**Raychem**
**Energy Division**

# Report

| Title | Pages: |
|---|---|
| QUALIFICATION OF ADHESIVE COATED WCSF-N HEAT SHRINKABLE TUBING TO ANSI C119.1-1974 | 9 |
| | Enclosures: |

| Report Number: | Date: | |
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**Raychem Corporation**
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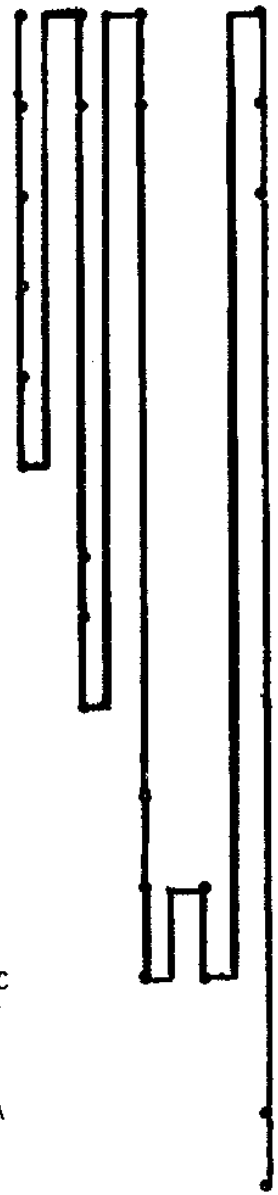
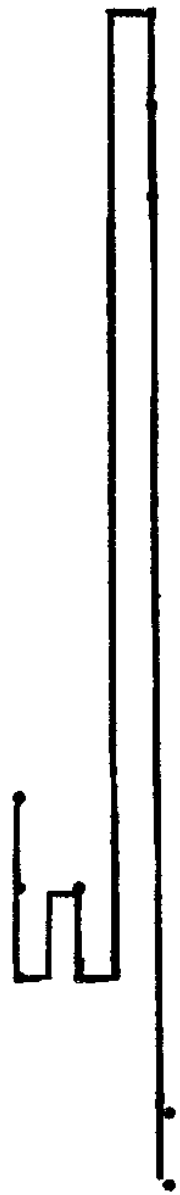
TABLE I
SUMMARY OF TEST RESULTS

| TESTS | TEST REQUIREMENTS | GROUP I TEST SEQUENCE | GROUP I TYPICAL VALUES | GROUP II TEST SEQUENCE | GROUP II TYPICAL VALUES |
|---|---|---|---|---|---|
| 1. Water Immersion | Samples under 12-inch head of water at 23°C ± 3°C for 24 hours |  | Passed |  | Passed |
| 2. Insulation Resistance | Greater than $2.5 \times 10^6$ ohms measured at 500V d.c. | | $>10^{10}$ ohms | | $>10^{10}$ ohms |
| 3. Dielectric Withstand | 2.2kV a.c. 60 hertz for 1 minute | | Passed | | |
| 4. Heat Conditioning | 72 hours at 90°C ± 5°C or 192 hours at 80°C ± 5°C | | Passed | | |
| 5. Flexing Test | Ten flex cycles through an arc of 180° | | Passed | | |
| 6. Twist Test | Five longitudinal axis twists through an arc of 30° | | Passed | | |
| 7. Cold Temperature Test | Four hours at -23°C | | Passed | | |
| 8. Cold Flexing Test | Similar to (5) with samples at -23°C | | Passed | | |
| 9. Cold Twist Test | Similar to (6) with samples at -23°C | | Passed | | |
| 10. Water Immersion (loop) | Samples under 12-inch head of water at 23°C ± 3°C for 24 hours | | Passed | | Passed |
| 11. Insulation Resistance (loop) | Greater than $2.5 \times 10^6$ ohms measured at 500V d.c. | | $>10^9$ ohms | | $>10^9$ ohms |
| 12. Current Cycle/Water Immersion | Conductor current cycled to 90°C within 1-hour followed by water immersion of samples for 30 minutes, 50 cycles | | Passed | | Passed |
| 13. Leakage Current | Leakage current less than 2.5mA at 600V a.c. 60 hertz. | | 70 μ amps | | 70 μ amps |
| 14. Voltage Breakdown (optional) | Increase voltage at 500V a.c./ sec. until failure | | >26kV | | >26kV |



EDR 5008
3/18/80

## OBJECTIVE

To demonstrate the performance of Raychem's low voltage in-line field splice system (type WCSF-N). Testing was conducted in accordance with American National Standard Institute, ANSI C119.1, 1974 "Sealed Insulated Underground Connector System Rated 600 Volts".

## SUMMARY

A total of 75 in-line splices were evaluated. The first set of test samples were tested on the extremes of the conductor size the splice was capable of accommodating (Items 1, 2, 8 to 11, Table II) to verify performance at the design limits. Cable conductor sizes #8 AWG through 1000 MCM were used.

The second set of test samples (Items 3 to 7, Table II) were chosen to evaluate the sealing performance of the splices to the different cable type substrates.

All test samples passed the specific and design criterion. The results are summarized in Table I.

## CONCLUSION

The test program results indicate that the splices exceeded the ANSI electrical requirements after the sequential testing. The product is qualified as an environmentally sealed insulation system for low voltage power applications.

SAMPLE PREPARATION

Samples consisted of crimped splices insulated with WCSF flame-retarded tubing coated with type S-1119 adhesive. Cable lengths two feet long were spliced together in accordance with standard installation instructions. The test sample matrix used in the evaluation is given in Table II

TABLE II
GROUP I SAMPLE MATRIX

| | | | Cable Type | | |
|---|---|---|---|---|---|
| Item | No. of Samples | Product | Cond. Size | Insulation Type | Voltage |
| 1 | 3 | WCSF-200-6-N | #8 AWG | XLPE Type XHHW | 600V |
| 2 | 3 | WCSF-200-6-N | #4 AWG | XLPE Type XHHW | 600V |
| 3 | 3 | WCSF-300-6-N | #2 AWG | XLPE Type XHHW | 600V |
| 4 | 3 | WCSF-300-6-N | #2 AWG | EP Type RHH or RHW | 600V |
| 5 | 3 | WCSF-300-6-N | #2 AWG | PVC Type THW Oil Resistant | 600V |
| 6 | 3 | WCSF-300-6-N | #2 AWG | HM Black Polyethy-lene | 600V |
| 7 | 3 | WCSF-300-6-N | #2 AWG | Neoprene Jacketed Cable | 600V |
| 8 | 3 | WCSF-500-6-N | 4/0 AWG | XLPE Type XHHW | 600V |
| 9 | 3 | WCSF-500-6-N | 250 MCM | EP type RHW | 600V |
| 10 | 3 | WCSF-1000-12-N | 750 MCM | XLPE Type XHHW | 600V |
| 11 | 3 | WCSF-1000-12-N | 1000MCM | XLPE Type XHHW | 600V |

TESTING

The qualification test program consisting of a sixteen step sequence as detailed in Section 3.3, "Seal Test Procedures" of ANSI C119.1, 1974 was implemented as follows:

TESTING (Cont'd)

Step 1 All spliced samples were immersed under a 12-inch head of tap water at 23°C ± 3°C for 24 hours.

Step 2 Insulation resistance measurements were taken on the immersed samples between conductor and the grounded water bath using a megohmeter set at 500V d.c.

Result: Nominal value of 33 samples: $3.0 \times 10^{11}$ ohms
Minimum value of 33 samples: $6.0 \times 10^{10}$ ohms

Step 3 Dielectric withstand tests were performed at 2.2kV a.c. 60 hertz applied between conductor and the grounded water bath.

Result: All samples passed.

Step 4 Samples were heat conditioned in an air circulating oven for 72 hours at 90°C ± 5°C.

Step 5 After cooling down to room temperature, the samples were subjected to flex cycles through an arc of 180°.

Result: The 750 MCM and 1000 MCM cable size samples were not tested. It was difficult to manually flex the cable. All other samples underwent this test with no visible damage observed.

TESTING (Cont'd)

Step 6 All samples were twisted around the longitudinal axis of the splice through an arc of 30°.

Step 7 Samples were then water immersed as described in Step 1.

Step 8 Insulation resistance measurements were taken as described in Step 2.

Results: Nominal value of 33 samples: $1.0 \times 10^{11}$ ohms Minimum value of 33 samples: $1.0 \times 10^{10}$ ohms

Step 9 The samples were placed in a circulating air refrigeration chamber and cooled to -23°C for a period of 4 hours.

Step 10 While at -23°C, the samples were flexed as described in Step 5.

Result: The 750 and 1000 MCM size cable splices were not tested due to difficulty of flexing these sized cables.

A PVC insulated cable and a HM black polyethylene insulated cable cracked during flexing. The cables were repaired by shrinking coated WCSF tubing over the cracked area. All other samples passed the test with no visible damage observed.

TESTING (Cont'd)

Step 11 While at -23°C, the samples were twisted around the longitudinal axis of the splice through an arc of 30°.

Step 12 Samples were water immersed as described in Step 1.

Step 13 Insulation resistance measurements were taken as described in Step 2.

Result: Nominal value of 33 samples: $7.0 \times 10^{10}$ ohms.
Minimun value of 33 samples: $1.0 \times 10^{10}$ ohms.

Step 14 A maximum of six conditioned splices of same conductor size were connected to form a loop. This splicing generated a second group of splices, Table III, which were subjected to the current cycling test sequence only.

Each loop was subjected to 50 cycles consisting of one hour heating in air by current induction through the conductor followed by immersion under two feet of 23°C $\pm$ 3°C water for one-half hour. Insulation resistance of the loop was taken on completion of the 25th and 50th cycle.

The minimum value of insulation resistance of the loop was $3.0 \times 10^{9}$ ohms.

The XLPE and EPR insulation type cables were tested to 90°C $\pm$ 5°C Conductor temperature. The PVC, HMPE and neoprene insulation type cables were tested to 75°C $\pm$ 5°C as rated by the cable manufacturers.

TESTING (Cont'd)

At the conclusion of the current cycling tests, the splices were separated and insulation resistance measured. The 75 samples had insulation measurements of greater than $6.0 \times 10^9$ ohms which far exceeded the test requirement of $2.5 \times 10^6$ ohms.

Step 15 Dielectric withstand tests were performed as described in Step 3.

Result: All samples passed.

Step 16 Leakage current readings were obtained for each sample at 600V a.c. 50 hertz between the conductor and the grounded water bath.

Result: Nominal values of 75 samples: 70 microamps
Lowest value: 30 microamps (#8 AWG)
Highest value: 250 microamps (1000 MCM)

To provide additional dielectric strength data beyond the scope of the specification, all samples were subjected to an a.c. voltage breakdown. Breakdown values greater than 26kv were observed.

TABLE III
GROUP II - SAMPLE MATRIX (STEP 14)

| Test Loop | Number of Splices | | Product | Cable Type | |
|---|---|---|---|---|---|
| | Conditioned | Non-Conditioned* | | Conductor Size | Insulation |
| 1 | 3 | 4 | WCSF-200-6-N | #8 AWG | 600V XLPE |
| 2 | 3 | 4 | WCSF-200-6-N | #4 AWG | 600V XLPE |
| 3 | 6 | 7 | WCSF-300-6-N | #2 AWG | 600V XLPE and EPR |
| 4 | 6 | 7 | WCSF-300-6-N | #2 AWG | 600V HMPE and PVC |
| 5 | 3 | 4 | WCSF-300-6-N | #2 AWG | 600V Neoprene |
| 6 | 3 | 4 | WCSF-500-6-N | #4/0 AWG | 600V XLPE |
| 7 | 3 | 4 | WCSF-500-6-N | 250 MCM | 600V EPR |
| 8 | 3 | 4 | WCSF-1000-12-N | 750 MCM | 600V XLPE |
| 9 | 3 | 4 | WCSF-1000-12-N | 1000 MCM | 600V XLPE |

*Non-Conditioned splices are those used to connect the individually conditioned samples into a test loop.

# DATA ACQUISITION INSTRUMENTS

1. Instrument No. 6571
   Inst. and Mfr.: GR 1864 Megohmeter Type No. 1864
   Range/Features: 100k - 50T ohms
   Date Calibrated: 8-1-78

2. Instrument No. 227
   Inst. and Mfr.: AR Hypot
   Type No. 4030
   Range/Features: 0-4 Kilovolts, 0-5 milliamps
   Date Calibrated: 8-1-78

3. Instrument No. 16813-1
Inst. and Mfr : Sub-Zero Test Apparatus, Amer. Instrument Co.
   Type No.: -
   Range/Features: -150°C to +100°C
   Date Calibrated: 6-20-78

4. Instrument No. 05075-014
   Inst. and Mfr.: Amprobe Meter
   Type: RS-1000
   Range/Features: 0-1k amps
   Date Calibrated: 1-19-78

5. Instrument No. 3112
   Inst. and Mfr.: Digimite
   Type No. 31160
   Range/Features: 0-740°C
   Date Calibrated: 8-1-78

6. Instrument No. 23074
   Inst. and Mfr.: Hypotronics AC Corona Test Set
   Type No. 7100-20CT
   Range/Features: 0-100kV
   Date Calibrated: 6-6-78

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