CONDITION ASSESSMENT OF INSTALLED NUCLEAR POWER PLANT (I&C) CABLES

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Abstract

Twenty-five to thirty-five year old nuclear power plants are undergoing rehabilitation programs to extend the plant life to 50 or 60 years. Instrumentation and control (I&C) cables are identified as one of the major components examined in the life extension programs. Cable insulation is exposed to ionizing radiation, elevated thermal, vibration, and moist environments during normal operation in addition to extra ordinary radiation and thermal conditions in a postulated design basis accident event. Aged insulations are prone to either embrittlement and cracking or an alteration in material chemistry causing changes in dielectric properties which leads to shorting when moisture is present. This presentation discusses the techniques used to perform a condition assessment of cable insulation by means of visual and other non destructive techniques, namely, EPRI Indenter measurements and near infrared (NIR) scanning technology. Low voltage installed cables which are insulated with PVC, FRXLPE, and FREPR, and which are jacketed with PVC, are considered. The techniques discussed will allow plant personnel to extend cable life without additional qualification tests.

1.0 Introduction

FRXLPE (fire resistant cross linked polyethylene) and FREPR (fire resistant ethylene propylene rubber) are common insulation materials used for safety related applications inside the containment areas of CANDU nuclear power plants. PVC (polyvinyl chloride) insulated wires are also used for safety related applications outside the containment areas but are used in non safety related applications inside containment in older plants.

Cables installed in a nuclear generation plant remain largely undisturbed for the life of the plant. Exposure to elevated temperatures, ionizing radiation, and atmospheric oxygen cause polymers in the cable to deteriorate. As a polymer ages, its physical properties change, resulting in reduced tensile properties and ultimately leading to embrittlement of the cable insulation and cracking if the cable is disturbed. Practical experience has demonstrated that electrical parameters are not representative of cable aging; electrical failures usually follow after mechanical degradation.

Most CANDU stations were designed for a 30 to 40 year operating life. A major goal for many operating nuclear stations is the extension of the operating life of the plant to 60 years. However, real-time aging data over a long-term time period is unavailable for the specific materials in use. In particular, accelerated thermal and radiation aging models used to simulate the normal service life do not replicate the real life thermal and radiation conditions that exist in the field [1-2]. A programme of ongoing condition monitoring and condition assessment is the most promising method to ensure that the cable system is in good health, and will remain in good health until after the next assessment is performed.

The traditional method of monitoring insulation degradation and the measurement of tensile elongation, requires installed cable samples from the field for destructive testing. The present acceptance criterion used for installed XLPE and EPR insulated cables is 50% absolute elongation-at-break. It is generally assumed that this elongation value will provide sufficient margin to ensure that the XLPE and EPR insulated wires maintain their electrical properties during a design basis event [3-4]. A similar criterion does not exist for PVC insulated wires. Most PVC cables that qualified for the MSLB event had elongation values in excess of 170%, representing an approximate 50% reduction from the original properties [5]. A higher elongation threshold will be required to assess the condition of PVC insulated wires used in safety applications. The requirement of the removal of a relatively large sample size from a plant for elongation measurements makes this method impractical for evaluation of the condition of installed cables. The ideal solution would be to develop non destructive techniques whose results would correlate with the absolute tensile elongation values.

In this study, commonly used yellow PVC jacketed cables containing FRXLPE and FREPR insulations were evaluated. These cables were irradiated and subjected to elevated thermal environments to study the effect of radiation and combined radiation plus thermal aging representing installed cable environment inside containment. In addition, thermal only aged FRXLPE, FREPR, and PVC insulated wire specimens were also included in the study to represent cables installed outside containment environment. The chemical changes as a result of oxidative aging of PVC, FRXLPE, and FREPR were quantified by measuring structural and mechanical property changes by non destructive means using spectroscopic techniques [6] and Indenter modulus measurements. The spectroscopic and Indenter modulus changes were correlated to elongation at break values. By comparing near infrared spectroscopic (NIR) scans and Indenter Modulus values of installed cables with the developed aging models the condition of installed cables can be determined.

2.0 Experimental

2.1 Cable samples

Two of the most common FRXLPE and FREPR insulation qualification groups with yellow PVC jackets used in Bruce Power's and OPG's nuclear cable systems were selected for this study. The cables were manufactured by the common cable suppliers, namely, Phillips, Canada Wire, Pirelli and Northern Telecom during the 1978 to 1990 period. The cables were rated for 300 to 600V applications and the sizes ranged from 8 to 16 AWG. Though FRXLPE and FREPR insulations made by different manufacturers belong to the same qualification group the formulations of the PVC jackets were different. It may be noted that the FRXLPE and FREPR qualification groups evaluated represent 60 to 70% of the safety related cables installed inside containment. PVC insulated wires evaluated were also manufactured by the same cable manufacturers, but each formulation was different.

2.2 Thermal aging of FRXLPE, FREPR and PVC

For each of the FRXLPE and FREPR cable designs, ten 200 mm long complete cable sections (with jacket intact) were prepared. Each of the cable specimens was aged at temperatures of 110°C and 120°C until the yellow jackets blackened or reached the embrittlement stage. Periodically, samples were removed from the ovens and the jackets were cut open to obtain samples for elongation measurements. In addition, compression moulded and tubular (after removing the conductors) FREPR insulation specimens and tubular FRXLPE specimens were also evaluated in the aging studies. PVC insulation specimens were thermal aged in the complete cable configuration and tubular form at temperatures ranging from 90 to 110°C. The samples were aged in ASTM type II air circulating ovens with 100-120 air exchanges per hour.

2.3 Irradiation (FRXLPE and FREPR)

Cable sections (with jacket intact) were exposed to a Cobalt-60 source at an approximate does rate below 0.08 Mrad/h for total doses of 5, 10, 20, 30, 40, 50, and 60 Mrad. A cable specimen was removed after each exposure point for elongation measurements. The compression moulded EPR insulated specimens used in the study were irradiated at a dose rate below 0.02 Mrad/h.

2.4 Thermal aging of irradiated FRXLPE and FREPR

Tubular insulation specimens were prepared from the irradiated insulated wires described in Section 2.3 and subjected to additional thermal aging. The ends of the specimens were sealed with RTV silicone prior to thermal aging. The first set of FRXLPE and FREPR test specimens were subject to thermal aging equivalents of 20, 30 and 40 years at 60°C. Another set of irradiated insulations was subject to the equivalent aging at 10, 20, 30 and 40 years at 47°C.

2.5 NIR spectroscopy

The Fourier Transform – Near Infra Red (FTNIR) Spectral scans were collected using the Bruker Vector 22/N spectrometer according to procedures described in Kinectrics technical work instruction TWI 530-033. The equipment was configured for the NIR region (14,000–4000cm^{-1}) and equipped with a fiber optic reflectance probe and preloaded with processing software, OPUS version 3.0.3. Each wire specimen was scanned five times in different positions to average the samples homogeneity effect.

2.6 Indenter modulus

The EPRI indenter [4] uses an anvil which is driven into the cable jacket or insulation at a constant speed during which both force and deformation depth are measured to yield Indenter modulus. At a specific force, the anvil is retracted to preclude damage to the cable. The indenter is a portable, self contained device which is battery powered and robust enough to be used in the field. For each cable, a minimum of 5 measurements was taken. If the standard deviation variations exceeded 10%, ten or more measurements were obtained. Indenter modulus measurements were made on outer jackets and single conductor wires that were directly heat exposed.

2.7 Tensile testing

Tensile strength and elongation tests were performed with a Lloyd tensile testing machine at a crosshead speed of 50 mm/min. Typically, three 100 mm long tubular insulation specimens and three die cut jacket tensile specimens were tested. The majority of FRXLPE and FREPR insulations contained a Mylar coating over the conductor which tended to bond to the insulation during aging. Delamination of the Mylar from the insulation during tensile elongation altered the elongation at break values depending on the degree of bonding. Consequently the data uncertainties for elongation values could be higher than ±15%.

3.0 Results and discussion

3.1 Visual inspection

The use of yellow colored PVC jackets in Canadian Nuclear Power plants provides a unique opportunity to visually determine the condition of cable insulations in situations where there has been exposure to heat. The extent of the color change in the yellow PVC jacketed cables is a very good indicator of the degree of thermal aging. Figure 1a shows the color change of one of the seven yellow PVC jacketed cables evaluated [6] with aging time at 120°C. It shows that the color of the jacket changed from yellow to light brown, dark brown, and then to black. It should be noted that the rate of color change will be dependent on the formulation type. Regardless, of the rate of discoloration, the elongation properties of the underlying FRXLPE and FREPR insulations were not significantly affected for those PVC jackets that were blackened. Therefore, cable jackets installed outside containment that do not exhibit any color change or just minor discoloration can be considered to have been subject to a minimal amount of thermal aging. However, if the cable jacket is blackened or exhibits cracking, insulation samples shall be separately analyzed to evaluate the condition of the cable.

Note, color changes are also expected for radiation aged PVC jackets. However, exposures in excess of 100 Mrad are required in order to produce signs of a visible physical deterioration. Radiation levels in excess of 30 to 50 Mrad will result in detrimental effects on the underlying XLPE and EPR insulations. Hence, even if there was no color change, additional verification of the condition of the insulation will be required in case the cable has been exposed to a radiation field. It was found that thermal aging will darken the PVC jackets subjected to an irradiation level in excess of 20 Mrad. Figure 1b illustrates that PVC jackets (having the same formulation as those in Fig 1) which have been irradiated to a 20 Mrad dose were darkened following thermal aging, even with minimal thermal aging levels (i.e., an equivalent of 10 years of aging at 47°C). From the above discussion it can be inferred that PVC jackets installed inside containment that do not exhibit color changes were exposed to either minimal thermal aging levels or less than 20 Mrad of irradiation exposure with minimum thermal aging. However, an exposure to a high radiation only environment will result in detrimental effects on the insulations of cables.

Therefore, a methodology to estimate the amount of radiation only induced damage on the insulation is required.

Figure 1a

Figure 1b

Figure 1a Thermal aged PVC jacketed cable jacket and Figure 1b Cable irradiated to 20 Mrad and aged at 90˚C to represent additional 10, 20, 30, and 40 years of service at 47˚C.

3.2 Indenter modulus (IM)

Under controlled conditions indenter measurements provide an indication of the compressive modulus of the cable insulation material. Generally speaking, the compressive modulus correlates inversely with tensile elongation at break. The cable Indenter has been shown to be sensitive to detect aging of PVC insulations or jackets subjected to a thermal aging environment. However, this technique has not been found to be responsive enough to detect aging of XLPE / EPR-insulated wires subjected to either thermal or radiation fields, nor can it detect aging of PVC-insulated wires subject to radiation fields. In the case of installed cables with yellow colored jackets, this technique essentially provides similar information that would otherwise be obtained via a visual inspection as discussed earlier but, in addition, also provides quantitative results. This technique is most useful in the assessment of the condition of PVC insulated wires installed outside containment, where all the cables have black jackets with light colored insulations. Another advantage of this technique is that since it essentially reacts to changes due to thermal aging of PVC jacket materials, it can distinguish cables that have been subjected to primarily thermal aging from those that have been exposed to a radiation environment or to a combined thermal plus radiation environment.

IM values of three of the seven yellow jacketed cables evaluated with underlying FRXLPE and FREPR are plotted in Figure 2 as a function of aging time at 110˚C. The figure shows that cable C2 aged at a slower rate while cable C6 aged at a faster rate and then reached a plateau. As discussed earlier, none of the underlying insulations exhibited any change in the elongation properties within the maximum aging period attained. The PVC jackets of cable C6 reached the embrittlement level when the IM values were >150 N/mm. The rapid change of IM values for cable type C6 suggests that by conducting IM measurements of this cable type the condition of the installed cables in that particular room or environment can be discerned. Only if significant change is observed will the other cable types require testing. It should be noted that NIR technology can be used to identify the jacket formulation type.

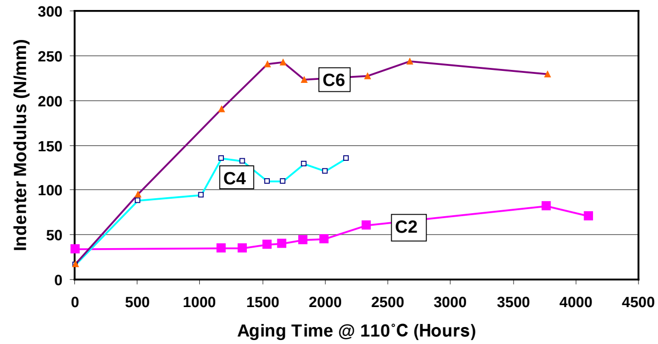

Figure 2 Indenter modulus of yellow PVC jacketed (FRXLPE/FREPR insulated) cables as a function of aging time at 110˚C

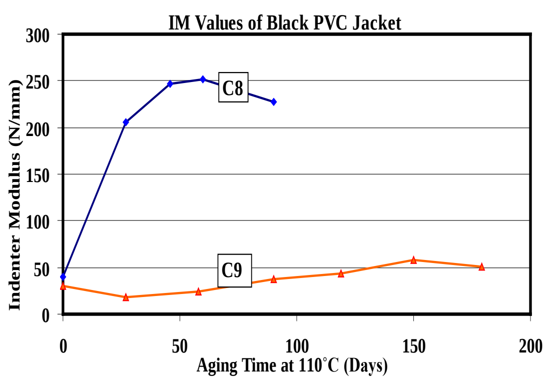

Figure 3a

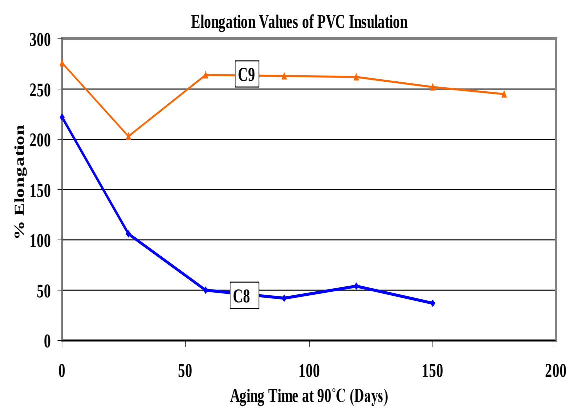

Figure 3b

Figure 3a IM values of PVC jacketed cables as a function of aging time at 110˚C and Figure 3b Elongation values of PVC insulations as a function of aging time at 90˚C

IM and elongation values for two of the most common PVC insulated and jacketed cables are plotted in Figures 3a and 3b. Both jackets are black and the underlying insulations are light colored. IM values were obtained from complete cable sections that were aged at 110˚C and the insulated wires were aged at 90˚C to acquire elongation data. With increasing aging time C8's elongation value decreased while the IM value of the jacket increased. These changes occurred at a much slower rate for C9. Again, the aging trends for these two cables suggest that the condition of the installed cables can be obtained with reduced effort and cost by concentrating measurements to fast aging cables.

3.3 NIR spectroscopy

Near Infra-Red (NIR) spectroscopy is a non-destructive technique that can be used on polymeric based materials of light colour, such as cable insulation and jackets, to indirectly determine the material elongation at break value. This technique has been successfully used in the field for the identification of the insulation formulation types for over 10,000 installed cables in CANDU nuclear plants.

Chemical changes produced by the oxidative aging of PVC, FRXLPE, and FREPR were quantified using NIR spectroscopy. The spectroscopic changes were correlated to the elongation at break values of the FRXLPE and FREPR insulations subjected to thermal, radiation, and combined thermal plus radiation aging environments. Similar correlations were obtained with thermally aged PVC insulation specimens. In this manner, models were developed which would allow for the determination of elongation at break for NIR scanned cable insulation based on NIR spectral features. When properly modeled, NIR spectroscopy provides a statistically valid method for determining the condition of cables aged in service.

As an example, the NIR spectra of irradiated and thermally aged PVC jackets are shown in Figures 4. The major features seen in the NIR spectral region are due to combinations and overtones of fundamental vibrations that absorb energy in the mid infrared region of the spectra. As with FTIR spectroscopy, strong NIR absorbers include species such as C-H, O-H, N-H, C-O, C-H, COOH and aromatic C-H groups. The relative concentrations of these functional groups change with aging. As illustrated in Fig 4, significant changes in various spectral regions are taking place as the PVC jacket material was irradiated and thermally aged to different extents. Prominent changes are evident in the wavelength band region of 4815 to 5350 cm^{-1}. The origin of this change is not yet known.

PLS chemometric analysis techniques [7] were applied to the NIR spectral data to develop calibration curves (models) for various PVC and FRXLPE / FREPR insulations. The chemometrics analysis was performed using the Thermo-Electron PLSplus IQ Analyst software package. The software allows for the selection of the spectral regions showing maximum change with aging and correlation with elongation values, as shown by the blue line in Fig 4. The correct model is obtained through an iterative process with the best solution resulting in minimized calculated residuals. The applicability of the model is expressed in a number of ways, one of which is Mahalanobis distance **(M-Distance)**. This distance is a statistical measure of the distance between samples and the calibration set.

For each FRXLPE, FREPR, and PVC formulation, a number of models were constructed by varying the sample size and wavelength regions. For the same formulation type, the sample size was increased by adding field aged samples, cables manufactured during different periods, different cable sizes and sample thicknesses. In some cases insulated wires were aged directly and in other cases they were aged as part of a complete cable. Additionally, samples scanned with 3 meter long NIR probes were also incorporated to enhance the models' applicability to cables located in difficult to reach locations. Probes of different lengths have different NIR attenuation characteristics. In most cases, increases in the sample size corresponded to improved predictive capability. In a few cases added samples diluted the models predictability. When the models are applied to determine the condition of unknown cables, the most appropriate model will result in low M-Distance and, in general, a correlation with conservative elongation data.

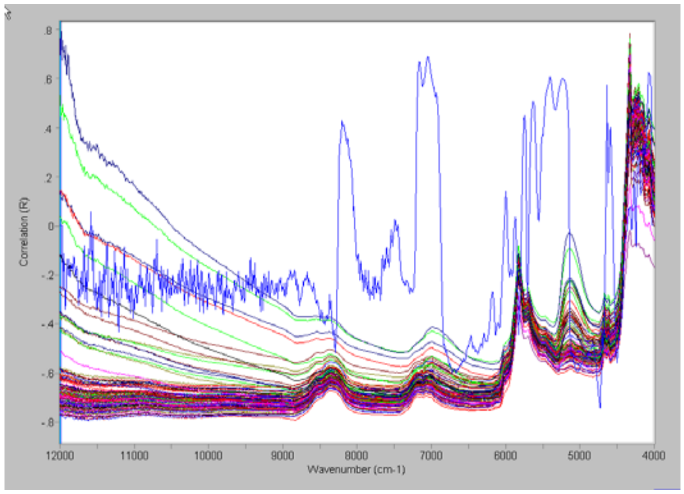

Figure 4 NIR spectra of radiation and thermal aged PVC jackets and the wave length regions showing correlation (blue trace) with aging (elongation at break)

3.3.1 Modeling FREPR insulations

One of the FREPR models was constructed using 147 thermal, radiation, and radiation plus thermal aged FREPR samples along with their respective elongation values. The predictive model is shown in Figure 5. After removing 23 outliers, a correlation value R^2 of 0.917 with a standard deviation value of 20% elongation (absolute) was attained. It should be noted that out of the 23 outliers, 11 of them of were severely aged such that 7 samples had zero percentage elongation and 4 samples had elongation values in the 50% range. Among the remaining 12 outlier samples, 2 of them were grey in colour and grey colouring produces suspect NIR measurements. The remaining 10 outlier samples were rejected due to suspect elongation value measurement or that they would require rescanning in order to be incorporated into the model. Currently the FREPR models have been expanded to include 252 and 297 representative samples.

To verify the accuracy of the predictive models, sample sets from similar insulation formulations which were not used in the original modeling were selected. For the FREPR insulation with irradiation plus thermal aged samples from cable material EQ59, the FREPR 252 sample model was found to be the most appropriate, as it resulted in lower M-Distance values compared to other models. The predicted and actual elongation values of the unknown sample sets are shown in Table 1. Within the experimental error, the predicted values closely matched the actual values for majority of the cable insulation types.

3.3.2 Modeling of FRPVC insulations

At least 15 PVC insulation qualification groups were identified among the installed cable materials in CANDU plants. It was found that formulations having similar plasticizer types can be grouped together for modeling purposes. These formulations contain similar plasticizers at different ratios and also had differences in the level of other additives, namely, the fillers and fire

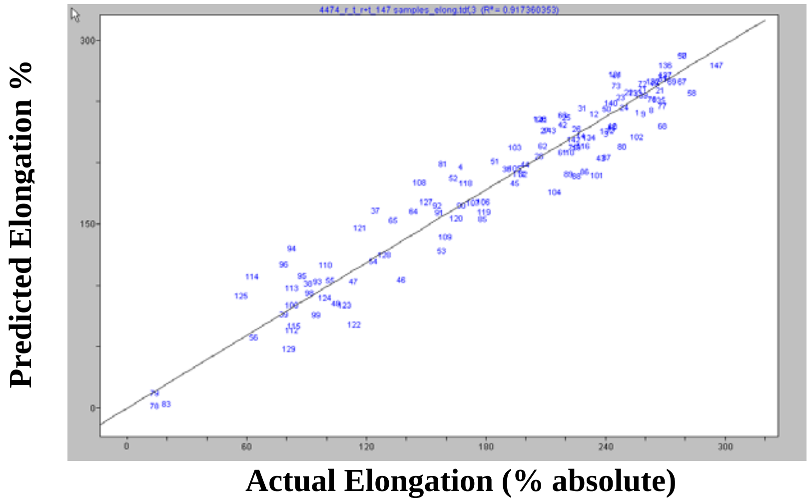

Figure 5 Actual elongation values Vs predicted for thermal, radiation, and radiation plus thermal aged EPR 3,4,5 insulations (except 23 outliers) R^2 = 0.917

Table 1 Actual and predicted elongation value (% absolute) for thermal, radiation, and radiation plus thermal aged FREPR insulation

Sample	Aging Condition	Calibration Model	Pred. Elong.	M-Dist.	Actual Elong.
5915R20	15 Mrad+20y @ 50C	EPR_252 Samples	179.0	0.75	191
5915R40	15 Mrad+40y @ 50C	EPR_252 Samples	180.8	0.83	184
5925R20	25 Mrad+20y @ 50C	EPR_252 Samples	146.3	1.00	175
5925R40	25 Mrad+40y @ 50C	EPR_252 Samples	159.4	0.93	158
5940R20	40 Mrad+20y @ 50C	EPR_252 Samples	111.5	1.01	148
5940R40	40 Mrad+40y @ 50C	EPR_252 Samples	130.1	0.86	127
5955R20	55 Mrad+20y @ 50C	EPR_252 Samples	78.2	1.34	109
5955R40	55 Mrad+40y @ 50C	EPR_252 Samples	97.4	0.99	97

retardants. It is well known that, upon aging, the low volatility plasticizer components evaporate and this essentially transforms the insulation into another PVC formulation type. As a result, it was found that one of the most common PVC formulations can be grouped with another three PVC qualification groups to construct a model with 179 representative samples. After removing 18 outliers, mostly severely aged and discoloured samples, the resulting model had a correlation value R^2 of 0.814 and standard deviation value of 36% absolute elongation.

Thermal aged insulations samples of cable material EQ79 were selected to validate the PVC predictive model constructed from 179 samples. As shown in Table 2, except for the two severely aged and discoloured samples which were aged for 150 and 179 days at 110°C, the predicted elongation values were close to the actual values for all other samples. For the severely aged samples, specifically for the most aged insulation, the M-Distance was high, which suggests that the model cannot accurately predict the condition of the cable. It is well known from the qualification tests conducted on PVC insulated wires that severely aged and discoloured samples will not satisfactorily perform through the accident event [5]. Based on the Arrhenius analysis, 150 days of aging at 110˚C corresponds to 40 years of continuous operation at a temperature of 69˚C. In this situation visual inspection alone would indicate the cable had been severely aged and there would be no point in conducting NIR testing.

Table 2 Actual and predicted elongation value (% absolute) for thermal aged FRPVC insulation

Sample	Aging Condition	Calibration Model	Pred. Elong.	M-Dist.	Actual Elong.
79027B	27 d @ 90C	PVC_179Samples	231.9	0.57	203
79090B	90 d @ 90C	PVC_179Samples	235.8	0.66	263
79179B	179 d @ 90C	PVC_179Samples	234.5	0.81	245
79I027D	27 d @ 110C	PVC_179Samples	241.5	0.78	285
79I090D	90 d @ 110C	PVC_179Samples	237.8	0.66	176
79I119D	119 d @ 110C	PVC_179Samples	227.9	0.68	222
79150D	150 d @ 110C	PVC_179Samples	247.3	1.74	197
79I179D	179 d @ 110C	PVC_179Samples	265.2	5	166

3.3.3 Application of the Models – Installed Cables

From 1999 to 2003 Kinectrics Inc. has collected NIR spectrum scans from about 10,000 installed cables at the Pickering and Bruce NGS's (PNGS and BNGS). The service period during which the cables were evaluated corresponds to the date of scanning. Therefore the analysis lags the cable service period by about 7 to 10 years, as the data was collected between 1999 and 2003, but it is being analyzed in the year 2010. Cables installed in radiation and temperature harsh rooms were selectively evaluated. According to the OPG room condition manual for Bruce B NGS, cables in room 206 at elevations 615' and 639' can be expected to be exposed to a temperature of 50˚C and radiation dosage ranging from 0 to 75 Mrad. Rooms 106 and 107 in Bruce B NGS also experience high radiation fields. In PNGS A and B NGS, cables in rooms 401, 402, 403, 404 are exposed to the highest temperatures, whereas rooms 101, 108, 109 in PNGS A NGS, and rooms 113, 115, 208 and 209 in PNGS B NGS expose cables to high levels of radiation.

NIR models were applied to assess the condition of selected cables installed in the harsh areas of PNGS Units 4 and 5, and Bruce B NGS Unit 5 vaults. Cable information related to the cable location obtained from the power plant's on-line wiring system and reported in NIR identification reports are provided in Tables 3 to 5. The predicted elongation values of FRXLPE and FREPR insulated cables installed in PNGS Unit 4, PNGS Unit 5, and BNGS Unit 5 are listed in Tables 3 to 5, respectively. The elongation values were greater than 210% for the FREPR insulations and above 300% for FRXLPE insulations. These elongation values are in the range of values measured for stock cables and thus suggest that these cables are only minimally exposed to either, thermal, radiation or combined radiation plus thermal aging.

4.0 Conclusions

- The condition of installed PVC, XLPE, and EPR insulated wires can be assessed by non destructive in-situ techniques namely: visual inspection, Indenter modulus measurements, and NIR spectroscopy.
- Visual inspection can identify cables that have operated in thermal hot spots and Indenter modulus measurements can quantitatively determine the extent of thermal aging.
- Unique NIR predictive models are available for the most common XLPE, EPR, and PVC insulation qualification groups used inside and outside containment. With data provided by NIR scanned in-situ cables, these models allow for the determination of elongation at break (the most reliable property which determines the acceptable condition of the cables) using quantified spectral absorptions.
- The results predicted by different NIR models in conjunction with visual inspection data will act as a crosscheck on each other and improve the confidence of the predicted data.

5.0 References

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Table 3 Predicted elongation values of installed cables in PNGS A, Unit 4, Boiler room reactivity deck

Cable #	SCI	NIR Struct.	Term No	Room	Elev	LOAD	Qual. Group	Pred. Elong.	M_Dist.	Scan Date
4-64832	63173	4-63170-J	6	R4-402	317’	4-63170-JB302	EPR 3,4,5	266	0.84	12/19/99
4-64840	63173	4-63170-J	6	R4-402	317’	4-63170-JB306	EPR 3,4,5	297	0.62	12/19/99
4-64842	63173	4-63170-J	38	R4-402	317	4-63170-JB306	XLPE 1,2,3	374	0.99	12/19/99
4-64843	63173	4-63170-J	88	R4-402	317	4-63170-JB306	XLPE 1,2,3	383	1	12/19/99

Table 4 Predicted elongation values of installed cables in PNGS B, Unit 5, Vault

Cable #	J/B#	Room	Elev.	Term#	Remarks	Qual. Group	Pred. Elong.	M_Dist.	Scan Date
53904	JB5108	R405	321	158	CDF127V	XLPE 1,2,3	312	0.72	5/2/99
2490	JB267	R403	317	18	PL337 in UECC	XLPE 1,2,3	327	0.65	5/5/99
2488	JB204	R101	254	33	PL337 in UECC	XLPE 1,2,3	332	0.54	5/6/99
896	JB617	R101	254	11	PL337 in UECC	XLPE 1,2,3	392	1.16	5/5/99

Table 5 Predicted elongation values of installed cables in BNGS B, Unit 5, Vault

SCI/Cbl#	Room	Elev.	JB/PL	Term #	Qual. Group	Pred. Elong.	M_Dist.	Scan Date
6322-05021	R5-107	591	JB1707	6	EPR 3,4,5	215	1.05	11/6/01
6333-05138	R5-206	615	JB554	2	EPR 3,4,5	245	0.62	10/26/01
3472-05033	R5-206	619	JB553	34	EPR 3,4,5	253	1.63	11/1/01
6322-05023	R5-107	591	JB1707	20	EPR 3,4,5	213	1.04	11/6/01
3332-05046	R5-206	629	JB550	10	EPR 3,4,5	242	0.74	11/1/01
6372-06038	R5-206	639	JB1540	8	EPR 3,4,5	269	1.06	10/26/01