DESIGN CHALLENGES:
PROTECTING CRITICAL CIRCUITS FROM FIRE

Pentair Thermal Management

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AGENDA

- LATEST INFORMATION ON UL/ULC DECERTIFICATION OF FIRE RATED CABLES
- CODE REQUIREMENTS FOR FIRE PROTECTION OF CRITICAL CIRCUITS
- FIRE PROTECTION METHODS
- MI CABLE FOR FIRE PROTECTION OF CRITICAL CIRCUITS
Tyco Thermal Controls is now known as Pentair Thermal Management. Pentair is a global company delivering exceptional depth and expertise in filtration and processing, flow management, equipment protection, and thermal management.

Pole to Pole, the Thermal Controls legacy lives on, only better. We are the world leader in Thermal Management Solutions continuing to bring you the inventive technology, brands and expert turnkey solutions you have come to trust.

Pentair Thermal Management offers heat tracing, floor heating, snow melting & de-icing, temperature measurement, fire and performance wiring, and leak detection solutions under brand names such as Raychem, Tracer, DigiTrace, Pyrotenax, and TraceTek.

But now, with Pentair, we can deploy new solutions for our changing world to contribute to healthier, safer environments to solve a full range of residential, commercial, municipal and industrial needs.
UL and ULC announce important changes to certification programs (Release 12PN-51)

Northbrook, IL - September 12, 2012 - UL has recently conducted research on a wide array of current products and systems originally certified under UL 2196, Tests for Fire Resistant Cables and ULC-S139, Standard Method of Fire Test for Evaluation of Integrity of Electrical Cables and determined that they no longer consistently achieve a two-hour fire-resistant rating when subjected to the standard Fire Endurance Test of UL2196 or ULC-S139. Consequently, UL and ULC will not be able to offer certification to the currently existing program related to these standards.

As a result, manufacturers are no longer authorized to place the UL mark or ULC mark on the following products:
UL TIMELINE

- NOV 2011 – RMC ISSUE UNCOVERED
- JUNE 2012 – ZINC FREE DICTATE GIVEN FROM UL
- SEPTEMBER 12, 2012 – FHIT/FHJRC DECLASSIFIED FOR ALL FIRE RATED CABLES
- SEPTEMBER 17, 2012 – INTERIM TEST PROGRAM ANNOUNCED
- SEPTEMBER 19, 2012 – PENTAIR PROPOSES MI CABLE SAMPLING PLAN TO UL
- NOVEMBER 15, 2012 – MI CABLE SUCCESSFULLY PASSES INTERIM TEST AT UL
- DECEMBER 21, 2012 – MI REINSTATED BY ULC

MORE DETAILS SHORTLY...DISCUSSION OF CODE REQUIREMENTS FIRST
CODE REQUIREMENTS FOR PROTECTION OF ELECTRICAL CONDUCTORS.

HIGHRISE BLDGS. – Part 3
# Pertinent N.B.C. Code References

<table>
<thead>
<tr>
<th>Type of electrical circuit</th>
<th>NFPA requirements</th>
<th>2010 National Building Code (Canada)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency Power Supply Generator to transfer switch, transfer switch to emergency distribution switch board</td>
<td>“...be a listed electrical circuit protective system with a minimum 1-hour fire rating” NEC Article 700</td>
<td>“...all buildings within 3.2.6” Ref. 3.2.7.8(3)(b)(i) Ref. 3.2.7.8(3)(b)(ii) 3.3.2.7.10(1 to 9)</td>
</tr>
<tr>
<td>Firefighters’ elevator</td>
<td>“...be a listed electrical circuit protective system with a minimum 1-hour fire rating” NEC Article 700</td>
<td>“...all buildings within 3.2.6. over 36 m in height” Ref. 3.2.6.5(6)(a) &amp; (b) 3.2.7.9(1)(a) 3.3.2.7.10(1) “...buildings designed for barrier free access – nonsprinklered” Ref. 3.3.1.7(1)(a) 3.2.6.5(6)(a) &amp; (b) (1-hour fire rating)</td>
</tr>
<tr>
<td>Fire pumps</td>
<td>“...be a listed electrical circuit protective system with a minimum 2 -hour fire rating” NEC Article 695, NFPA 20</td>
<td>“...all buildings within 3.2.6.” Ref. 3.2.5.7. 3.3.2.7.10(1) Chapters 6 &amp; 7 of NFPA 20</td>
</tr>
<tr>
<td>Pressurized fans and smoke dampers</td>
<td>“...be a listed electrical circuit protective system with a minimum 1-hour fire rating” NEC Article 700 NFPA 101, Life Safety Code</td>
<td>“...all buildings within 3.2.6.” Ref. 3.2.6.2(2) &amp; (3) 3.2.7.9(1)(c) 3.3.2.7.10(1)</td>
</tr>
<tr>
<td>Smoke venting fans</td>
<td>“...be a listed electrical circuit protective system with a minimum 1-hour fire rating”</td>
<td>“...all buildings within 3.2.6.”</td>
</tr>
</tbody>
</table>

Please see H57442 data sheet for more information.
LIFE SAFETY ELECTRICAL CIRCUITS

Smoke Extraction Fans

Emergency Generator

Firefighters’ Elevator

Fire Pump

Pressurization Fans

Fire Alarm System

Main Trunk

Fire Pump

Pressurization Fans

Fire Alarm System

Main Trunk

Smoke Extraction Fans

Emergency Generator

Firefighters’ Elevator

Fire Pump
TYPICAL FIRE ALARM SYSTEM

Fig. 1.6 Typical fire alarm system
TYPICAL LOCATIONS

- HIGH-RISE BUILDINGS
- HOSPITALS AND OTHER INSTITUTIONS
- HISTORIC BUILDINGS (RETROFIT TYPE APPLICATIONS)
- TUNNELS AND SUBWAYS (NFPA 130 AND 502)
- AIRPORTS, STADIUMS, CONVENTION CENTERS, HOTELS, BANKS, ETC.
FIRE PROTECTION
METHODS ALLOWED BY
CODE
FIRE PROTECTION METHODS ALLOWED BY CODE

CONSTRUCTION METHOD

- Conduits encased in a minimum of 50mm (2in) of concrete (1 hr.)

- Conventional wiring protected by a fire rated gypsum assembly.

LISTED ‘ELECTRICAL CIRCUIT PROTECTIVE SYSTEMS’

- 2-hour fire rated cables
UNDERSTANDING THE CONCRETE NFPA CURVES
HISTORY OF FIRE RESISTANCE TESTS

• Tests on metal and masonry conducted in Germany as early as 1884–1886. The first large-scale fire tests in the US are reported to have been conducted on masonry arches in Denver, Colorado, in 1890. These were followed by tests in New York City in 1896.

• A test method for floor constructions was proposed in 1906 and adopted by ASTM in 1907. A procedure for testing wall and partition constructions was proposed in 1908 and adopted in 1909. These standards were presented to the NFPA Committee on Fire-Resistive Construction for consideration in 1914.


• ASTM E119 is the successor standard, with the same title.

Does not address protecting electrical conductors
HISTORY OF FIRE RESISTANCE TESTS

• UL 2196 and S139 (in Canada) are the *Test for Fire Resistive Cables* in the US and Canada respectively. They are the same test as used for all construction materials, modified only to detect electrical failure of the cables being tested.
FIRE RESISTANCE CRITERIA

Acceptance criteria for the assembly or structural element tested include the following:

Failure to support load; Temperature increase on the unexposed surface 250°F (121°C) above ambient; Passage of heat or flame sufficient to ignite cotton waste; Excess temperature (as specified) on steel members; Failure under hose streams (walls and partitions)

Acceptance criteria for Fire resistive cables are circuit integrity throughout the fire test and after the hose stream test.

Does not address protecting electrical conductors
UNDERSTANDING THE CHARTS

NFPA Fire Protection Handbook, 2008 is an anthology of fire protection, focused on building construction. Section 19, Chapter 2 is on structural fire protection, and deals with structural integrity during a fire.

Figure 19.2.2 shows the temperature gradient in a 6 in. (152 mm) slab after a 2 hour fire exposure: 619°F at 2” into the concrete, 326°C – way too high for an electrical cable.
FIRE PROTECTION METHODS ALLOWED BY CODE

CONSTRUCTION METHODS

• Be encased in a minimum of 50mm (2in) of concrete

• Be protected by a fire rated assembly listed to achieve a minimum fire rating of 1 or 2 hours (depending on the application)

LISTED ‘ELECTRICAL CIRCUIT PROTECTIVE SYSTEMS’

• With a 2-hour fire rating

Concrete encasement does NOT protect an electrical circuit from failure
CONCRETE ENCASEMENT

Conduits in concrete encasement

Other limitations:

- Inability to visually inspect
- Accessibility versus fire protection (pull boxes and junction boxes)
- Spalling

Conduit boxes and cable supports compromise the system
Concrete spalling in the Chunnel after a fire. MI Cable survive the fire and continued to operate during the clean up.
FIRE PROTECTION METHODS ALLOWED BY CODE

CONSTRUCTION METHODS

• Be encased in a minimum of 50mm (2in) of concrete

• Be protected by a fire rated assembly listed to achieve a minimum fire rating of 1 or 2 hours (depending on the application)

LISTED ‘ELECTRICAL CIRCUIT PROTECTIVE SYSTEMS’

• with a 2-hour fire rating
**FIRE RATED ASSEMBLY (GYP BOARD ENCLOSURE)**

**KEY POINTS FOR CONSIDERATION OF A GYPSUM BOARD ENCLOSURE**

- Must be a dedicated assembly for life safety circuits
- NOT listed for electrical cable protection
- Difficult to build
- Extremely craft sensitive, workmanship dependent
- Subject to deterioration
- Adds more coordination difficulty at site
- Consumes valuable space
- NOT as cost effective as they are perceived to be

These conditions are rarely met for the life of the building
FIRE RATED ASSEMBLY (GYP BOARD ENCLOSURE)

No longer dedicated for life safety circuits
FIRE RATED ASSEMBLY (GYP BOARD ENCLOSURE)

Workmanship dependent
FIRE RATED ASSEMBLY (GYP BOARD ENCLOSURE)

PERFORMANCE TESTING

- **Unprotected circuits?**
  - Non-Fire Rated wire failed in less than three minutes!
  - Temperatures at failure: 450°F

*Warnock Hersey study*

This test was conducted in 1980
CONSTRUCTION METHODS

Concrete encasement and gypsum enclosures

Neither concrete or gypsum enclosures are tested or listed for the protection of electrical conductors!

Both are fire tested only for flame passage prevention and to verify that on the unexposed side the temperature does not exceed...

250 F average / 325 F max. above ambient
FIRE PROTECTION METHODS ALLOWED BY CODE

CONSTRUCTION METHODS

- Be encased in a minimum of 50mm (2in) of concrete

- Be protected by a fire rated assembly listed to achieve a minimum fire rating of 1 or 2 hours (depending on the application)

LISTED ‘ELECTRICAL CIRCUIT PROTECTIVE SYSTEMS’

- 2-hour fire rated cables
UNDERSTANDING THE UL 2196 and ULC S139 STANDARD
The UL/ULC test standard uses the same ASTM E119 Temperature Curve that is used to test building construction materials and is intended to represent a fully developed interior building fire. The added part of the UL/ULC test is to detect electrical failure of the cable.

The test follows the ASTM E119 Temperature Curve:

- 1000°F at 5 min.
- 1400°F at 15 min.
- 1550°F at 30 min.
- 1700°F at 60 min.
- 1850°F at 120 min.

ASTM E119 is not a UL Standard
UL 2196/ULC S139 TEST STANDARD DEVELOPMENT

The first edition of the UL 2196 / ULC S139 Fire Test standard was published in May 2001.

Several parts of this initial test standard did not address how polymeric cable types were affected under actual fire conditions.

The main factor was volatile gases that polymer insulation creates and reduces the strength of standard copper, causing a break in the copper under its own weight

A major change was incorporated in 2008 to include a tensile test for conductors in a vertical run.
The length of conduit in the test was intended to emulate normal installation conditions – long lengths of conduit.

In developing the test, the minimum length of conduit was arbitrarily picked at 12 in.

If the test is performed in this manner, the gases dissipate and the cables are largely unaffected.

The polymer insulated vertical strength test was flawed
FURTHER ISSUES OF POLYMER INSULATED CABLES

- Recent third party testing at UL demonstrating that polymer insulated cables products fail in conduits coated internally with zinc.

- Use of unapproved pulling lubricants which adversely affect cable performance under fire conditions.

- Many of the FHIT listing requirements are ‘hidden’ and ignored - conduit fittings, sensitivity to other material which can compromise system integrity e.g. ground wires, inadequate conduit support spacing.

- Flammable smoke – contractors have not consistently adhered to our installation instructions re intermediate box.

UL Announcement was based on inconsistent results of polymeric cables.
FIRE RATED ELECTRICAL CABLE SYSTEMS

All systems can be found on the Web:

- UL On-Line Certifications / Category ‘FHIT’
- ULC On-Line Directories / Category ‘FHVRC’

The system listing identifies:

- Installation requirements
- Manufacturers latest updates / changes
- Conductor sizes and configurations tested
- Splices if tested, and types of splices
- Support materials (steel, masonry or concrete) and method
- Horizontal distance between supports
- Vertical distance between supports

All of the UL/ULC Listing requirements must be fulfilled
MI Cable is tested to the UL 2196 / ULC S139 fire test:

- Fire exposure followed by water hose stream
- 1850 F and direct firefighters’ hose stream exposure

Cables are energized during fire test and after hose stream test to prove circuit integrity is maintained throughout.
PYROTECHNAX MINERAL INSULATED (MI) CABLE

- MI cable is unaffected by these issues.
- MI cable does not require conduit protection, and is not subject to volatile gases under fire conditions.
- MI cable is supported by the building structure and is tested energized.
- There are no lubricants necessary with MI cable
- Pyrotenax MI Cable successfully passed UL Interim testing program on Nov 15
- Pyrotenax MI Cable fully reinstated by UL on Dec. 21, 2012

**MI Cable has never failed a fire test at UL**
PYROTIENAX MINERAL INSULATED (MI) CABLE

- Invented in 1896, first produced commercially as “Pyrotenax” in 1936.
- Being made entirely from copper and magnesium oxide, the cable is inherently heat resistant, and can operate continuously at 250°C.
- It was a ‘natural’ for fire resistant applications, and was the first fire-rated cable listed by UL.
PYROTENAX MI CABLE CHARACTERISTICS

- Completely inorganic construction!
  - **zero smoke**
  - **zero flame spread**
  - **zero fuel contributed**

- Smaller diameter cable

- Smaller bend radius

- No tensile strength issues

- Ampacity advantage  (NEC Table 310.15(B)(17))
  (CEC 4-004 (11))
PYROTENAX MI CABLE FEATURES

- The first 2 hour UL/ULC listed fire-resistant system
- Uncontested electrical performance at extremely high temperatures
- UL listed factory splice
- No conduit required
- Can be installed in cable tray
- Exceptional cable life, longest warranty in the industry
- Inherently fire rated
SPACE SAVING: 25% SPACE COMPARED CONDUIT/WIRE
MI CABLE MANUFACTURING PROFILE

All Inorganic Materials

- Magnesium Oxide
  - High temperature resistance
  - Good electrical insulator
  - Inert

- Metal Tube
  - Copper
  - Alloy 825
  - Seamless

- Conductors
  - Copper
  - Nickel
  - Nickel-clad Copper

DESIGN CHALLENGES: PROTECTING CRITICAL CIRCUITS FROM FIRE
MI CABLE MANUFACTURING PROFILE

STEP NO. 1 – PLACEMENT OF RODS INSIDE THE TUBE

- Magnesium Oxide
  - High temperature resistance
  - Good electrical insulator
  - Inert

- Metal Tube
  - Copper
  - Alloy 825
  - Seamless

- Conductors
  - Copper
  - Nickel
  - Nickel-clad Copper

DESIGN CHALLENGES: PROTECTING CRITICAL CIRCUITS FROM FIRE
MI CABLE MANUFACTURING PROFILE

STEP NO. 2 – TUBES ARE FILLED WITH MgO POWDER

Magnesium Oxide
- High temperature resistance
- Good electrical insulator
- Inert

Conductors
- Copper
- Nickel
- Nickel-clad Copper

Metal Tube
- Copper
- Alloy 825
- Seamless

DESIGN CHALLENGES: PROTECTING CRITICAL CIRCUITS FROM FIRE
MI CABLE MANUFACTURING PROFILE

STEP NO. 3 – COLD DIE DRAWING AND ANNEALING

- **Sheath**
  - Seamless
  - Determines final coil length

- **Cold drawing**
  - Reducing dies
  - Draw down to AWG required
  - Work hardening

- **Annealing**
  - Furnace temp
  - Grain growth
RESULT – A rugged wiring cable...

becomes a completely sealed wiring system
PYRO TENAX MI CABLE PRODUCT RANGE

600 VOLT - POWER AND CONTROL CABLES

Single Conductor - #16AWG to 500kcmil

Multi Conductor – up to 7 conductors, various AWG

DESIGN CHALLENGES: PROTECTING CRITICAL CIRCUITS FROM FIRE
MI CABLE INSTALLATION – SETTING UP

Taking time to set up the pull makes the entire installation much easier
MI CABLE INSTALLATION

DESIGN CHALLENGES: PROTECTING CRITICAL CIRCUITS FROM FIRE
MI CABLE - TRANSITION AND TERMINATION
MI CABLE - TRANSITION AND TERMINATION

MI Cable is different, not difficult
PYROTENAX MI CABLE

- **FHTRC.R11251 - Fire-resistive Cable**
- **FHITC.1850 - Electrical Circuit Integrity Systems**

- The premier fire rated electrical cable for over 70 years
- MI Cable all inorganic construction – zero smoke, zero flame, zero fuel
- A tough standalone cable that can be crushed until flat and still remain operational
- Uncontested electrical performance under fire conditions