the consequence catastrophic, then the risk area. All detection systems must be designed and installed to conform to a recognised international engineering standard such as SANS/ISO 10139 and SANS 369 parts 1 and 2.

Although controlling the probability of fire is the first important step, the control of consequence is more crucial to reducing the risk score significantly due to the inherent high levels of energy present within a substation.

Once a fire occurs, it can escalate rapidly before any manned response is able to arrive and extinguish fire, resulting in great damage. A reliable yet early means of detection is crucial. However, more importantly, a fire extinguishing intervention point must be in place immediately after fire detection.

This is important, given that fires can occur at odd times and they can escalate quickly, once ignited. These are not predictable factors. Therefore, a suitable fire protection method is important as an effective means to control the consequence of a substation fire.
A hand-held fire extinguisher should be installed within the substation in compliance with regulations. The type and number should conform to local standards and regulations. All extinguishing systems must be designed and installed to appropriate, internationally recognised engineering standards.

Other fire protection operations

All louvers are to be sealed when fire is first detected. All air conditioning devices are to be tripped and air conditioning ductwork must have dampers sealing the duct in the event of first detection of fire.

All cable trenches are to be sealed properly with a fire rated medium of at least one hour or in compliance with local standards and regulations. All detection, alarm and extinguishing circuits must be monitored for fire and fault.

The substation fire protection system should operate a local audible and visual alarm system, normally a local sounder or strobe on first detection and fire bell and a second distinguishing audible sound on second detection. The substation fire protection system must then report to a central 24-hour manned operations security room and, wherever possible, a local fire brigade. These measures provide the best means of fire protection for substations. It adheres to a comprehensive list of requirements laid down by an appropriate design philosophy. It is best practice and in-line with international engineering standards.

Policy and procedures

The fire protection system should form part of the safety policy and procedures for any substation. The owner should visually check the system once a month for any faults reported on the control panel and anything that might appear out of the ordinary.

The owner should immediately report any concerns or faults to a competent fire engineering contracting company. A trained fire engineering company should also be contracted to inspect the system on a three-monthly basis. It must check that the system is fully operational in terms of its design and report immediately to the owner and make corrective actions in the event of a fault. Should any physical alterations be made to a substation, a review on the fire protection system must be conducted to ensure that performance has not been compromised.

A mandatory annual room integrity test shall be carried compliant with SANS/ISO1520 part 1 for any gaseous extinguishing system.

Impact on substation risk score

By following the steps mentioned here to control probability, one can reduce the probability of a fire somewhat. Given the inherent fire potential due to the high levels of energy plus the unpredictable nature over the escalation of a fire, however, the probability score remains at “occasional” (see Fig. 2).

Even if one ranked the probability score to “remote” (“Unlikely but possible to occur sometimes in the life of an individual item or system, or can be reasonably expected to occur in the life of a large number of similar components”) the fire risk score would remain “medium”.

Installing a fire detection and fire extinguishing system as mentioned here reduces the consequences to “marginal” (“Minor injury, minor system damage, minor confined and non-damaging environment exposure or other event”).

Fig. 2: Probability score at “occasional”.

Fig. 3: The impact on the risk score of the substation.