



# **Hemyc & MT Electrical Raceway Fire Barrier Systems (ERFBS) Confirmatory Fire Performance Testing**

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# Purpose of Fire Testing

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- Confirmatory Fire Performance Testing
  - No NPP Site Specific Configurations
- Follow on to Generic Letter 92-08
- Scope of Testing Limited to Fire Performance
  - No Ampacity Derating
  - No Seismic Position Retention
- Follow on Material Property Testing
  - Siltemp shrinkage
  - Siltemp/Refrasil Equivalence

# Use of Hemyc & MT

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- Hemyc is a One-Hour Electrical Raceway Fire Barrier Systems (ERFBS) used to protect Post-Fire Safe-Shutdown circuits
  - Hemyc may also have been used as Radiant Energy Shield
- MT is a Three-Hour ERFBS used to protect Post-Fire Safe-Shutdown circuits
  - MT may also have been used as a One-Hour ERFBS

# Background

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- ERFBS Installed in 1980's
- 10CFR50 Appendix R Compliance
- Generic Letter 92-08 "Thermo-Lag" Follow-On
- SECY 99-204 Kaowool
  - V.C. Summer Performance Testing
- TIA 99-028 Hemyc
  - Identified Concerns with Fire Performance Testing

# Fire Performance Test Plan

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- ❑ Develop “Typical” Electrical Raceway Configurations
- ❑ Install the ERFBS in accordance with Manufactures Vendor Manual & Procedures
- ❑ Interfaced with Industry to better understand what was installed in NPPs
  - ❑ No NPP Site Specific Installations
- ❑ Testing Performed in accordance with Generic Letter 86-10 Supplement 1

# Generic Letter 86-10 Supplement 1

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- Provides Standardized Performance Test Method and Acceptance Criteria
- Expanded Methodology
  - Tested Empty & Fully Loaded Conduits
  - Tested Supports Independently
- Acceptance Criteria
  - Average Temperature Rise ( $\Delta T_{ave.}$ )  $\leq 250$  °F
  - Maximum Single Point Temperature Rise ( $\Delta T_{max.}$ )  $\leq 325$  °F
  - Hose Stream Test

# Hemyc Test #1 - March 11, 2005

## Omega Point Laboratories

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- 1", 2-1/2", and 4" Rigid Steel Conduits
  - Empty and Fully Loaded
  - Alternate 6" collars and 2" overlap joints
- 18x24x8 Junction Box
  - Direct Application - Stitched Only Hemyc Installation
- Structural Supports
  - Unistrut
  - 2" Tube Steel

# Hemyc Test 1 - Results

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- 1", 2-1/2", and 4" Rigid Steel Conduits
  - Exceeded  $\Delta T_{\max}$ . ~ 33 to 43 minutes
  - Both joint designs opened during test
- 18x24x8 Junction Box
  - Exceeded  $\Delta T_{\max}$ . ~ 15 minutes
  - ERFBS Fell off during test
- Structural Supports
  - Unistrut Exceeded  $\Delta T_{\max}$ . ~ 22 to 32 minutes
  - 2" Tube Steel Exceeded  $\Delta T_{\max}$ . ~ 13 to 25 min.



# Hemyc Test 1 Observations

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- Siltemp Shrinkage
  - Joint Openings
  - Non-Uniform Results
  - Follow-on Material Property Testing performed by Sandia National Laboratories
- Structural Steel Support/Intervening Items Protection
  - Testing Minimum 3" Required Protection was Limiting

# Test 1 - Conduit , Supports & Junction Box HEMYC 1 Hour Fire Performance Test Results

Raceway	Time to $\Delta T_{ave} \geq 250^{\circ}\text{F}$ (min.)	Time to Single Point $\Delta T > 325^{\circ}\text{F}$ (min.)	Max. Temp. Bare #8 @ 1 hour ( $^{\circ}\text{F}$ ) (Note1)	Joint Failure/ Structural Failure Yes/No (Note 2)	Pass Hose Stream Yes/No (Note 3)	Final Grade Rating (Mins) (Note 4)
1" Conduit (Empty)	46	42	1013	Yes	Yes	42
1" Conduit 1.02 lb./lin.ft. Cable Fill	44	34	1177	Yes	Yes	34
2 ½ " Conduit (Empty)	48	41	709	Yes	Yes	41
2 ½ " Conduit 5.85 lb./lin.ft. Cable Fill	51	38	446	Yes	Yes	38
4" Conduit (Empty)	49	33	865	Yes	Yes	33
4" Conduit 14.84 lb./lin.ft. Cable Fill	57	43	199	Yes	Yes	43
Junction Box 18" x 24" x 8" (Note 5)	17	15	NA	Yes	Yes	15
Unistrut Support (Note 6)	NA	22 - 32	NA	NA	Yes	22 - 32
2" Tube Steel Support	NA	13 - 25	NA	NA	Yes	13 - 25

# Conduit , Supports & Junction Box

## HEMYC 1 Hour Fire Performance Test Results

(cont.)

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- Note 1 - Bare #8 temps should be viewed with caution
  - Instrumented Bare # 8 located in center of cable bundle
  - Outer layers experienced joint failures ~ Hotspots
- Note 2 - All Hemyc experienced thermal shrinkage of outer Siltemp
- Note 3 - All assemblies would have failed hose stream testing
  - No Additional Hemyc was dislodged during hose stream test
- Note 4 - All raceways failed on single point criteria ( $\Delta T > 325^{\circ}\text{F}$ )
- Note 5 - Junction Box experienced catastrophic failure when Hemyc mat seams opened & the Hemyc mat fell off the JB
- Note 6 - Structural support failure occurred when time to Single Point temperature rise ( $\Delta T$ ) exceeded  $325^{\circ}\text{F}$  at 3-inches into Hemyc protected structural steel.

# Hemyc Test #2 - March 25, 2005

## Omega Point Laboratories

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- 12", and 36" Ladder Back Cable Trays
  - Tested Empty
  - Alternate 2" Air Gap and Direct Attachment
- 18x24x8 Junction Box
  - Direct Attachment with SS Bands
- Cable Air Drops
  - Direct Attachment
  - 2" Air Gap

# Hemyc Test #2 - Results

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- Ladder Back Cable Trays
  - Exceeded  $\Delta T_{\max.}$  ~ 18 to 35 minutes
  - Both designs opened during test
- 18x24x8 Junction Box
  - Exceeded  $\Delta T_{\text{ave.}}$  ~ 31 minutes
  - ERFBS remained in place during test
- Cable Air Drops
  - Direct Attachment Exceeded  $\Delta T_{\max.}$  ~ 32 min.
  - 2" Air Gap Exceeded  $\Delta T_{\max.}$  ~ 28 min.

# Hemyc Test #2 Observations

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- Siltemp Shrinkage
  - Joint Openings / Tearing of Siltemp
  - Non-Uniform Results

# Test #2 - Cable Tray, Junction Box, & Airdrop Hemyc 1-Hour Fire Performance Test Results

Raceway	Right Side Tray Rail $\Delta T_{ave} \geq$ 250°F (min.)	Right Side Tray Rail Single Point $\Delta T > 325^\circ\text{F}$ (min.)	Left Side Tray Rail $\Delta T_{ave} \geq$ 250°F (min.)	Left Side Tray Rail Single Point $\Delta T > 325^\circ\text{F}$ (min.)	Bare #8 $\Delta T_{ave} \geq$ 250°F  (min.)	Bare #8 Single Point $\Delta T > 325^\circ\text{F}$  (min.)	Burn- Through/ Structural Failure Yes/No (Note 1)	Pass Hose Stream Yes/No (Note 2)	Final Grade  Pass/ Fail (Note 3)
12" Cable Tray Empty, Direct Attachment	36	34	27	18	32	32	Yes	Yes	18
12" Cable Tray Empty, 2" Air Gap	37	35	38	35	33	34	Yes	Yes	35
36" Cable Tray Empty, Direct Attachment	41	39	34	33	35	35	Yes	Yes	33
36" Cable Tray Empty, 2" Air Gap	32	31	33	32	28	27	Yes	Yes	31
Air Drop, Direct Attachment	NA	NA	NA	NA	35	32	Yes	Yes	32
Air Drop, 2" Air Gap	NA	NA	NA	NA	32	28	Yes	Yes	28
18" x24" x 8" Junction Box, Direct Attachment with Bands	31	32	NA	NA	NA	28	Yes	Yes	31

# Test #2- Cable Tray, Junction Box, & Airdrop Hemyc 1 Hour Fire Performance Test Results (cont.)

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- Note 1 - All Hemyc experienced thermal shrinkage of outer Siltemp covering
- Note 2 - All assemblies would have failed hose stream testing since raceway was exposed to joint failure
  - No Additional Hemyc was dislodged during hose stream test
- All raceways except junction box failed on single point criteria ( $\Delta T > 325$  °F)



# MT Test #3 – April 25, 2005

## Omega Point Laboratories

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- 1", 2-1/2", and 4" Rigid Steel Conduits
  - Empty and Fully Loaded
  - Direct Attachment
- 18x24x8 Junction Box
- Cable Air Drop
- Structural Supports
  - Unistrut
  - 2" Tube Steel

# MT Test #3 - Results

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- 1", 2-1/2", and 4" Rigid Steel Conduits
  - Exceeded  $\Delta T_{\max.}$  ~ 87 to 113 minutes
- 18x24x8 Junction Box
  - Exceeded  $\Delta T_{\max.}$  ~ 122 minutes
- Cable Air Drop
  - Exceeded  $\Delta T_{\max.}$  ~ 159 minutes
- Structural Supports
  - Unistrut Exceeded  $\Delta T_{\max.}$  ~ 58 min.
  - 2" Tube Steel Exceeded  $\Delta T_{\max.}$  ~ 56 min.

# MT Test #3 Observations

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- Siltemp Shrinkage
  - Joint Opening in Outer Layer
  - Damage to Second Layer
  - Non-Uniform Results
- Structural Steel Support/Intervening Items Protection
  - Testing Minimum 18" Required Protection was Limiting

# Test #3- Conduit, Cable Air Drop, Supports & Junction Box

## M.T. 3 Hour Fire Performance Test Results

Raceway	Time to $\Delta T_{ave} \geq 250^{\circ}\text{F}$ (min.)	Time to Single Point $\Delta T > 325^{\circ}\text{F}$ (min.)	Max. Temp. Bare #8 @ 3 hour ( $^{\circ}\text{F}$ ) (Note 1)	Joint Failure/ Structural Failure Yes/No (Note 2)	Pass Hose Stream Yes/No	Final Grade Rating (Mins) (Note 3)
4" Conduit (Empty)	121	110	961	YES	YES	110
4" Conduit 14.58 lb./lin.ft. Cable Fill	143	113	374	YES	YES	113
2 ½ " Conduit (Empty)	119	103	119	YES	YES	103
2 ½ " Conduit 5.68 lb./lin.ft. Cable Fill	126	112	577	YES	YES	112
1" Conduit (Empty)	98	87	1314	YES	YES	87
1" Conduit 0.95 lb./lin.ft. Cable Fill	108	96	1084	YES	YES	96
Junction Box 18" x 24" x 8"	122	134	NA	YES	YES	122
Unistrut Support (Note 4)	NA	58	NA	YES	YES	58
Bare Copper Wire Air Drop	169	159	607	YES	YES	159
2" Tube Steel Support	NA	56	NA	YES	YES	56

## Test #3 - Conduit, Cable Air Drop, Supports & Junction Box M.T. 3 Hour Fire Performance Test Results (cont.)

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- Note 1 - Bare #8 Temps should be viewed with caution
  - Instrumented Bare #8 located in center of cable bundle
  - Joint failure occurred in two outer layers
- Note 2 - All M.T. experienced thermal shrinkage of Siltemp covering and hydrate packet layer
- Note 3 - All raceways except junction box failed on single point  $\Delta T > 325^{\circ}\text{F}$
- Note 4 - Structural support failure occurred when single point  $\Delta T > 325^{\circ}\text{F}$  at 18-inches into protected structural steel

# Sandia National Laboratories Material Testing

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## ■ Material Properties

- Compared Tested Material (Refrasil) to New Old Stock Material (Siltemp)
- “Siltemp” equivalent to “Refrasil”
- Both manufactured in a “Standard” and “Pre-Shrunk” Version
  - Tan color = Standard
  - White color = Pre-Shrunk

## ■ Shrinkage

- Radiant Heating Testing
- Shrinkage starts ~ 842 °F
- Shrinkage on order of 5 – 10%

## Conclusion / Photos

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- RES has completed all Confirmatory Fire Performance Testing
  - Hemyc Final Test Reports Available
  - MT Final Test Report Available in May 2005
- All Configurations Tested Failed to meet Acceptance Criteria