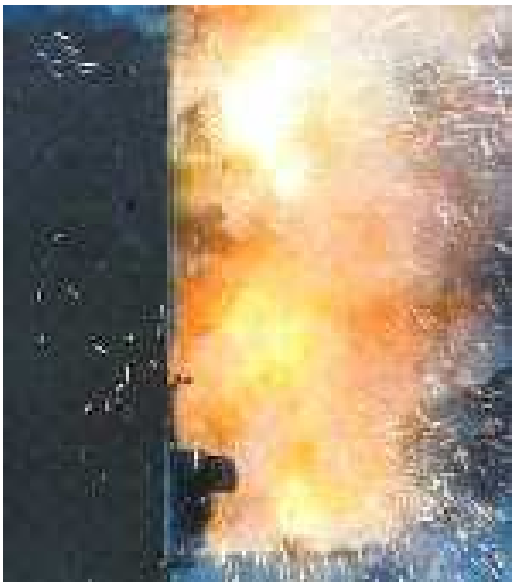
Industrial Maintenance Roundtable NSW
Common Interest Workgroup (CIWG) Report
from Meeting on June 18th 2008

High Voltage Electrical Maintenance CIWG



This document is compiled from discussions during the NSW IMRt Common Interest Workgroup (CIWG) on High Voltage Electrical Maintenance.
Document Compiled by Peter Todd - NSW IMRt Facilitator

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High Voltage Electrical Maintenance CIWG

Attendance List

Attendee	Organisation
Allan Muir	Alcoa
John Roncken	Alcoa
Noel North	Blue Circle - Berrima
Shane Leet	Blue Circle - Maldon
George Sarakiniotis	Bluescope Steel
Scott Spencer	Bluescope Steel
Claudio Lima	BOC
Kevin Carroll	BOC
Paul Lovasz	BOC
Joe Tusek	Connel Wagner
Russel Moate	Hunter Water
Terry Hughes	Hunter Water
Cliff Mansfield	Newcrest Mining
Craig Richards	Newcrest Mining
Russell Pankhurst	Newcrest Mining
Ben Jones	OneSteel
Dennis Robinson	OneSteel
Nathan Skyrm	OneSteel
Wing Lau	Qenos
David Pickles	Rio Tinto - Bengalla Mine
Mark Bucci	Rio Tinto - Kestral
Michelle Todd	SIRF Roundtables
Peter Todd	SIRF Roundtables
Peter New	Snowy Hydro
James Pascoe	Sydney Airport
John Merifield	Sydney Airport
Albert Lo	Sydney Water
Bruce Evans	Sydney Water
George Mitrevski	Sydney Water
Jim Wilson	Sydney Water
Joel Scott	Sydney Water
Nandu Marathe	Sydney Water
Pushpa Pathirana	Sydney Water
Leigh Dunkley	Tomago Aluminium
Ron Vanderweyde	Tomago Aluminium
Mark Smith	Xstrata Coal

Introduction

The NSW Industrial Maintenance Roundtable (IMRt) held a Common Interest Work Group (CIWG) meeting on **High Voltage Electrical Maintenance**. This meeting was held on the 18th June 2008 and was to be hosted by Sydney Water at their offices in Gilford West but with the large number of registrations for the meeting the venue was changed to the Guildford Leagues Club. The meeting was attended by 36 people from 14 different organisations. The information and ideas included in the document came directly from the discussions that took place at the meeting.

Only first names and company names have been used in the report so peoples full names don't register with web search engines (to improve privacy). The full name list of attendees is provided above in a picture format.

The meeting was started by a detailed presentations Bruce from Sydney Water. Bruce gave an overview of their organisation, the scope of their operation, the MAXIMO systems they use, the types of High Voltage equipment, their procedures & training and an overview of some of their problem area (See appendix 1). The rest of the meeting covered topics such as High Voltage supply reliability, safety management, maintenance strategies and a range of other issues that were of specific interest to the group. This meeting was the second and final equipment focused CIWG meeting in 2008 for the NSW IMRt. The other equipment meeting was 'Maintenance & Reliability of Structures'. Equipment focused CIWG topics from previous years have been Rotables, Process Pumps, Motors and Gearboxes. (See http://www.sirfrt.com.au/imrtwiki and select 'Equipment Best Practice Common Interest Workgroup's (CIWG's)')

The IMRt is a maintenance networking organisation coordinated by SIRF Roundtables (SIRF Rt) www.sirfrt.com.au . This report gives feedback to meeting attendees and other interested parties. The meeting included the development of a comparison matrix, which is shown on the following pages. This matrix was filled out by attendee organisations to enable comparisons to be made between organisations on the issues discussed.

High Voltage Comparison Matrix

High Voltage CIWG	Qenos	OneSteel	Bluescope Steel	Rio Tinto Coal/ Xstrata	Sydney Water
What are the major problems with your HV systems?	- Aging asset, some 60+yrs old. - Short or No outage for maintenance as plant is 24/7 continue operation.	Age of equipment - Cables - Switch Gear	- Cables - Retention of experienced employees - Aging assets	- High Voltage Competency - Supply/ Demand Limit	-High Voltage Contractors - External Contractors/ consultants & HV Designs & Planning - Earthing
What is your system tagging & or locking for isolation?	- Locking and Tagging - Unique HV lock + Personal Locks	Lockout system with personal locks	- Lockout for permit + personal locks - Access permit + recipient	HV Permits + HV lockout station + personal Locks	- Danger Tags & Loto Tape - Access Permit
What is your system of permits and access instructions?	- Switching instruction - Access Permit - Testing Permit - Switching agreement	Isolation plans Access permits Testing permits Switching instructions High Voltage Auhorisation	- All access to HV controlled by dedicated control officer - Verified switching instruction + access permit	- Isolation Permit - Access Permits	- Work Permit - Test Permit - Switching Instructions
What different HV standards does your organization use?	- NSW Electricity ACT and Regulation - Local supply authority COP - Site procedure	As per energy supply standards and Workcover regulations	- Australian Statutory - In-house procedures - Supply procedures - National Electrical Code	- HV Protocol “on-site” - AS Standards	- NENS Documents - Electricity Council guidelines - AS 3000 - AS ---- Switchgear – HV - Electrical Regulations & Acts
Who are your HV experts (External & Internal)?	- Site Distribution Engineer (internal) - Delicate HV group for site and delicate HV operators in each plant (Internal)	Internal HV technicians and external contractors eg Amp Control, Connell Wagner etc	- Dedicated HV Group in-house - Maintenance - Operations - Engineering Support by selected external providers	- Electrical Engineering Staff - Contractors (or both)	- Internal HV Experts (Authorising officer)
What CM & PM do you use for HV motors	- Partial Discharge (On-Line) - Machine monitoring - Vibration analysis	Regular PM inspections, vibration analysis and Thermal Imaging	CM & PM by dedicated service shop for motors	- NIL - Megger	HV Motors - Vibration Analysis - Motor Circuit/ Current - 2 month inspection and yearly service
What CM & PM do you use for Transformers	- DGA - Furans - On-load tap changer counter Temperature - Silica gel breather - Routine Inpsection	Regular PM inspections, Thermal Imaging, DGA, fans, pumps, Buchottz, temp devices, silica gels, pressure relief & PCB's	CM (in-house) – DGA, Thermal Imaging, Megger PM (external contractor – Non electrical aspects are Time Based	- SOT DGA - Thermal Imaging - Annual Maintenance	Transformers - Oil Analysis 2 monthly - Thermal Imaging yearly
What CM & PM do you use for cables and switch gear	- SAP - Hand held PD tester - Ultrasound - Oil change - Routine maintenance	Trip checks, protection settings, PCB's, Mechanical overhaul, ductor test Cables – Megger	CM (in-house) – Thermal Imaging, Megger, Ductor PM – Timed based	- Thermal Imaging - EC IR - Annual Maintenance Service - Ductor	Cables and Switchgear - Insulation Resistance yearly - Contactor Resistance yearly - Oil change yearly
What other CM & PM do you use for your HV systems?	- Earthing Check (Stakless earth tester) - Substation battery and charger (monthly and yearly test) - Protection relay testing	Ultrasonics, primary & secondary injection tests, DGA, Thermal Imaging	- Event system to reend - Inspections by operations - Thermal Imaging - Partial Discharge	- Earth Grid - Resistivity Check - Fall of Potential Test - Fault Level Study - Protection Testing	Other - Earth Test - Battery Test 2 Month - Protection relay yearly
How often are systems shutdown for off line maintenance?	Various from 3 months to 6 years	To fit in with production schedules Use of ring main systems	Elements of the network shutdown daily	- Systematic over 12 monrhs	- All maintenance off-line yearly - No live line work permitted - 60 day inspect and annual service
What training do you do for people involve with HV system?	- External training then Internal training before authorisation - In-house Computer Base HV training package (Intranet)	Internal and external training to meet statutory requirements	- HV Awareness - Safe Working Practices (external) - In-house specific courses - Annual In-house refresher - External technical training	- Energy Australia Safe Work Practices -Site HV familiarisation - Arc Flash - Competent Elect – Appointed	- HV Operating Protocol training yearly - Confined Space - Risk Analysis Training - Access permit issue training (External)
How do you manage the relationship with your HV supplier?	- Routine meeting - Outage planning section and control room	They communicate when outages are required	- Control Room to Control Room - Periodic Meetings	- High Voltage Safety Management Plan - Plenty of Notice	- Regular meetings - Operating protocol with Distribution Authority

High Voltage CIWG	Sydney Airport	Hunter Water	Blue Circle	Newcrest
What are the major problems with your HV systems?	Legacy issues with older switchgear and determining replacement priorities- Skills shortage/succession planning - Aligning maintenance and operational requirements with the engineering design process.	- Age 40 years + - Lack of maintenance in previous 10 years	- Training - Equipment age - Maintenance Procedures - availability	- Lack of Maintenance - Training - Production pressure/ availability
What is your system tagging & or locking for isolation?	- Locking & Tagging system with dedicated HV operators lock and keys	- Special HV Danger Tag/ Lock - Only HV switching - Operators have key to HV Locks	- Padlock on equipment + Keys into a lock out box + personnal lock onto lockout box - Sign on HV access permit	- HV Permits "EL Locks" - JSEA - Group Isolation Box - Switching Program - Personal Locks
What is your system of permits and access instructions?	- Access Permits - Sanction for Test - Vicinity Authority - SCAP; HV Clearance	- Access Permit - No formal standard written instruction for task - Written individually for each job	- Access Permit system combined with switching instructions - Authorised to carry out switching	- HV Permits - Issued, Witnessed & Tested - JSEA - Switching Procedures - Barriers
What different HV standards does your organization use?	NENS + Best Industry Practice -In House Safe Access Procedures	- Safety Management Plan - Australian Standards - HV operating instructions	- Comply with Integral Energy Requirement - NSW Service Rules	- Relevant Australian Standards - Internal Standards
Who are your HV experts (External & Internal)?	A mix of internal and external for maintenance; internal only for HV switching	- Internal for switching - External for maintenance fault rectification	Internal – On-site Electrical Engineer + selected Electricians - External – Some Maintenance Services for Transformers / Protection Relays	- External - ABB, CW, Dowding & Mills, Integral Automation - Internal – Eng Manager, Snr Electrical Engineer, Electrical Supervisor
What CM & PM do you use for HV motors	Maintained by another group, outside of the HV group	- HV motor testing annually - Visual inspections	- 6/12 monthly PI, IR, DLA - Monthly slip ring maintenance, Vibration & Daily inspections - Temperature Brushes - Investigating Partial Discharge	HV Motors CM – ABB (PI, Insulation), Thermal Imaging (APT), Temperature monitoring, Vibration Monitoring (APT) HV Motors PM – Filters, Brushgear changes & inspection, slipring skims, LRS checks, contactor checks
What CM & PM do you use for Transformers	MAXIMO time generated work orders for PM -Condition monitoring includes DGA.	- DGA 12 monthly now - Has been adhoc previously	- Annual oil tests – Standard + DGA + Furans on 33kV and 66kV transformers - Monthly visual	- DGA, Temperaure monitoring, inspections, Cooling system function checks, thermal imaging
What CM & PM do you use for cables and switch gear	MAXIMO time generated work orders for PM -Condition monitoring; includes periodic partial discharge	- Cables nil - Switchgear minimal – When fault occurs	- Circuit Breakers – Maintenance 2 yearly - Just started Partial Discharge on HV Cables	- Thermal Imaging LV switchger/ MCC- annual - Just completed cable coating in major substations - Pest control around substations
What other CM & PM do you use for your HV systems?	Visual, Battery testing, protection testing, routine cleaning -currently investigating earth grid testing mehods.	Visual	- Protection testing 1 or 2 yearly - Thermal Imaging on Aerials (HV)	Earth verification
How often are systems shutdown for off line maintenance?	1 year, 2 year and 4 year cycle, Generated by MAXIMO system. Shutdowns have to be negotiated with stakeholders, increasing use of auto sync portable generators, where possible to overcome this issue	- When required if redundancy good - Approximately 1 – 2 years	- 12 Monthly depending on equipment availability	As available (often driven by operations mill relines every 12weeks)
What training do you do for people involve with HV system?	- External RTO for Initial and Refresher HV operator, also electrical resuscitation and rescue - In-house training, for inductions and safe work procedures	- Energy Aust permit training - Internal HV permit refresher 12 monthly - Pole top, rescue, escape 12 monthly - On Job experience	- Access Permit - Hunter Tafe for refresher (yearly) - Resuscitation/ LV release (yearly)	- Currently on-the-job - Some arc flash awareness - Rolling out new plan
How do you manage the relationship with your HV supplier?	Co-operatively, Periodic meetings to discuss operating protocols	- Direct contact with maintenance department (Energy Aust) - Direct Contact with Enegy Aust control room Operating Agreements	Integral Energy HV Operating Protocol	- Pay them! - Advised of planned outages - Discuss each fault transients/ disturbances

High Voltage CIWG	BOC	Alcoa ARP	Tomago Aluminium	Snowy Hydro
What are the major problems with your HV systems?	- Old equipment/ Safety issues - HV Safe Management Plan	- Old Plant 60 year vintage - Obsolescence- end of life - Resources – People, Funding	Age of equipment	- Aging Assets 40-50 years - Access outages - Skill Shortages
What is your system tagging & or locking for isolation?	- Locks - Tags - PTW - EAP - JSEA	- Work Permit - Access Permit - Written switching procedures - Written isolation Procedures - Separate verification - Danger tags & Locks - Personal Locks - Lock Boxes and stations	Danger tag with HV equipment lock	Danger tagging and locking of all isolation points.
What is your system of permits and access instructions?	- PTW/ EAP - IMSS – Electrical Safety Rules	- Work Permits - Site Electrical Safety rules - Written Isolation & Switching procedures	- Access Permit - Testing access permit	- Access Permit system plus personal safety locks - Permit issued by authorised operator to authorised recipient - Work party must be athorised to Snowy Hydro safe access rules
What different HV standards does your organization use?	- Australian Standards - IEC - IMDD – Internal	- HV Equipment Manager (SPA) - HV Operating Team - Network with other Alcoa sites - External consultants	Internal HV standard derived from supply authority	For operational access: Internal safe access rules and practices, operating instructions, OH&S regulations, Australian Standards
Who are your HV experts (External & Internal)?	- ABB - AmpControl - Integral	- Australian Standards - Alcoa Standards - Electrical Safety Rules/ Acts - Also refer to IEE guidelines - Local Energy Provider Rules	External – Connell Wagner, AMP Control, Areva, Transfrid, Siemens, Reinhausen, ABB - Internal – Substation Electricians	Internal: engineers, technician and trades External: specialist engineering consultants, HV testing service providers, transformer manufactuers and service divisions
What CM & PM do you use for HV motors	- MAXIMO -Local PM's & Global PM's - IR, PI, Tan Delta, Thermal Imaging, Partial Discharge (on-line) - Enhanced DC Adsorption	- PI & Insulation resistance - VA (vibration) - Thermal Imaging, Temperature (eg RTD's, thermistors - CSA trending – Physical - Oil analysis on lube	- Machine monitor - Vibration analysis - Partial Discharge	CM – PD, IR , PI, visual inspections, Winding resistance, RTD , DDF/Capacitance , night corona test, oil analysis on bearings PM – time based routine maintenance
What CM & PM do you use for Transformers	- MAXIMO -Local PM's & Global PM's - DII analysis, Visual Inspection, Protection Tests, Thermal Imaging	- DGA, - Furans & other oil tests (water) - Thermal Imaging - Physical inspection	- DGA - Thermal Imaging - Visual Inspection - Yearly maintenance plan	CM – DGA + oil quality annually. 4 yearly Electrical testing incl.ddf/ Capacitance, IR, PI, winding resistance, PDC, ratio check, leakage/ reactance and FRA PM – Time based routine maintenance
What CM & PM do you use for cables and switch gear	- MAXIMO -Local PM's & Global PM's - Thermal Imaging - Ultrasonic	- Thermal Imaging - Ductor, Megger - Oil test for water - Oil breakdown tests - Physical Inspection	- Visual Inspection - Thermal Imaging	CM - 330kV oil filled - DGA, Cable sheath IR – 4 yearly PM Switchgear – Time based routine maintenance, starting to use RCA based maintenance. Ductor, time-travel tests, megger, thermovision, visula inspections, oil tests and DDF tests on bulk oil CBs
What other CM & PM do you use for your HV systems?	As above	- Test instrument testing - PPE testing - Protection relay tests - Battery tests & replacement program - Earthing system tests - Fire detection and prevention - Emergency lighting in Subs - Drawing maintenance	- Usage based equipment changeout	- Thermal Imaging - Visual inspections
How often are systems shutdown for off line maintenance?	5 yearly	- 8 Weekly regular shuts - monthly inspections - plus conditionally based impromptu shuts	- Once a year	- Depends on market requirements - 1-2 day 3 to 6 monthly (class 1) - 1 week 1 to 2 yearly (class 2) - 2 weeks 4 yearly (class 3) - major overhauls based on condition, approx. 10 yearly.
What training do you do for people involve with HV system?	- Trade Cert/ Eng - AEO 1 - IMSS - HV Training at EI Energy	- HV supplier off-site - Internal Alcoa training	- HV operators course (Gippsland TAFE) - HV access permit holders course - Internal training modules	- HV operator competency - Safe access rules assessment and annual recertification - CPR annually
How do you manage the relationship with your HV supplier?	Formal Requests for Switching	Good relationship	- Formal operating requests - Combined maintenance activities - Monthly usage report	A dedicated network compliance manager for dealing with NEM network compliance issues

Isolation Tagging and Locking Systems

Bruce from Sydney Water was asked if they use locking system along with their Tagging system. This topic generated a lot of discussions. Bruce indicated Sydney Water has a locking system their electricians can use but the main control is still through the HV Tags and Access Permit. Locks are not compulsory and are used as an addition to the tags. They are not used as the key control for the isolation of people on the job. Control is still through the access permit. He indicated that only HV authorised people are allow to do anything related to the isolation. The High Voltage Operator does the switching as per the switching instruction, carries out the isolation and then puts High Voltage tags on the isolation points. The Operator then issues an Access Permit to the authorised HV Recipient, who is the person that is in control of the job. Everyone else involved with the job works under the Access Permit and the Recipient ensures they all sign on and sign off the permit. Only a High Voltage Operator can remove the HV Tags.

A large number of the attendee organisations had changed their isolation philosophies from administrative controls through tags, as used by Sydney Water, to use of secure isolation locking systems. These secure isolation locking systems involves Personal Locks for individuals, secure locking of all isolation points with coloured Isolation Locks and use of key boxes/ isolation stations, which are secured by the Personal Locks of those working on the particular job (See Appendix 5 & 6). There was a show of hands and roughly 80% of the attendees were working under a secure locking system. There were a number of inputs from the group about how these secure locking systems interact with High Voltage isolation for their organisations. It was suggested that there are a number of advantages of locking systems including greater security if the job extends over multiple working shifts. The key point was made that for secure locking systems, there is no physical way an isolation can be removed without every individuals Personal Lock being removed first. David from Rio Tinto Bengalla indicated that in their system, the details of the isolation are stored at the isolation station so anyone involved can review the detail of the isolation. With their system, each of the isolation point has to be checked and verified during the isolation process. They have an isolation officer that controls the work site and for high voltage application makes sure the people working in the area are aware of any hazards in the work environment.

David suggested the process around secure locking is not easy to grasp quickly and you have to be careful with new contractors. Locks take you to a much higher level of comfort that isolation risks are controlled. He indicated that he now uses locks doing electrical work at home to ensure that no one can switch power back on while he is working on a circuit.

Bruce from Sydney Water indicated that they don't allow electrical contractors to work on their High Voltage systems unless they have been through the Sydney Water High Voltage and other relevant training. Even if the contractor has had High Voltage training/ authorisation elsewhere, this is not accepted until their competence has been verified by Sydney Water. A number of the other organisations indicated that contractors could work on the High Voltage equipment after it had been classed as 'disconnected apparatus', which has been proven safe to work on. Sydney Water had the arrangement that contractor even on working on 'disconnected apparatus' had to have Sydney Water training and authorisation.

Joe from Connell Wagner indicated that they visit many organisations to do testing on the High Voltage equipment. He suggested that all High Voltage and Isolation procedures are similar across these organisation but with some differences. **These differences represent a danger to contractors who visit multiple sites, as it becomes confusing.** Most local

organisations are not aware of how their procedures differ from other organisations procedures and so can't highlight this to contractors. (Previous CIWG meetings have suggested there should be generic industry standards for isolation and locking. This would make it easier to identify the differences between different organisations isolation systems Ed). Joe indicated that over the years they have seen examples of poor isolation practice where isolations carried out were not complete with issues such as back feeds, low voltage feeds or similar. The issue is not with the isolation systems, which are usually great, but how it is implemented for a specific isolation. The lock or the tag has to be on the right isolators to protect people. Both Nandu from Sydney Water and Wing from Qenos made the point that the final level of protection for isolation quality is always the on-site risk assessment that the contractor should carryout, especially if there is any suspicion of quality problems with the isolation.

There was some discussion about options of people working on jobs requiring High Voltage isolations to put their personal tags or locks on all the isolation points. John from Sydney Airport indicated that he has extensive experience, originally working for the Victorian power industry for 25 years and then many years of high voltage training around Australia. He made the point that different organisations have different HV isolation systems and this usually reflects their different needs. He suggested that in the Sydney Airport situation, it would not be practical for external people to personally check or put there locks/ tags on HV isolation points as there is often a number of kms between the isolation points. The process of isolation design and verification to generate the switching/ isolation instructions and the isolation process itself has to provide the required quality of isolation and must be defendable. In their situation, they have an isolation controller for a number of HV Operators due to the distance between the isolation points. John indicated electricity providers do isolation this way. The isolation system must suit the specific requirement of that business.

David from Rio Tinto Bengalla was asked, "how they handle testing of systems that have been worked on". David said that they have a Black Out-of-Service Lock and Information Tags and they pull everyone out of the area and use the locks & tags before any testing is carried out. He suggested testing is a difficult area with a number of problems and they are still working through it as an issue. Their current systems are safe but they feel there may be better ways to do testing than they currently do. It was suggested there may be benefit is sharing High Voltage and isolation procedures between organisations to better identify differences, good ideas and best practice.

Ron from Tomago commented on the amount of information on the Sydney Water High Voltage Tag. George from Sydney Water indicated that most of their isolations are relatively simple with a small number of tags and so the amount of information is not a problem. Others attendees suggested they have more complex isolations (eg 20 to 30 tags) and would be an issue. Someone commented that they had gone to an orange colour for their High Voltage tag to strongly differentiate it from other tags.

Reliability of High Voltage Supply

Russel from Newcrest asked Bruce if they generally operate with their bus bars open? Bruce indicated that the supply authorities will not let them parallel two feeders in a substation. If they want to change over supplies, the supply authority has to be involve and for example Integral Energy, will only allow them to parallel the supplies for 30 seconds to achieve the changeover. There was also some interest around the fencing around switchyards, with security becoming a major issue the fences are becoming higher and examples of multiple

strands of barbed wire or razer wire used. There was also some discussion around mesh for fences with Bruce suggesting that plastic coated fence mesh was not suitable as the regulations indicated that all metal in the fence has to be earthed.

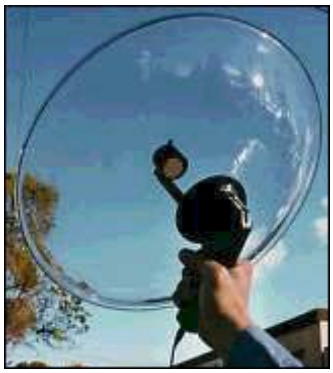
Ben from OneSteel indicated that the main problem they have is voltage dips from their external supply. This causes them major problems as they loose the main drives to the rolling mill, which causes major cobbles of the steel being rolled in the mill. It takes them hours to drag the cobbled steel of the mill and many $1,000's/hr from the lost production. Ben suggested that their contract with the supplier allow them to have occasional dips so the just have to accept it. George from Bluescope Steel indicated that security of supply is very important and they were set up with coupled parallel supplies. The supply to the plant is broken up into groups. They run groups of transformers as groups so that the loss of one circuit breaker or circuit will not disrupt operation. Ben from OneSteel indicated that they don't usually have any problems internally as they have similar ring main feeds but the dips come through their two external feeds.

Noel from Blue Circle Berrima indicated that their external feed is on a long run and they have a number of problems with voltage dips that trip out their system. Noel was asked what the supply authority was doing about it and he indicated that they had replaced insulators, replaced the aerial earth system and had long term plans is to put in a substation that would improve the problem but no short term solution. David from Rio Tinto Bengalla said they are on a radial feed 66kV and they are half way along the feed. They had an out-of-service (care & maintenance) mine at the end of the feed that was probably having no maintenance done to the switchyard. They had a number of outages costing them a considerable amount of money, which was eventually tracked down at the other mine to a VT where the oil had not been maintained and was randomly taking out the supply.

Trevor from Hunter Water suggested their supply problems are seasonal, as they usually occur with storms from November to February. He suggested that one way to predict when problems are more likely to occur, is to watch the local weather radar for storm activity. George from Sydney Water suggested that another predictor for supply problems is bush fires. High winds were suggested to be another factor. John from Alcoa said they had an increase in problems with the last dry spell, which he said was caused buy dust building up on the insulators during the long period without rain. Bruce from Sydney Water suggested the problem usually occurs when dust builds up and then having fine rain or mist, which is enough to wet the insulators but not enough to wash them clean. The tracking generated often causes fires on wooden poles. One suggestion was to coat insulators with silicon compound to limit the dust buildup. Bruce suggested that a major problem with the supply authorities is green slim, the sort you see on concrete in shady/ moist areas, building up on insulators.

David from Rio Tinto Bengalla said that they have had problems with Polymer Lightning Arrestors. In their open cut mining environment, they have serious problems with dust buildup. They have experienced failures taking their whole site out caused by the Polymer Lightning Arrestors at around 8 to 10 years service. They are now changing out their all their 66kV & 22kV arrestors, with the possibility of doing it routinely in the future at between 5 to 8 years. The are not going back to the porcelain insulated arrestors due to the risk of shrapnel if one explodes in a lightning hit. There was discussion about the root cause of the failure. David indicated that a supplier had indicated that the cause was likely due to a manufacturing defect of a seam in the polymer casting where the tracking initiated. David indicated he had also observed seams in the polymer. Another cause may be related to some arrestors being set up at an angle rather than vertical. The possibility was raised that these faults could be

detected by testing rather than now changing out routinely, especially if there is a good chance that the root cause has been eliminated. The possibility of Thermal Imaging or ultrasonics can detect this type of fault was raised (See photos for ultrasonic instruments suitable of the HV below. Great to use at the same time as Thermal Imaging. Ed). The possibility of failure of arrestors through loading from lightning strikes was also raised. Cleaning of the dust off arrestors was suggested but David indicated that it was not practical due to the level of environmental dust in their situation. Paul from BOC indicated that for a 132kV system they have put an on-line monitoring system on, which measures the resistive leakage current. This gives an indication of the amount of soiling of the insulation for the system. The system also measures the number of surge counts and other information that can be trended. They have only three arrestors on their system but the supply is very critical to their operation and so justifies the cost of the ABB system. The lightning arrestor monitors BOC are using on our 132kV switchyard are ABB Excount II. http://www.abbaustralia.com.au/product/db0003db002618/c12573e7003302adc1256a1700369fdb.aspx . The comment was made that these types of systems are more common on 132kV and up.

Ultrasonic Monitoring for High Voltage Tracking, Arcing and Corona Discharge

Bruce from Sydney Water indicated that, because supply can't be guaranteed, they are looking at putting mobile generator connection points into every critical location as a method of giving a backup supply. David from Rio Tinto Bengalla said that to keep all their computers and infrastructure running they also have a generator connection point installed. There was some general discussion about the desirability of the supply authority to have increased protection through drop out fuses on the incomer from the feed. John from Sydney Airport suggested that from his experience, the user must provide the additional protection.

Safety and PPE for High Voltage Switching

Craig from Blue Circle Maldon asked a question about the use of remote switching. He indicated that they can do some of their switching through SCADA or other system so that the HV Operator can control the switching but is not in front of the device when switching occurs. Bruce from Sydney Water indicated that they do not do any remote switching as they had difficulty stopping non HV authorized personnel carrying out such switching.

There was discussions about the developing standards in Australia around PPE for High Voltage based on the NFPA 70e from USA. Ben from OneSteel indicated that they are using the information from this standard and are assessing all their switch rooms and switch board locations for their Arc Rating. They have spoken to Bluescope Steel and a number of other businesses that are using this standard. They have up-rated their clothing specifications using FR clothing for their electricians to wear all the time. When they have finished their analysis of the Arc Flash rating they will have specific the PPE available, defined by the arc rating.

John from Alcoa indicated that they have carried out the Arc Flash Hazard Analysis, which gives the amount of energy you are dealing with and the type of clothing you should be using. They have all their electricians at level 1 protection clothing. For HV or high energy switching they use level 4 protection clothing. The problem they have found is that as the electricians have been doing switching for many years without this protection and it requires a bit of a culture change to actually get them to use it.

David from Rio Tinto Bengalla indicated that they are going through the process of Arc Blast/ Arc Flash mitigation process currently. He suggested that many organisations seem to be going down the PPE path but one of the problems with the clothing is that it is very hot to wear and can be a significant discomfort in hot weather. They have looked at what engineering controls can be put in place to reduce the hazard. In their coal preparation plants, they have setup a remote stop start station and they painted the danger areas and signed them as 'Do not switch in this area' and indicating where the remote switching station is located. They have also looked at the setup of the protection level on the systems. They sometimes have found that the tripping level is outside instantaneous fault level and so if there was a problem the fault would have sat and cooked. They had Worley Parsons in to do a study of their protections setups and as an example, they found the protection was set at 16 times the normal peak level and was able to be brought back to 4. This brought their arc flash hazard category down from dangerous to Category 2 in one instance and in the other eight, down to Category 1 (normal heavy cotton clothing OK). With the PPE approach, people are still likely to sustain injury, so the protection setting review approach has many advantages for hazard reduction. Ben from OneSteel said that in their current study of Arc Hazards, some area had come out as a Category 3 or 4 and they have reviewed trip times. This has reduced the hazard down to a Category 2 where their standard specification for clothing is OK. This approach follows there Hierarchy of Hazard Control method. David suggested the culture change issue is less of a problem if there is only one or two areas of the plant that require special (hot) PPE cloths, as this seams more reasonable to people. Ben indicated that the reason they went to the FR clothing as a standard for their electricians is that they have a lot of open panels in cranes etc and so a higher standard for their normal clothing was the best solution for them. Some electricians say it is hotter but others say it isn't. Ben was asked there suppler for the Indura Ultra Soft and indicated it was through Australian Safety Specialists (http://www.austsafety.com.au/) who buy the material in and get someone to sew it to OneSteel's specifications.

Below is the information provided by Wing from Qenos about the supplier they use for PPE and are very happy with what they are getting.

Flame and Arc Flash Proof garment manufacturer details. (For Indura Ultra Soft and Nomex Garments)

Glanda International
Ned Wallis, National Sales Manager
(03) 9457 5458
149 Northern road, West Heidelberg, Vic, 3081
www.glanda.com.au

Wing indicated that they have analysed the arc flash ratings of their HV and LV switch rooms and some up to 50kA have been rated at low voltage system.

The suggestion was made that where there are higher arc flash ratings on specific devices, the area should be specially marked to highlight and make obvious the higher risk area.

John from Sydney Airport stressed that it is not just High Voltage systems that are a problem. High energy low voltage system can be worse and this point was strongly supported by a number of other attendees. They have been having many problems convincing non high voltage personnel to wear the required PPE for switching of this lower voltage equipment. John from Sydney Airport suggested that the problem of arc flash hazard is often further down the system on distribution boards and often it's not recognised that the arc flash rating may be just as high. John from Alcoa confirmed that the biggest arc flash risks in their study was from some of their low voltage systems.

Scott from Bluescope was asked what arc flash PPE protection they are using. He indicated that they were using a shirt or switching coat made from PR97 material with approved face shields and leather gloves. They currently source these via their clothing contract with BOC. There was then some discussions about leather, rubber and cotton gloves and when you would wear them. Scott indicated that they did not use rubber gloves during switching as the gloves were for arc protection and not insulation. John from Sydney Airport said that he had been told that leather gloves have a potential increasing the level of burns received in a arc flash incident as leather holds heat in the gloves. No one else was able to confirm this problem. Bluescope Steel did a significant amount of testing related to arc flash where they simulated, as well as they could, in service arc flash incidents to test PPE options. That is how they arrived at their current PPE specifications. Scott indicated that if you want a copy of their arc flash PPE test report or the associated DVD you can contact him (02) 4275 7713.

Partial Discharge Monitoring of High Voltage Systems

Noel from Blue Circle Berrima asked a question about on-line Partial Discharge (PD) testing and who was using it. Paul from BOC indicated that they were using on-line PD on 11kV motors. There were questions about what was the definition of on-line, as there are systems that monitor PD automatically and there are also system that allow PD testing while the item (eg motor) is in service with a manual routine monitoring survey. There is also the more standardised off-line PD testing approach that has been available for a number of years, which was suggested can pick up problems earlier than the on-line systems. On-line PD testing requires hardware to be permanently installed. Joe from Connell Wagner described the off-line PD test as inputting an increasing voltage supply to detect early electrical discharge indicators that are the very early symptoms of faults developing. Joe suggested that on-line partial discharge is a very useful tool for HV motors, especially if there is a know fault with the winding. HV motor faults are known to develop very slowly and on-line PD can trend the fault to prompt when motor change-out becomes more urgent.

Noel from Blue Circle Berrima indicated that they recently had a PD survey done on their HV cables. James from Sydney Airport said that they don't have any on-line PD but they have a PD cable survey done one a year. The person that carried out the PD testing for Noel and Sydney Airport is Peter Rhodes, details below.

Peter Rhodes - High Voltage Solution
e-mail: prhodes@highvoltagesolution.com Web : www.highvoltagesolution.com
New Zealand Phone: +64 - 274 - 199952 NZ Fax: +64 - 3 - 4542446
24 Mannering Street, Dunedin Post Code 9013 New Zealand

Cable Maintenance and Cable Testing

The PD testing that Noel from Blue Circle Berrima had recently carried out as a trial on his cables, picked up 3 potential faults. One was a fault in a cable termination and they have some repair strategies that they will be trying to fix it with, using a heat shrink joint and to do away with the current insulators. Another fault was in a terminal box for a new transformer they have installed. This problem was solved by cleaning the insulators and adding some breathing to the terminal box. The suggestion was that a small amount of partial discharge in an enclosed space would generate products that will accelerate the tracking across insulators. It was suggested by Noel that the trend to use of smaller terminal boxes might have increased this possible failure mode. Testing had indicated that another terminal box has early PD problems that Noel still has to check out.

Noel indicated that he is now proposing to do PD testing on his 33kV cables every 12 months and his 6.6kV cables every 2 years. The PD test that he is using is on-line. and now that the initial test data had been done, future testing will be much cheaper. The initial on-line PD testing took 2 weeks and cost $40k.

Shane from Blue Circle Maldon asked a question about an issue they are having with some 6.6kV high voltage lead armoured cables where the outer cloth cover has deteriorated. He said that some of their cables have been submersed in water in the past and since there is deterioration, he does not want to disturb them. John from Sydney Airport indicated that they would do 2 yearly HV Megger tests and setup a recorded history of the tests. There was discussion on what voltage to use for the Megger with general agreement in just doing a 2.5kV test for two minutes. With comparisons to a baseline, this would give some indication that there are problems. If there are problems you would do other tests. Wing from Qenos indicated there is now a test called Non-Destructive Low Frequency testing that can assist in these problems. John from Sydney Airport indicated that they use VLF for testing new cables, repaired cables or cables with faults, suggesting it is a more expensive test. He also raised the issue about possible damage from regular testing (being a High Voltage test). Wing indicated that a similar test can be used for condition monitoring for maintenance and that Energy Australia has a truck that is setup to do the testing and suggested it was different and much more expensive compared to the equipment used by the tester at Sydney Airport. John suggested that they have another supplier of this testing and he indicated it would be applicable to Shane's problem cables. James from Sydney Airport indicated that they have set a standard that this test is the only Hi Pot test acceptable for HV cables and especially for XLPE cables. Through the discussion it was concluded that there was a different instrument for VLF testing for new installation to the test you would use for regular maintenance testing (more expensive). John suggested that the maintenance version of the test would be useful to do at the same time as a Megger of their cables.

Mark from Xstrata indicated that the testing routine standard for underground mines in their 11kV systems is an 18kV DC Hi Pot test done annually and the practice has been in place for about 15 years. John from Sydney Airport suggested that this is a test that is accepted for testing newly installed or repaired cables but suggested that the cable manufactures would not likely recommend it as a regular test. Mark indicated that earlier on they had been testing with up to 25kV DC Hi Pot and this had induced problem. Their current 18kV testing often detects faults when done on cables that have not been tested before but other than that, there are not too many problems.

Bruce from Sydney Water asked if others had problems with AVC overhead cables that are being UV affected. They have some cable that was installed about 15 years ago and now the plastic cover is completely failed. They suspect it may have been a material quality problem of the cable by the manufacturer.

Bruce from Sydney Water also made the comment that Sydney Water does very little condition testing of its HV systems other than inspection and yearly servicing and have very few problems and questioned if the problems people face in other industries are not due to their installation standards or caused from the testing itself. Ben from OneSteel indicated that he strongly supported sensible testing strategies and suggested that they have just taken over a plant that did not have much HV monitoring in place and currently they have been having continual problems with cables blowing up, insulators failing and they have had fires. He suggested that the monitoring standard they have is essential to give the good reliability and plant availability that they require.

Peter from Snowy Hydro gave some information on some excellent papers by Trevor Lord on Medium Voltage (MV) cable management. He supplied the link below. In the paper he gives the range of testing methods available and gives recommendation for monitoring strategies.
http://www.lordconsulting.com/techpapers/cable-management/cable-management.php
James from Sydney Airport suggests you need to look at all these monitoring techniques as a value added proposition. If another technique can pick up a fault that you would have missed and this fault would have caused an expensive business interruption, then it is worthwhile.

High Voltage Motors

Paul from BOC indicated that they have been using PD on their critical 11kV motors for 2 or 3 years. The monitoring system BOC are using on our 11kV machines up to 15.8MW is Eaton Cutler Hammer's Insulgard Partial Discharge system. http://www.eaton.com/EatonCom/Markets/Electrical/Products/PowerQualityManagement/PartialDischargeMediumVoltagePredictiveDiagnostics/index.htm. It also uses the coupling capacitors on the motor terminals but also uses the stator RTD's as antennas. Paul suggested that one of the problems with Partial Discharge in motors is that it can sometimes occur deep in the winding. Because the discharge is high frequency and attenuation occurs over distance, PD in the winding away from the motors terminal may not show up very well at the terminal box. As the RTD's are installed in the stator windings (to measure winding temperature), they can act as an excellent aerial for PD signals. Paul indicated that the HV motors come with around 6 RTD's and the PD signal output from these and from the motor terminals input to their monitoring system. The system carries out the testing 4 times a day into a standalone monitoring PC. The system will generate rate of change alarms etc that input into the SCADA. As they have motors around Australia & NZ, they are uploading data around monthly for each motor. Paul indicated that the predictive ability of the technique is in the trending. The results are sensitive enough to see seasonal variations. Most of their motors are stable with small increases, which Joe from Connell Wagner suggested was normal. They have been told that a doubling of PD activity in a six-month period represents a serious alarm. Joe suggested the using the additional RTD aerials approach has advantages of giving better PD signals for problems low in the winding but just using the motor terminal test points is still probably OK as most failures occur in the end winding area where the highest stresses are (eg. during starting).

Joe from Connell Wagner suggested that one area to be careful of is totally enclosed HV motors such as are sometimes used in chemical plants. Joe suggested that partial discharge

can generate acids and other corrosive products, which even at lower levels of PD can damage the motor through corrosion and damage to any plastics. This sounded like a similar issue to that raised by Noel with smaller junction boxes in the section above.

Wing from Qenos indicated they installed Partial Discharge monitoring on an 11kV motor 6 years ago after they had some failures. Their system is set up so that the testing is done in-service every 6 months with the information sent away for expert analysis. 3 years ago, the testing did find a problem, which was confirmed on inspection. Now the system has been setup on a number of other motors. Wing said they have fully enclosed motors and they have not yet seen the problem of corrosive product deterioration that Joe spoke about.

Joe from Connell Wagner suggested that many problems with HV motors etc occur in industries that are less experienced with specifying, installing and testing HV equipment. He suggested that where HV equipment is properly specified, and tested properly before and during commissioning, many of these problems just don't occur. Joe suggested that often these days the equipment suppliers determine the specifications of the HV equipment supplied. They often choose equipment that may be adequate to operate initially but may not give the long and trouble free service that the more experienced electricity authorities achieve with their HV equipment. Often acceptance testing is done in the factory but no testing is done at installation and commissioning. Claudio from BOC suggested that they do have some specifications for what testing is done prior to operation of new equipment. Joe suggested that there is often a serious gap with testing of rewound motors. He suggested that it is very easy for faults to be generated in the rewind process and unless there is adequate testing with PD and other more common tests, then this is a serious reliability risk.

Joe from Connell Wagner was asked what their standard testing strategy for HV motors was. He indicated that for a 6.6 to 11kV motor they would do a Partial Discharge (PD) on the stator, a Insulation Resistances, a Polarisation Index (PI) and a Dielectric Dissipation Factor (DDF). Joe suggested that the DDF gives an indication of the overall aging of the winding and always tends to rise over time. The PD test gives information on what specifically is causing the deterioration of the windings. The test voltages that are used for PD tests should be higher (2E+1) in original factory test and a lower test voltage level is used with any field tests. The important thing is to get a baseline for measurements. If you do not have original installation baselines then comparing other similar motors in your plants will assist setting a baseline. Care needs to be taken when comparing motors from different manufactures as some motor baselines start at a higher level. Joe suggested that an important thing for testing is that the motors heaters go on when it is shut down, as moisture entry will cause major variation in test results.

Joe was asked about their use of motor current spectrum analysis. Joe indicated that this was an on-line technique for detection of rotor bar problems, which is not as significant reliability problems as stator and bearing failure (Rotor problems can also be picked up by vibration analysis if the VA is set up correctly for motors. As VA should already be carried out, this is usually the preferred approach. Ed). Some organisations set up with connection points to be able to take motor current spectrums on a routine analysis. (Often done for motors that take a high number of starts or with a history of rotor bar failures Ed)

Joe indicated that in some industries, they seem happy to get 3 to 5 years out of their motors, while others, if they don't get at least 20 years out of a motor before failure then they think they have been sold a dud. He suggested the way to go from 5 years to 20 years MTBF is make use of the motor standards that are available.

Hand Held Partial Discharge and Ultrasonic Tester

Wing from Qenos said that they have had a number of successes with a low cost hand held Electromagnetic and Ultrasonic instrument. Information on the UltraTEV instrument is shown in Appendix 2. Wing suggested they only cost a few thousand $ for the latest unit. The unit they are using has both Ultra Sound non-contact monitoring and Electromagnetic Activity through contact with the HV equipment metal casing. Partial Discharge and other fault effects can generate electromagnetic activity in the equipment casing through radio frequency noise etc.

The way Wing has set up to use this instrument is, he has routes for the tradesmen to visit every HV cubical and top and bottom of cable chambers, circuit breakers etc. He has had many successful cases of detecting problems. He indicated that the system works best with setups with an air chamber. The use of the instrument is very simple as, if it detects a problem then a light on the instrument will go red or if severe will flash red. Wing was initially sceptical of the instruments effectiveness but after he did a number of investigations of the faults found, he now is a strong advocate of the technique. This technique significantly aids the usefulness and predictive ability of inspection activities of electricians. He has found faults of up to 2000 to 5000 Micro Coulomb level (serious faults). Wing suggested you should be aware that the unit can give false alarm on variable speed motor supplies and similar equipment. He said he has had good success with CT bushing type faults and cable termination faults.

Wing has tried on occasions to identify the faults found by the instrument with other detection techniques and often they did not indicate the fault that the UltraTEV found. John from Sydney Airport indicated that they have had similar experiences that a fault was identified by the hand held instrument but had not been identified by the partial discharge testing. John suggested that techniques such as Partial Discharge testing are not foolproof and should not replace routine tradesmen based maintenance and inspection programs. Joe from Connell Wagner agreed that PD can prove there is a fault, but it can not prove there is not a fault. James from Sydney Airport suggested that Partial Discharge should only be one tool in your armoury.

Transformers

Peter from Snowy Hydro asked a question on the problem of failures of transformer bushings with short time to failure. He had seen technical papers suggesting these bushings can have a short time to failure. They are currently doing 4 yearly off-line ddf testing and is interested in on-line PD testing. Joe from Connell Wagner indicated the time to failure can be short, especially with paper oil insulated bushing where there is only a small volume of paper. He indicated that in high voltage transformers this tends to be an explosive fault where the protection is usually not capable of tripping in time. Joe indicated that on-line Partial Discharge monitoring does give some protection against these faults but they also give false

alarms as Connell Wagner get a lot of work doing off-line PD from checking out these false alarms.

Joe indicated that the other key predictive technique for transformers that people should be using is Dissolved Gas Analysis (DGA) as this can also pick up some of these of bushing and many other types of faults. He stressed that since it is so useful in problem detection and is relatively low cost, it along with other oil tests such as Furan and moisture is a must do for all oil filled HV equipment. Most organisations carry out DGA every 12 months but on very critical system down the 3 monthly and power stations sometimes do DGA monthly. Joe stressed that with CM testing, it is very important to do baseline testing and with transformers, this should be done both before they are energised and after they has seen some initial service.

Claudio from BOC asked a question about the use of Furan Analysis and DGA. Joe from Connell Wagner spoke about the Furan test, which tries to measure the degree of polymerisation of the paper in transformer insulation. It is one of the main tests that is used to indicate an approaching end of life for transformers in relation to insulation. As the paper in a transformer ages it shrinks and this reduces the clamping on the winding and other component, which eventually leads to final failure.

David from Rio Tinto Bengalla spoke about a transformer problem they had on a dragline. (22 mVA 9kV). The situation was that it had not been DGA tested for some time and the test result showed acetylene had exceeded the standard alarm levels by double, which indicates internal arcing. There was an outage coming up in two months, so they monitored every 2 weeks. One problem was that the dragline had been built around the transformer, with no contingency made to be able to change it out. Supply of a new transformer was going to be 3 to 6 months. On the shutdown, they took the lid off and found a loose connection to the secondary of the transformer, on a bushing within it. They had initially thought it would most likely be the tap changer. They filtered the oil, put it back into service, and continued to monitor it. What they found was that the DGA gas levels started to rise again. After some initial panic with more 2 weekly monitoring, the gas levels stabilised and they realised the gas was coming out of the paper. They will now filter again and go back to more routine monitoring. As this dragline is a common machine within Rio and is so critical to operations, they are now looking at buying a spare transformer.

David from Rio Tinto Bengalla asked the group if they can confirm that regular DGA will pick up problems with transformer tap changers. The answers were that yes it generally would but it depended on the construction with some higher voltage transformers having a separate compartment for the selector. Joe from Connell Wagner made a point about off-load tap changers or normal tap connections that are not used regularly. He indicated that they are a particular source of problems. His suggestion that before you initiate any repairs that you measure the resistance of the contacts and then exercise the connections a very large number of times and see if the resistance comes down again.

Bruce from Sydney Water suggested that they have a significant number of HV transformers but have very few problems. The problems they do have are usually related to the gaskets on the insulators and Buchottz relays that after 10 to 12 years start to weep a bit but if you go around and nip them all up you don’t have any more problems. If there are serious leaks he suggests that you should not try to do a patch repair but is better to empty to oil strip and do a proper repair.

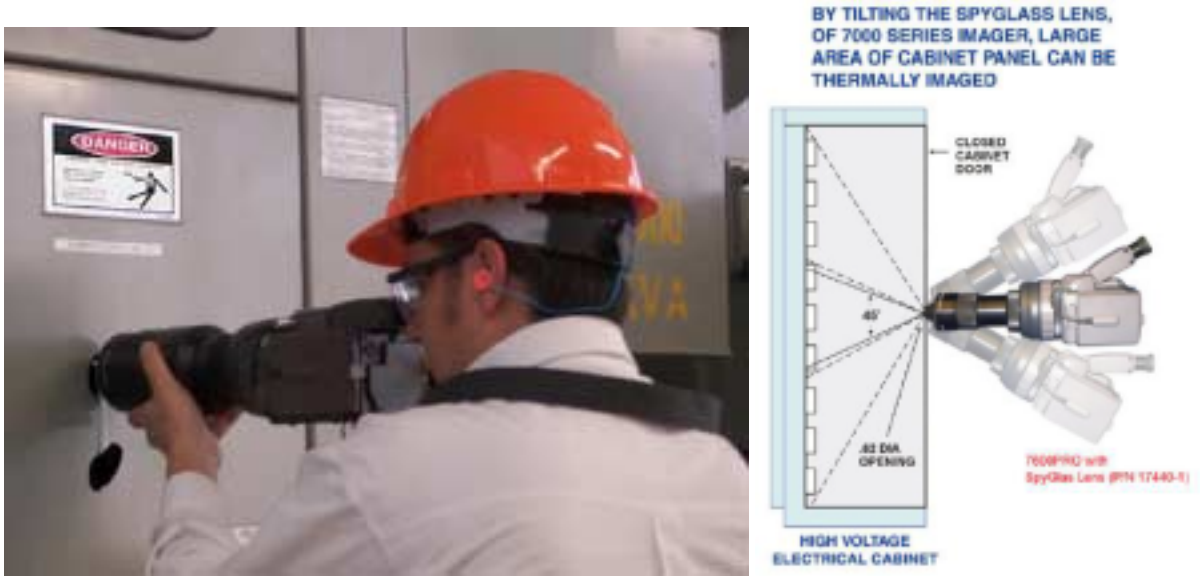
Paul from BOC provided the information that they will be installing a Dynamic Ratings DMRCC-T3 (http://www.dynamicratings.com/pdf/general_downloads/T3SalesInformation/DRMCC-T3Brochure.pdf) early in 2009 on our 132/11kV, 60MVA transformer and the bushing monitors that will look at Tx bushings and CT's and interface to the DMRCC T3 will be supplied by EDI (http://www.elec-di.com/index.html).

Thermal Imaging

Claudio from BOC suggested that the main problem with Thermal Imaging is access to cubicles containing high voltage gear, as there are too many risks involved with opening them. He suggested that it is a great technology and cheap to perform. Joe from Connell Wagner suggested that Thermal Imaging should be a mandatary must have test for electrical equipment, as it is such a useful and flexible general tool. The main faults it finds are hot joints but can give indications of many other problems such as cooling problems on transformers, unbalanced 3 phase supplies, broken wires etc.

On the issue of access, Joe from Connell Wagner suggested that there are lots of high voltage possible fault locations such as bushings that can be easily tested with Thermal Imaging. He also suggesting that more sever faults within cubicles can be detected by thermal patterns on the outside of the cubicle or differences in temperature from one side of the cubicle to the other. George from Bluescope Steel indicated that they have been successfully using Thermal Imaging inspection from the outside of cubicles and he suggested that you would be surprised what you can pick up. It is not as good as looking at the equipment directly but is much better than doing nothing. George gave the example were Thermal Imaging detected a hot control relay from the outside of a junction box.

There was discussion on use of Thermal Imaging widows to allow visual access to HV equipment and connection within cubicles without opening doors. One approach discussed was to use special crystal windows that Thermal Imaging cameras can see through (TI can't see through glass. Ed). There was a lot of interest in the more recent and lower cost approach of using a special Thermal Imaging wide-angle lens (See Appendix 4). This approach only requires a simple hole with a cover through the cubical door for the tip of the camera lens to fit through. Neither approach compromises the arc flash rating of the cubical.



New Approach for Inspection of HV Cubicles

One problem with Thermal Imaging is that faults only show up when the loading is there. Finding faults on intermittently used equipment is difficult. Joe suggested that on High Voltage system Thermal Imaging can often show faults such as tracking, just with voltage on a fault. (Off-line inspection for colour changes in temperature sensitive paints is a cheap and proven technique. Ed).

Paul from BOC asked what frequency people were using Thermal Imaging. George from Bluescope suggested it varies with criticality. 6 monthly or 12 monthly was suggested to be common but there was also examples given where much more frequent checks are made for know faults the can't be repaired until an outage occurs.

Switch Gear and Circuit Breakers

Joe from Connell Wagner suggested that moisture in the oil for oil circuit breakers is one of the main precursors to failures and a key monitoring variable. Monitoring contact resistance of switchgear was also mentioned. Claudio from BOC asked a question about what is an acceptable value for contact resistance. George from Bluescope indicated the Ductor test values can vary for a range of reasons and so values should be compared with a base line test and trended. Joe from Connell Wagner indicated they calculate the equivalent heat dissipation in the joint from the resistance. He suggested that one option is to ask the OEM what the maximum allowable value should be but he also suggested if an oil submerged HV contact got up to 1kW from a 200W energy from the resistance, Connell Wagner would consider that a significant problem and required action. When there is a significant problem, often the additional heat will be visible in a Thermal Image of the device. Joe discussed a special method they use to test contact resistance in tap changers that the have found successful.

A question was asked about use of Ultrasonic Monitoring on High Voltage systems. Claudio from BOC said they were using ultrasonic instruments and so did Ben from OneSteel. One of the uses for this type of instrument is to listen around the air gaps in high voltage cubicles for arcing, tracking and corona. Claudio said it is usually used in combination with Thermal Imaging. (There are the simple units like the Ultra TEV and there are instrument types that convert the ultrasonic sound into the audible range to assist with diagnosis, especially for lower level problems. The instrument suppliers provide sound recordings of the different types of faults to assist with training for technicians using the instruments. Ed).

A question was asked about optical detection of arc flash. Ron from Tomago indicated that they were using an ABB optical fibre arc detection system and suggested that it works well. A link to the ABB web site for their REA fibre optic light protection system is given below.
http://www.abb.com/product/db0003db004281/c12573e700330419c1256e4500319b27.aspx?productLanguage=us&country=AU

Maintenance Strategies, FMECA & Spares

Nandu from Sydney Water spoke about their system of development and recording of their maintenance strategies using a Failure Mode Effects & Criticality Analysis (FMECA). He indicated that this is a good format to develop, improve and justify the required monitoring and PM approach. John from Sydney Airport suggested that the criticality of HV equipment can vary significantly and is a key item in strategy decisions. He indicated that Electricity Authorities usually have lot of redundancy and spare equipment so they can accept failures

without severe consequences. Organisations that can recover by hiring emergency generators have lower criticality. John suggested there are many industrial, mining and critical facilities like Airports where failure of HV system have major consequences. This is due to little or no redundancy and this easily justified good Preventive Maintenance and Condition Monitoring practices. This is especially so when replacement item lead-times can me many months even it emergencies. Wing from Qenos made the point that even for lower criticality systems, failure can be the source of fires and OH&S issues and this needs to be considered. Bruce from Sydney Water made the point that this has to be balanced against the proven very low failure rate of most HV equipment. He also suggested that a number of the failures that do occur are from overloading or misuse of the HV equipment or from known faults that are not acted on, so addressing these issues should also be a part of your strategy. John suggested that Electricity Authorities often load their transformers to 150% and still don't have too many reliability problems.

Noel from Blue Circle Berrima spoke on their path the toward more a condition monitoring based approach due to the availably requirements of their plant. Their strategy analysis looks at the criticality of the plant to determine what item and how often monitoring will be carried out and also considers equipment spares availability and lead time.

Claudio from BOC indicated that, as they are an international company, they have global PM standards that have been developed by the best of their people around to glob and from supplier and other expert advice. This BOC Global MAXIMO based standards have some time based maintenance but also condition based as well. Even though they have time based PM's, these are always challenged before they are implemented. For example if a large motor was scheduled for an out of service 60 month inspection, the question is always raised if it should go ahead or if they have enough information to say that it is still OK. The timed based maintenance schedule acts as a prompt to review the current situation and assess the need.

The question was asked, what people do if customer demands stop access to equipment to scheduled maintenance. The first suggestion was to mitigate the risk by doing whatever on-line CM testing that is practical and economic and with other available information to further assess the risk. The other suggestion was to document on paper exactly what you believe the risk is so that there is no question by management of what risk they are taking. James and John from Sydney Airport indicated that they are very firm with their customers and that they can accept some delays for a yearly outage in a 3 monthly window but as there are multiple customers, they will not accept higher risks for all supply customers because one customer does wants to have a substantial delay on an outage. John from Sydney Airport suggested that as they have little maintenance history available for their system prior to the introduction of Maximo; they have now put a strong time based PM outage system of either 1, 2 or 4 years to guarantee that proper servicing is done. They may be able to be less rigid in the future with these outages once they build up more history. Claudio from BOC suggested that they would use DGA and other non-invasive testing to further assess the risk. David from Rio Tinto Bengalla indicated he had made these decisions to delay HV outages using a more detailed assessment of the actual loading and usage on the system, as well as additional CM checks. He suggested that if current loading is low compared to its rating and switching rates are low, then the likelihood that deterioration since the last inspection would also be lower.

Ben from OneSteel indicated that they had an example of this on a transformer in one of their Sydney plants that was due for an outage in April. This transformer had a problem with high moisture levels and a problem with the tap changer. The decision was also made that they wanted to change out the transformer. Due to the Steel market, the decision was made that

they wished to delay the shut, which will now be at Christmas. Various CM tests like DGA were carried out, the oil was dried out on-line and a short off-line service was done on the tap changer. The risk of delaying the work on the transformer was considered acceptable by management when they compared to the benefit of staying in service to the more suitable time. Ben was asked if there were any safety related measures like exclusion zones around the transformer since it has a known problem. He indicated that since they were able to bring the moisture level down to a reasonable level, actions like exclusion zones were not necessary. In assessing the consequences of a failure, OneSteel considered what the upstream effects of a failure would be as the upstream protection will typically take out a large area and effect many people.

John from Sydney Airport related an example in the past where an old HV switchboard was planned be replaced but was not acted upon in time. A failure occurred which had major consequences. He stressed that it is very important to fully communicate the risks associated with older assets and potential consequences of a failure to management. Formalised risk assessment is now beginning to take a more central role in the management of the HV assets. David from Rio Tinto Bengalla indicate that in their problem with the Dragline transformer they quarantined the whole area to manage any safety consequences in the case of a failure occurring. You need to think through all the OH&S issues and manage them, which is your responsibility. He suggested that if there is a need to run systems with a know fault it is important to fully study the potential consequences and how they can be minimised as management can't do this.

Justifying Replacement of HV Equipment

Ben from OneSteel suggest they justify replacement of equipment on Operational Security and safety of their people. They look at the full consequence and the likelihood of having a failure, compared to the equipment it would be replaced with. With safety, they specifically look at HV Operator safety. John from Sydney Airport said they looked at in order of priority:-

- Safety of the people operating the equipment
- The criticality of the equipment
- What spares are available to maintain the equipment and if identical or compatible replacement items are available (especially for older equipment).

The discussion was that it is often the case that Electrical Engineers and others who are involved with scoping projects and selection of HV equipment have very little experience in operations of HV equipment. It was suggested that they typically don't put the required level of priority on HV operator safety. James from Sydney Airport suggested that there is often a disconnect of priorities between project planning and maintenance engineering and that these gaps need to be bridged to achieve the best operational outcome. James suggested that to assist with making a strong business case for major equipment replacement/upgrade programs, after collecting the required information an external consultant/ authority can be hired to assist with writing up the justification and specification.. There was general agreement that management often tend to suspect that internal experts will put forward a case that is best for them rather than put up a balance business decisions.

Another comment was made that the time to push for approval of an existing case for replacement of older HV gear is very soon after there has been a significant incident with something equivalent ether internally or externally. David from Rio Tinto suggested that in the mining industry these days, there are no problems getting older gear replaced if it can be

shown there is a higher risk of human injury. He suggested that most larger mining companies are very serious about safety.

John from Sydney Airport suggested that best way to change people's attitude to HV safety is to send them to a burns ward in a hospital where someone is suffering from arc flash burns.

Appendix 1

Sydney Water High Voltage Presentation

Presentation is on the HV CIWG web page for downloading in 4 files of less than 2 megs each.

Appendix 2 – Portable Instrument for Partial Discharge/ Arc / Corona Detection

Thew & McCann
....total reliability in electrotechnology

UltraTEV

Description:

The UltraTev is a firstline tool to quickly detect the presence of discharge activity in H.V. indoor metalclad switchgear 3.3kV up to 33kV. It provides an indication if further investigation is needed through detection of both ultrasonic and electromagnetic activity.

Features:

Hand held, easy to use instrument.

Clear LED results of the measurement.

Portable and lightweight.

High impact case.

Rechargeable internal battery will provide up to 7 hours of continual operation.

Minimal training required.

***General Operation:**

With unit clear of any metalwork press ON/OFF button and the LEDs will light and do a self check.

To survey for ultrasonic activity, scan the ultrasonic probe around the openings in the switchgear and look for ultrasonic discharge status LED changing from green to red.

To take transient earth voltage (TEV) measurement, hold the probe end of the instrument squarely in contact with the metalwork on which the measurement is to be taken and look for TEV discharge status LED changing from green to red.

Weight: 300g

Dimensions: 1 80 x 52 x 52 mm

Code: ULTRA-TEV

**Follow detailed operating procedure explained in Operating Manual supplied with each instrument or upon request.*

Ph:(+61) 07 3821 3399 Fax:(+61) 07 3821 4666 Email:sales@thew.com.au Website: www.thew.com.au
43 Enterprise Street Cleveland (PO Box 1796 Cleveland DC) Queensland 4163 Australia

Appendix 3 - High Voltage Testing Technical Paper by Joe Tusek

Presentation is on the HV CIWG web page for downloading

Appendix 4 - Mikron SpyGlass system for Thermal Imaging inspection of electrical cubicles

Presentation is on the HV CIWG web page for downloading

Appendix 5 - Rio Tinto Coal Australia Isolation System Users Handbook

Presentation is on the HV CIWG web page for downloading

Appendix 6 - Rio Tinto Coal Australia - Isolation Procedure - Live Testing

Presentation is on the HV CIWG web page for downloading

Appendix 7 - Rio Tinto Coal Australia - Isolation Procedure - Project Isolation (Group Locking)

Presentation is on the HV CIWG web page for downloading

Appendix 8 - Sydney Water - Customer Safety Plan (Blank Template in MS Word)

Presentation is on the HV CIWG web page for downloading

Appendix 9 - Sydney Water - Customer Safety Plan - Integral Energy Version

Presentation is on the HV CIWG web page for downloading

Appendix 10 - Sydney Water - Customer Safety Plan - Energy Australia Version

Presentation is on the HV CIWG web page for downloading

Appendix 11 - Sydney Water High Voltage Operating Procedures - Maroon Book

Presentation is on the HV CIWG web page for downloading