TECHNICAL NEWS

from

THE OKONITE COMPANY

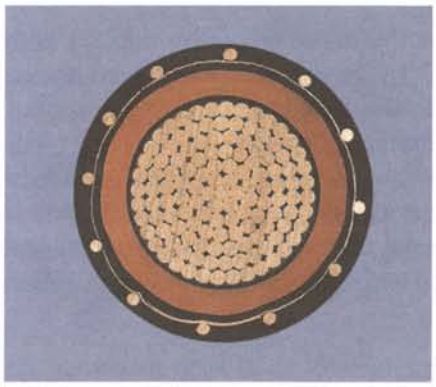
Engineering Information for the Utility Industry

March 30, 1999 **Edition: 002**

OKOGUARD EPR TAKES THE HEAT

A cable problem was reported to Okonite's Los Angeles office in August of 1998 by the City of Anaheim Public Utilities electrical engineering department. The call to Okonite was made when the Anaheim engineers found a substation feeder consisting of six ducts had smoke emitting from one end of the circuit.

The circuit was a 2H x 3V concrete encased 4 inch PVC duct bank with each duct consisting of 1-1/C 2000 kcmil copper conductor, 220 mils Okoguard all EPR insulation system, 5 mil copper tape shield with 12 x # 10 AWG copper concentric wires, 110 mil LLDPE Okolene jacket overall, **(see photo left)** rated 15KV 133%, two cables per phase, and closed shield operation. The cable was manufactured and installed in 1995.



Anaheim reported the circuit was designed to have a peak load rating of 1300 amps(650 amps/cable) with a load factor of 75%. At the time the problem was discovered the cables were carrying a peak summer load of approximately 900 amps at a 75% load factor. One cable was removed from its duct and found to have severe heat damage to the jacket. The jacket was melted to the point that the metallic shielding system was exposed for a large portion of the circuit length. The smoke was actually steam coming from boiling ground water in the conduit.

The City of Anaheim electrical engineering department requested assistance from Okonite in determining the problem. Okonite's applications engineering department suggested a complete ampacity analysis of the system. The results of the study revealed an overload of the circuit, heating the cable and duct to extremely high temperatures due to the closed shield operation. The closed or short circuited shield operation caused a significant level of current to be induced into the grounded copper shield which was further aggravated by the physical separation (inductive reactance) of the six cables - a worst case scenario. These results are tabulated in following tables.

Table 1 - Calculated Rated Ampacity at 90°C with Closed Shield Operation

Ampacity - 547 Amps at 75% Load Factor				
Phase Temp.	Conductor Temp.	Shield Temp.	Cable Surface Temp.	Duct Temp.
A	90°C	79.8°C	72.8°C	64.1°C
B	90	75.4	71.1	65.5
C	90	88.2	79.9	68.5

Table 2 - Calculated Rated Ampacity at 90°C with Open Shield Operation

Ampacity - 1026 Amps at 75% Load Factor				
Phase Temp.	Conductor Temp.	Shield Temp.	Cable Surface Temp.	Duct Temp.
A	90°C	80.1°C	73.4°C	64.8°C
B	90	83.6	77.0	68.5
C	90	81.7	75.1	62.9

Table 3 - Rated Circuit Ampacity of 650 Amps with Closed Shield Operation - 75% LF

Phase Temp.	Conductor Temp.	Shield Temp.	Cable Surface Temp.	Duct Temp.
A	103.8°C	101.2°C	92.6°C	81.1°C
B	97.9	95.3	90.0	82.9
C	113.9	111.2	101.1	87.3

When compared to the calculated ampacity with closed shield operation shown in Table 1, the Anaheim rated load of 650 amps and actual load of 900 amps shown in Tables 3 and 4, far exceeded the temperature rating of the cable insulation system of 105° C. In the case of the actual load of 900 amps, the rating of the insulation system, LLDPE jacket and PVC duct were all exceeded. Temperatures reached by the insulation system were approximately 161 to 184° C.

The shielding system was unaffected by high heat conditions, except for some minor discoloration from water or moisture in the conduit. A cross section of the cable shows no insulation deformation after being heated to high temperature extremes.

Table 4 - Peak Load 900 Amps with Closed Shield Operation - 75% LF

Phase Temp.	Conductor Temp.	Shield Temp.	Cable Surface Temp.	Duct Temp.
A	169.7°C	163.9°C	151.8°C	134.1°C
B	161.3	155.5	148.0	137.2
C	184.7	178.8	164.9	144.4

As a result of this study, the City of Anaheim changed their circuit configuration to an open shield operation.

In addition to this ampacity study, Okonite recommended Anaheim send a 50 foot sample of the cable to our EHV Cable Laboratory for electrical and physical testing of the Okoguard insulation system. The results of the tests showed that the excessive heating of the cable had no effect on the physical and electrical properties of the insulation system. The test results are tabulated in Table 5.

Table 5 - Electrical and Physical Test Results

AC Breakdown - 206.8 kV - 944 v/m average stress - 1061 v/m max stress.

DC Volume Resistivity of Screens (ohm/meters) -	RT	90°C	110°C	130°C	AEIC Max.
Strand Screen	0.69	1.87	—	1.72	1000
Insulation Screen	1.93	6.13	6.35	—	500

Physical Properties -	Tensile (psi)	200% Modulus (psi)	% Elongation
Okoguard	1234	1040	340
Insulation Screen	1809	1562	270

DC hi-potential tests were performed on all six cable of the circuit at 51KV for 15 minutes. This is longer than the time of 5 minutes recommended by AEIC. The HVDC tests were excellent and had readings you would expect with new cable.

The City of Anaheim also asked Okonite's opinion of the remaining service life of the cable. Although no one can predict the service life of a cable after it has been thermally stressed as these cables have, Okonite does feel and is confident that the insulation system has substantial service life remaining. Despite the loss of the jacket, the cable will remain serviceable as long as no detrimental chemical environmental intrusion is introduced. Water will have little or no effect on the cable.

In summary Okonite's Okoguard all EPR insulation system has proven **again** it can take the 'heat'. Since introducing this system using triple tandem extrusion for all medium voltage levels through 69KV in the late 1960's, we have proven over and over again the amazing thermal stability of Okoguard.

THE OKONITE COMPANY
Ramsey, New Jersey 07446
www.okonite.com

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