Asset Management Case Study - FMJL Current Transformer (CT) Failures

In 2009 there had been five failures of equipment reported in the UK (three in 2009 and two before 2000) and a further six were removed from service following poor oil results. A significant number of failures have been reported worldwide - 22 in total.

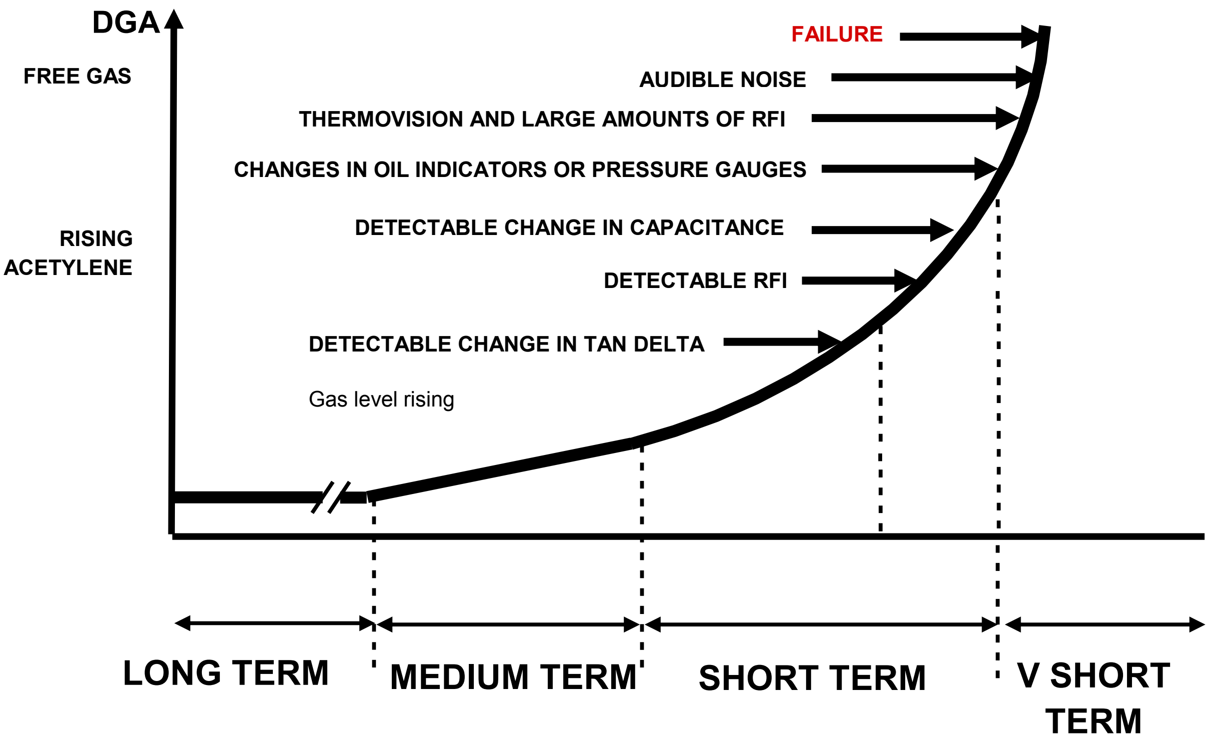
Understanding the Failure Modes

In order to manage the risk and mitigate against further failures you must first understand the different failure modes:

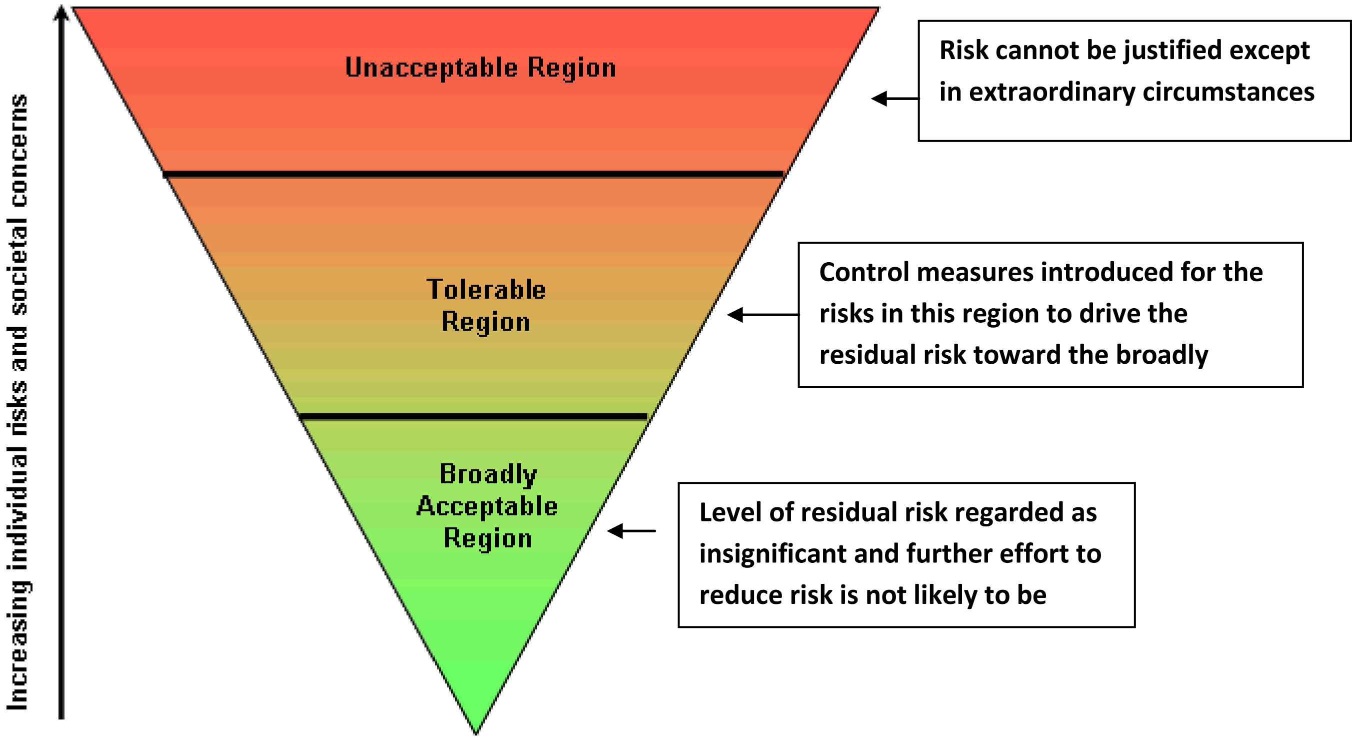
Major insulation failure of toroid or stem insulation can be due to:-

- Materials / Manufacturing Defect (normally 'burn in' issue)
- Degradation by partial discharge
- Degradation due to thermal or moisture or poor quality of oil
- High Temperature Operation
- HV internal bonding lead connection failure
- Loss of Insulation oil
- Breather blockage
- Open Circuit CT / CT Test Tap
- CT on open circuit develops an infinite voltage leading to rapid insulation breakdown and disruptive failure

Progression Mechanism for a Dielectric Failure of the Insulation in an Oil Impregnated Instrument Transformer



A Quantified Risk Assessment was carried out based on ALARP principles using historic failures, number of units, length in service, equipment condition data, ballistic data, diagnostic data, exposure, and vulnerability. The findings were that there was an unacceptable risk under normal site operating conditions putting public and staff at risk. In 2009 this impacted 142 sites affecting 40% of the transmission network.



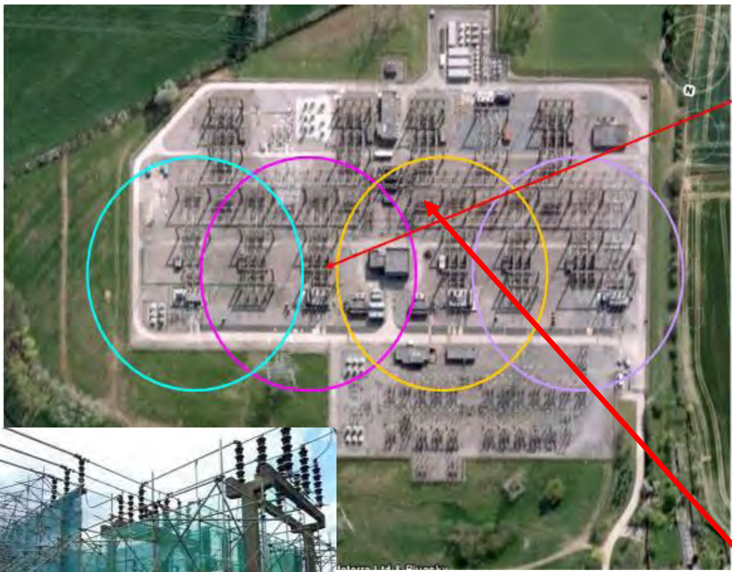
Risk mitigation considerations (following the ERICPD principles – Eliminate, Reduce, Isolate, Control, PPE, Discipline):

- Switch Out (remove the hazard)
- Risk Management hazard zones (75m)
- Physical Barriers (ballistic screening)
- PD Monitoring and alarm

A Partial Discharge (PD) Trailer and Alarm Pod was developed: A mobile PD monitoring trailer which could be deployed and set up in any position in the substations using wireless communication and gave:

- Directional coverage to indicate location and specific area of PD, i.e. detection of the first signs of electrical breakdown prior to a fault
- Time of flight measurement calculated to give range and direction onto a 2D layout drawing hosted onto a web server for remote access
- Alarm pod built with audible (sounding alarm) and visible warning (flashing lights):
- Sent a text alert when activated to selected staff and our Networks Operations Centre

Overlapping RMHZ – Restricting Access, Impact of Overdue Maintenance and Mitigation Measures



All SGTs have RMHZs applied to FMJLs on the HV

In order to replace SGT2 FMJLs and outage is required on SGT1, 2 and potentially 3 to allow access to the work area for cranes. This is not always possible

Steel containers are good for perimeter protection but due to phase & earth clearances can not always be applied within the substation

Ballistic Screening takes up a large footprint requires outages to erect and cannot always be applied between circuit bays

Failure to maintain CB due to FMJL RMHZ may incur an additional 50m RMHZ until complete

In 2009, 94 Site Specific Risk Assessments were undertaken in one week where the hazard zone extended onto public land.

An ENA Dangerous Incident Notice (DIN) and Suspension of Operating Practice (SOP) notice were issued and a working group was set up to develop an industry response.

Intensive Forensic Analysis of FMJL failures indicated:

2011 failure - Materials / manufacturing defect

2010 failure - Moisture ingress

2009 failure - Test tap circuit failure

2009 failure – Moisture ingress

2009 failure - Moisture ingress / manufacturing defect

1997 failure - Not established / breather manufacturing defect

1992 failure – Not established / possible insulation design

Overall Conclusion – Remove from the System

The original population was 467 circuits. As of November 2012, 336 circuits have been removed to date (72% of population). 54 circuits were removed prior to 2011/12, 145 circuits removed in 2011/12 and 137 circuits in 2012/13. Volumes achieved by changing working practices and procedures i.e. taking slightly more operational risk in order to remove the greater safety risk.

The aim is to have all FMJL Current Transformers and FMVG Metering Units removed by the end of 2013/14.

Lessons

When dealing with assets in an abnormal condition:

- Understand potential failure modes and determine cause of actual failures
- Quantify the risks using a quantified risk assessment using ALARP principles
- Use ERICPD Principles to mitigate the risks
- Understand and deal with your secondary risks