During the last three decades, there have been many new developments in condition monitoring (CM) of high voltage equipment in electrical power systems. Hundreds of new instruments are in use around the world. Enormous quantities of CM data are collected from on-line and off-line tests every day. Now it might be the right time to ask “Are we using CM instruments wisely?” In fact, one of the problems often encountered by industry is how to interpret the mass of CM data. Of course, CM program must be accurate, reliable and cost-effective. The cost includes instrumentation and on-going testing and data interpretation. The common problems experienced by industry are:

- Over-usage of techniques and instruments, making CM costly;
- Misunderstanding of the principles underlying the operation of CM equipment, and its capability and applicability;
- Difficulty in interpreting complex and voluminous data, and therefore in diagnosing incipient faults;
- Difficulty in determining the critical fault levels on which repair/replacement decisions should be based;
- Difficulty in estimating sufficiently accurately the remaining service lifetime of insulation.

Given the above problems, a new concept of Smart Condition Monitoring (SCM) is proposed to wisely apply and develop new condition monitoring techniques. It should not be confused with “smart grid” which obviously has different meaning. Smart condition monitoring would be concerned with the following:

1) Smart selection of CM techniques
2) Smart sensor development
3) Smart data interpretation and diagnosis
4) Smart failure investigation and failure prevention
5) Smart sharing

In this seminar, the idea of SCM will be presented using case studies from power industry.

**About the speaker:**

Dr. Su received his MEng in 1981 and PhD in 1990 (University of New South Wales, Australia). He was a tests and operations engineer from 1971-1978 and an honorary research associate at the University of Western Australia in 1985. From 1991 until 2001 he was senior lecturer, associate professor and head of the HVICM Group at Monash University, Australia. Commencing in 2002, he worked as the chief technologist at Singapore Power (SPPG) for 5 years. From 2007 to 2011 he was a professor and the chair of the Research Committee at the Petroleum Institute, UAE. He is a guest professor at the Electrical Power University, Beijing in 2012 and at Wuhan University in 2013. Prof. Su has published two books and over 150 journal and conference papers. He received the Vice-Chancellor’s Special Commendation for Teaching Excellence at Monash University in 2001 and an IEEE Standards Award for contribution to the standard “Guide on the Measurement of Partial Discharges in Rotating Machines” in 2002. He has also provided consulting services to many utilities in the world and has conducted a number of training courses for the industry in Australia, UAE, Singapore, Malaysia, Taiwan, Hong Kong and Indonesia. He is a Fellow of the IET (former IEE), a member of CIGRE A2, and a Senior Member of IEEE since 1991.
Books published by the speaker:

1. **Condition Assessment of HV Insulation (IET Press, UK 2008)**  
   [http://digital-library.theiet.org/ebooks/iet/power_and_energy/po053e?isAuthorized=no](http://digital-library.theiet.org/ebooks/iet/power_and_energy/po053e?isAuthorized=no)

2. **Electromagnetic transients in transformer and rotating machine windings (ISI Global, USA 2012)**  
Smart Condition Monitoring

I have worked on high voltage and condition monitoring (CM) for around 40 years. During this time, I have seen many changes in that field. Twenty-five years ago I approached the chief engineer of a utility, proposing a condition-monitoring project for his generators. He replied “What for? We are already overloaded.” It was not easy to sell the CM idea to the industry. Fortunately, since then the application of CM to improve the reliability of HV equipment and cables has been gradually accepted by most utilities. Hundreds of new instruments are in use around the world. Enormous quantities of CM data are collected from on-line and off-line tests every day. Now might be the right time to ask “Are we using CM instruments wisely?” One of the problems commonly encountered by industry is how to interpret the mass of CM data for HV equipment and cables. A CM program must of course be accurate, reliable, and cost effective [1]. Cost includes instrumentation and on-going testing and data interpretation. The common problems experienced by industry are

- over usage of techniques and instruments, making CM costly;
- misunderstanding of the principles underlying the operation of CM equipment, and its capability and applicability;
- difficulty in interpreting complex and voluminous data, and therefore in diagnosing incipient faults;
- difficulty in determining the critical fault levels on which repair and replacement decisions should be based; and
- difficulty in estimating sufficiently accurately the remaining service lifetime of insulation.

Given these problems, I suggest a new concept that might be called smart condition monitoring. It should not be confused with smart grid. Smart condition monitoring would be concerned with the following.

1. Smart selection of CM techniques
   Each technique has its own advantages and limitations, determined by the principles underlying its operation. Thus insulation resistance measurements are useful for assessment of terminal contamination, moisture seepage into joints, and aging of power-cable insulation. However, they may not be effective in detecting unbridged air gaps and water trees in XLPE cables because of the high-volume resistivity of XLPE [2]. The technical staff of utilities must have a sound understanding of the principles and limitations of a CM technique before adopting it.

2. Smart sensor development
   During the last a few decades, a wide variety of sensors has been developed for CM applications, including electrical (e.g., partial discharge), mechanical (e.g., vibration), thermal (e.g., temperature), and chemical (e.g., acidity in oil) sensors. Unfortunately, a single type of sensor cannot detect all types of defect in a piece of HV equipment or in a cable. False alarms due to interference are a serious problem. Constant effort is required to improve existing sensors and to develop new types for more accurate detection of incipient faults [3].

3. Smart data interpretation and diagnosis
   When a large quantity of data is collected from CM instruments, the really useful information about defects and their severity may be hard to find. It is important to analyze the data intelligently, using trend analysis, phase comparison, digital signal processing, and even artificial intelligence techniques such as fuzzy logic [4], [5].

4. Smart failure investigation and failure prevention
   Insulation failure in HV equipment and cables will always be a problem for utilities. The root causes of a failure can usually be determined, and therefore its recurrence should be avoidable. Failure investigations should be carried out using a structured and systematic approach. Honest and objective appraisal is important, avoiding pre-existing bias. In-depth examination may help to determine whether a failure is an isolated case or is due to a type of fault that may affect other equipment and cables [6], [7].

5. Smart sharing
   Finally, smart condition monitoring is probably not a completely new concept, since it is essentially a summary of do’s and don’ts for the CM society. It can be effectively implemented and its targets achieved only if experience, data, and findings are freely shared between utilities.

References


