STANDARDS, HEAT TRACING OPTIONS, & APPLICATON OPTIMIZATION

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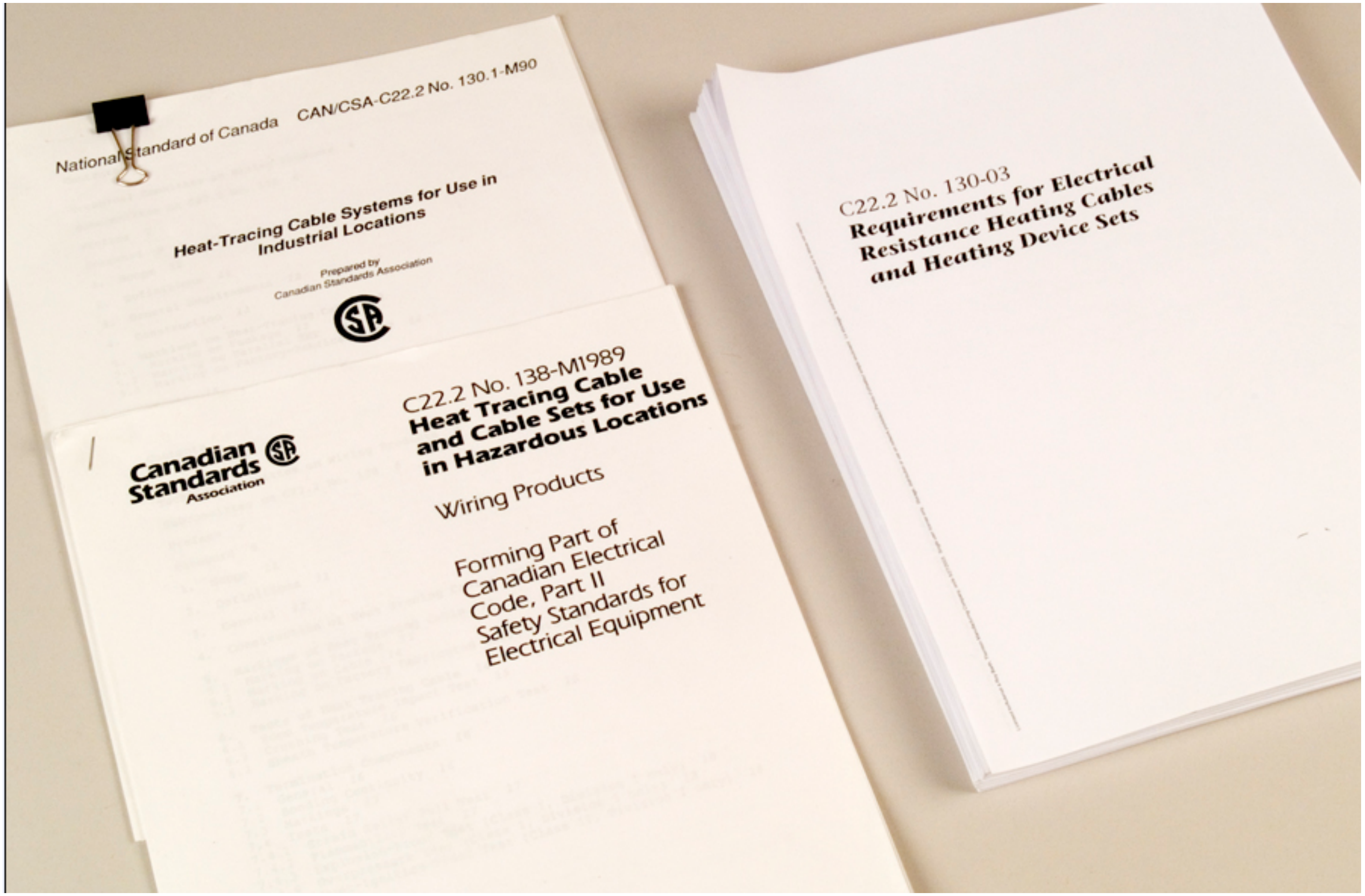
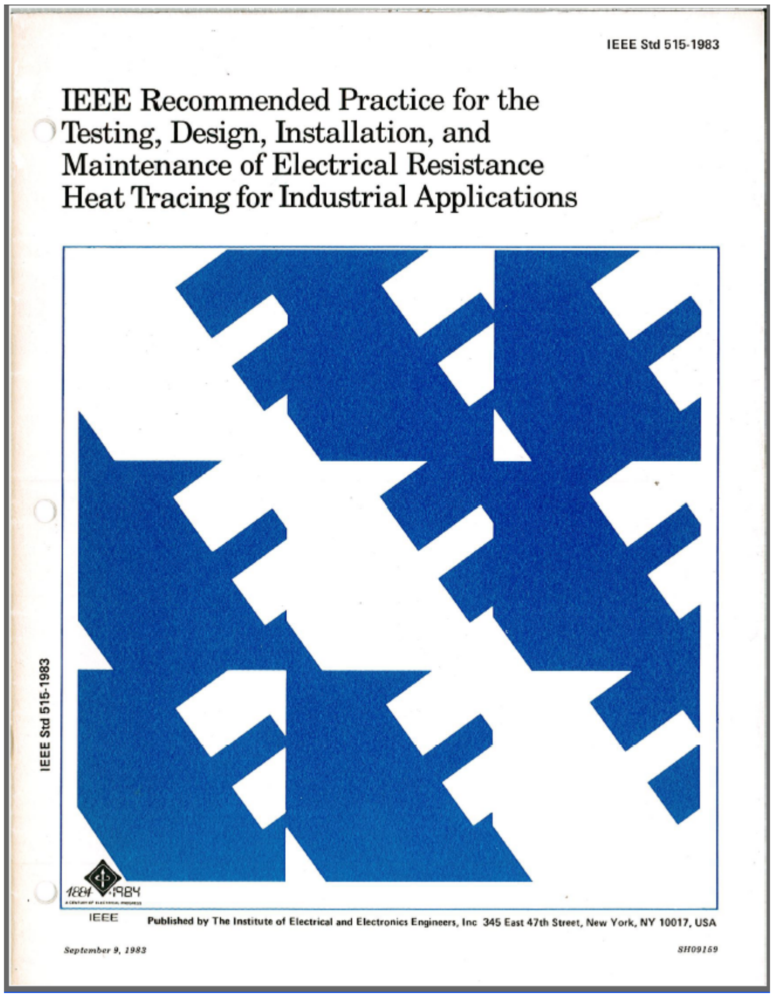
What You Will Learn

- Standards that apply to heat tracing
- How they are related
- What they address
- Recent changes
- What is next in standards
- What is next in the CEC

Canada – 1980's to Present



United States – 1980's to Present


IEEE Std 515-1983

IEEE Recommended Practice for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications

IEEE Std 515-1983

1884 1984

IEEE Published by The Institute of Electrical and Electronics Engineers, Inc 345 East 47th Street, New York, NY 10017, USA

September 9, 1983 SH09159


IEEE STANDARDS ASSOCIATION IEEE

IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Industrial Applications

IEEE Industry Applications Society

Sponsored by the
Petroleum & Chemical Industry Committee

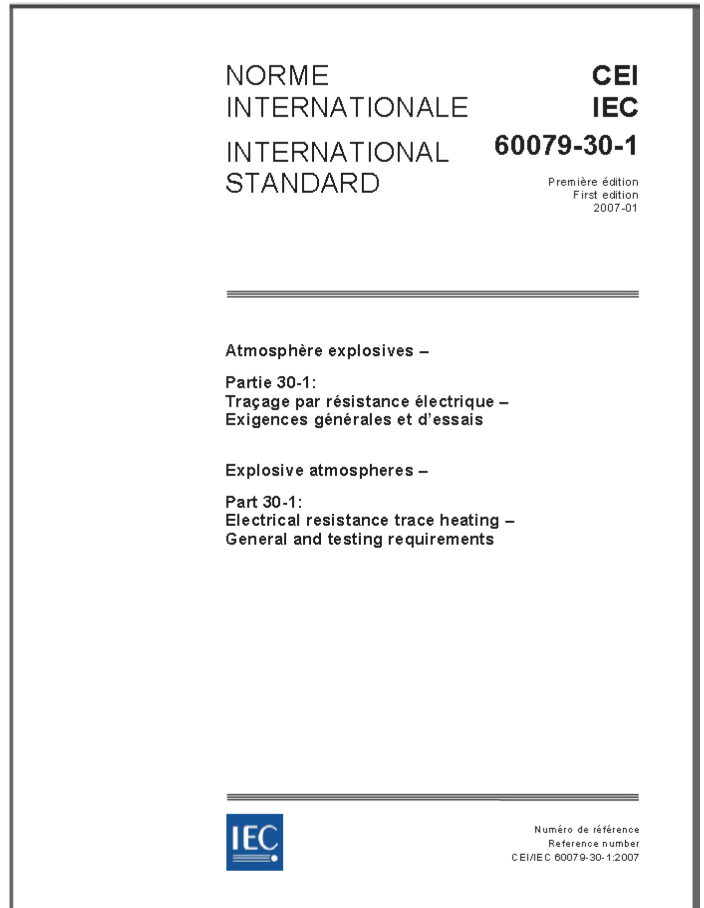
IEEE
3 Park Avenue
New York, NY 10016-5997
USA

9 September 2011

IEEE Std 515™-2011
(Revision of
IEEE Std 515-2004)

Europe / Intl - 1980’s to Present

- PTB
- BASEEFA
- LCIE
- NEMKO
- ISSEP
- DEMKO
- VDE



NORME INTERNATIONALE
INTERNATIONAL STANDARD

CEI
IEC
60079-30-1

Première édition
First edition
2007-01

Atmosphère explosives –

Partie 30-1:
Traçage par résistance électrique –
Exigences générales et d’essais

Explosive atmospheres –

Part 30-1:
Electrical resistance trace heating –
General and testing requirements

IEC

Numéro de référence
Reference number
CEI/IEC 60079-30-1:2007

How They Are Related

- Development of IEEE 515 started in 1979
  - Approved as an IEEE/ANSI Standard in 1983
  - Revisions in 1989, 1997, 2004, and 2011
- Became basis for other H/T standards
  - CSA 130-03
  - IEC 62086 now IEC 60079-30
  - IEEE 515.1
  - IEC 62395
- Iterative approach used for harmonization

What the H/T Standards Address

Durability and Performance

- Electrical
- Mechanical
- Environmental
- Operational

Suitability in explosive atmosphere

- Minimization of an arcing source
- Heating cable surface temperature below AIT or T-Rating

Durability and Performance

TYPE TESTS

Type Tests

Electrical

- Dielectric
- Insulation resistance

Mechanical

- Impact
- Deformation
- Cold Bend

Test Apparatus - Mechanical

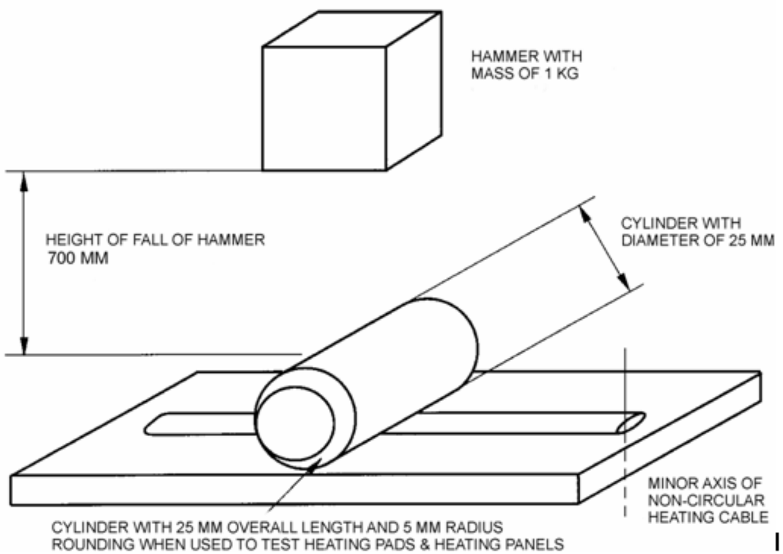


Figure 2—Trace heater room temperature impact test apparatus

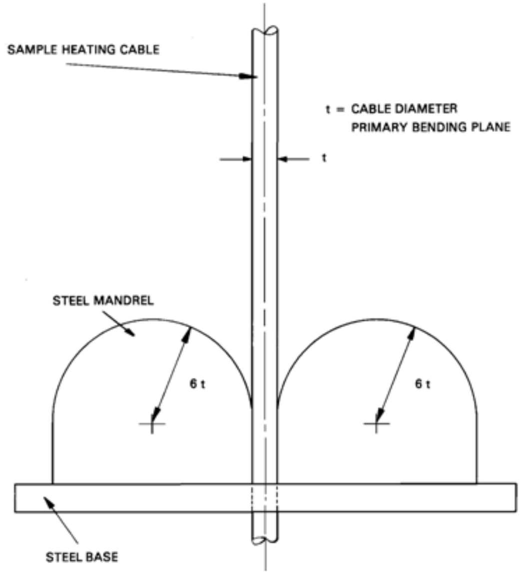


Figure 3—Cold bend test apparatus

Type Tests

Environmental Exposures

- Water-resistance
- Integral components resistance to water
- Flammability
- Elevated temperature
- Chemical resistance (Division 1 only)

Test Apparatus - Environmental

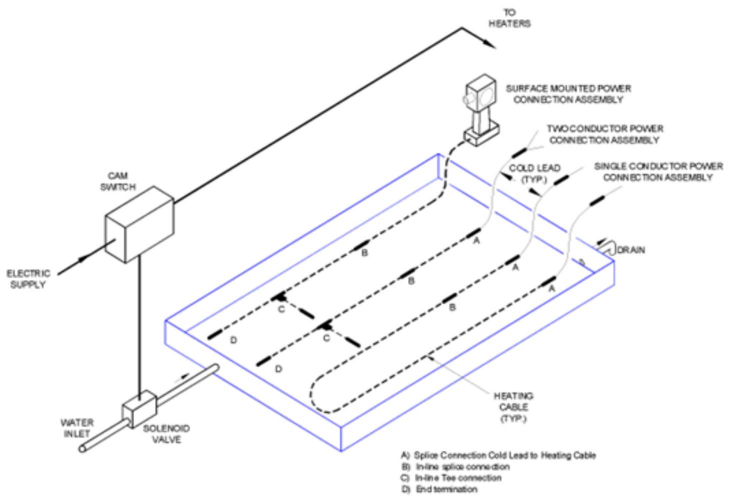


Figure 1—Trace heater termination and splice test apparatus

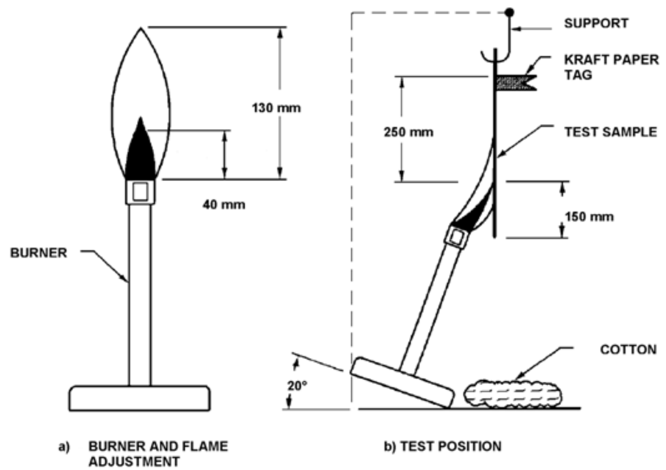


Figure 4—Flammability test

Division 1 - Additional Testing

- **Chemical exposure tests**
- The heating device and any integral components shall be exposed (completely immersed except for the connections) to the following chemicals: acetone, ethyl acetate, isooctane, hexane, methanol, methyl ethyl ketone, methylene chloride, and toluene. The exposure duration shall be 24 h. The chemical shall be maintained at a temperature not less than 5 C below the boiling point. Boiling points shall be obtained from NFPA 497.

Type Tests

Operational

- Verification of rated output
- Verification of start-up current
- Verification of braid or sheath conductivity
- Thermal performance benchmark

Test Apparatus - Operational

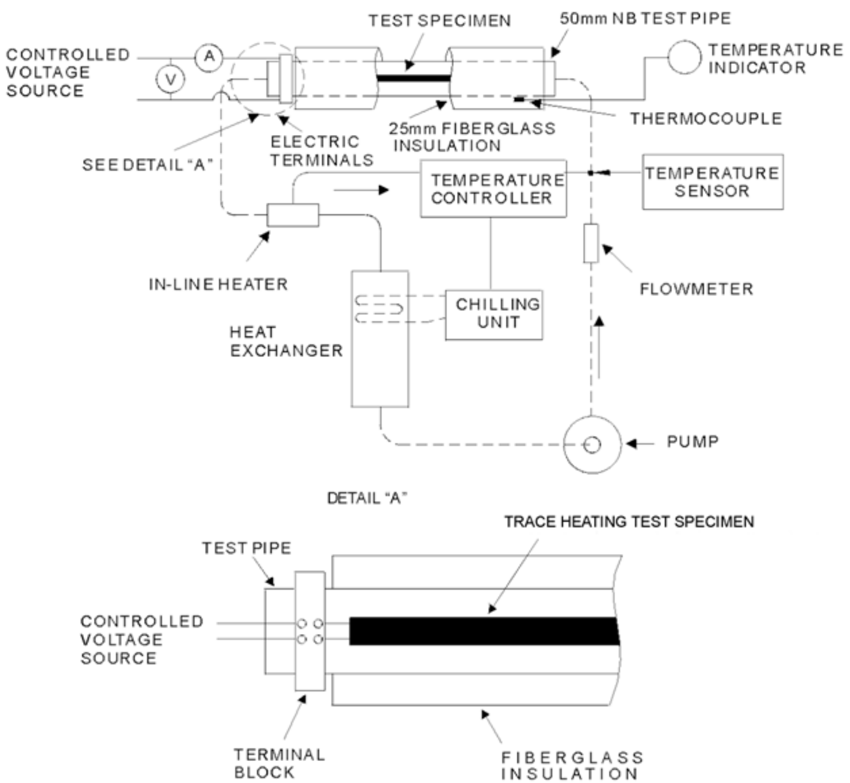


Figure 5—Verification of rated output

Type Test –Thermal Performance Benchmark

Conditions

- The heating cable is thermally cycled
  - Between the manufacturer's declared maximum maintain temperature and 23 °C
  - Minimum time dwell at each extreme temperature is 15 minutes.
  - Total duration is 1500 cycles
- Following the 1500 cycles is the test for maximum intermittent temperature rating
  - The cable is exposed at the maximum rated temperature for 250 hours.
  - Power ON or OFF condition during this exposure is based on the manufacturer's rating

Acceptance Criteria:

$$0.75 \leq P_{final} / P_{initial} \leq 1.20$$

Explosive Atmospheres

Minimization of an Arcing Source

IEEE 515:

Ground-fault protection of equipment

Each heating device branch circuit or each heating device shall have ground-fault equipment protection_capable of interrupting high-impedance ground faults. This shall be accomplished by a ground-fault equipment protective device with a nominal 30-mA trip rating or a controller with ground-fault interruption capability for use in conjunction with suitable circuit protection. For higher leakage current circuits, the trip level for adjustable devices is typically set at 30 mA above any inherent capacitive leakage characteristic of the heater as specified by the manufacturer.

Minimization of an Arcing Source

NEC

427.22 Equipment Protection. Ground-fault protection of equipment shall be provided for electric heat tracing and heating panels. This requirement shall not apply in industrial establishments where there is alarm indication of ground faults and the following condition apply:

(1) Conditions of maintenance and supervision ensure that only qualified persons service the installed systems.

(2) Continued circuit operation is necessary for safe operation of equipment of processes.

Minimization of an Arcing Source

CEC

62-300 Electric surface heating

(4) Ground-fault protection shall be provided to de-energize all normally ungrounded conductors of electric heating cable sets and heating panel sets, with a ground fault setting sufficient to allow normal operation of the heater.

(5) In establishments where conditions of maintenance and supervision ensure that only qualified persons will service the installed systems and that continued circuit operation is necessary for safe operation of equipment or processes, alarm indications of ground fault shall be permitted in place of the requirements of Subrule (4).

Methods to Establish $T_{\textbf{max sheath}}$

Stabilized Design

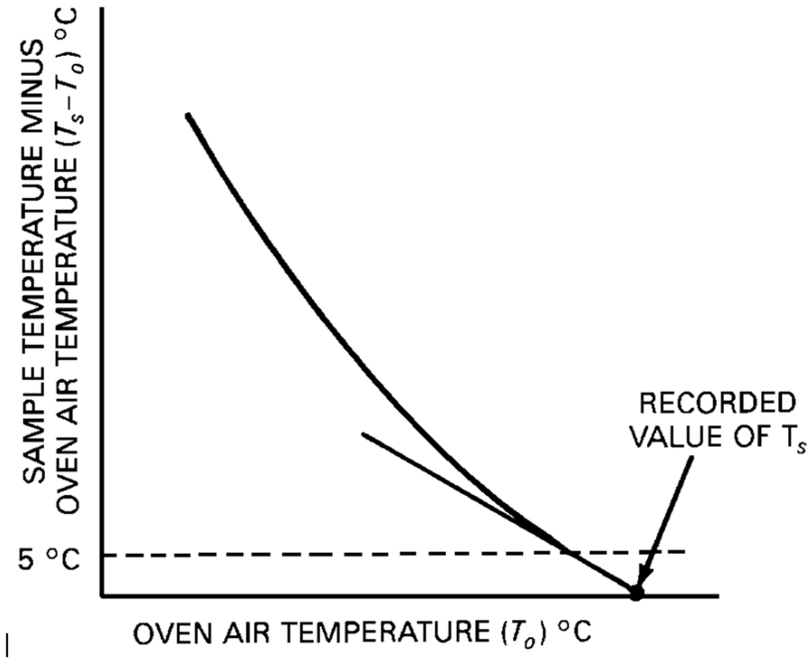
- Product Classification Approach
  - *Unconditional*
- Systems Approach
  - *Worst case conditions with no control (no thermostat or limiter)*

Controlled Design

  - *Relies on a controller or limit switch*

Product Classification Approach

- Primarily used for self-regulating heating cables
- The maximum sheath temp is not depending on design or installation conditions
- T-rating is part of the heat tracing cable marking

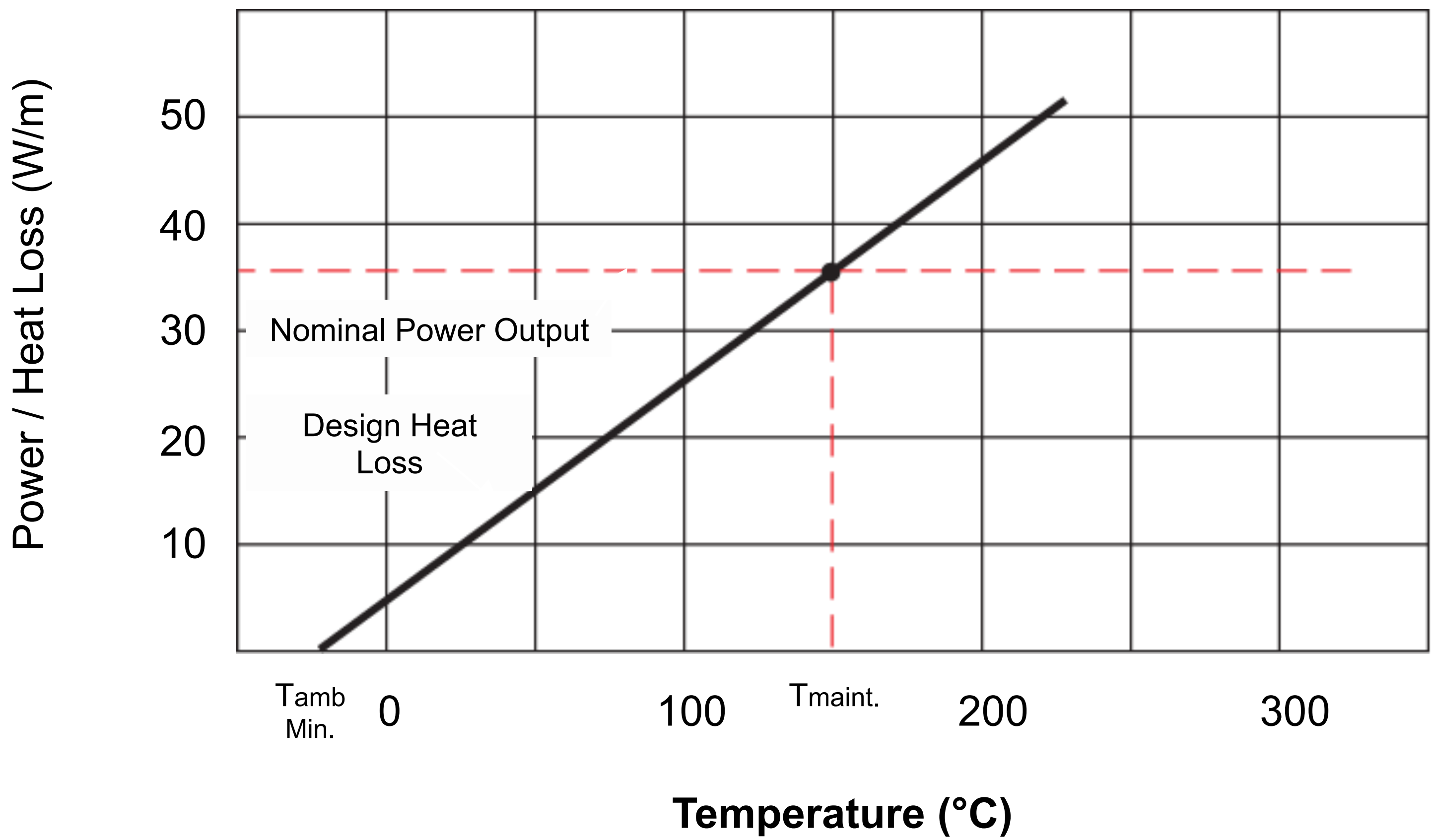


Systems Approach Requirements

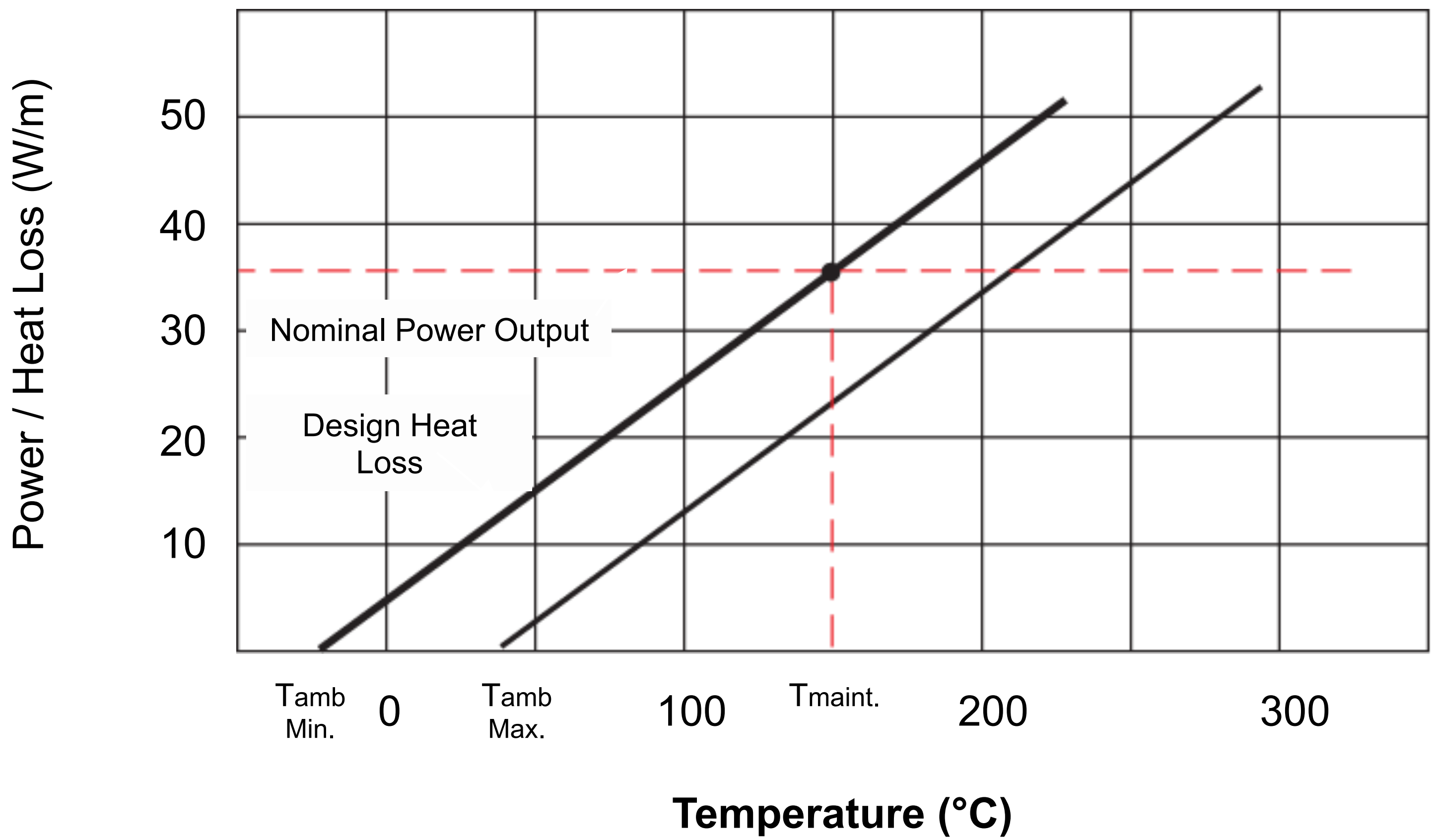
The maximum sheath temperature is calculated using the following conditions:

- No control (runaway pipe temperature)
- No wind (still air)
- Maximum of heating cable output tolerance
- Overvoltage condition (110% or 120% depending on Division or Zone)
- No safety factor for heat loss
- U-factor (sheath to pipe) for flange or valve area

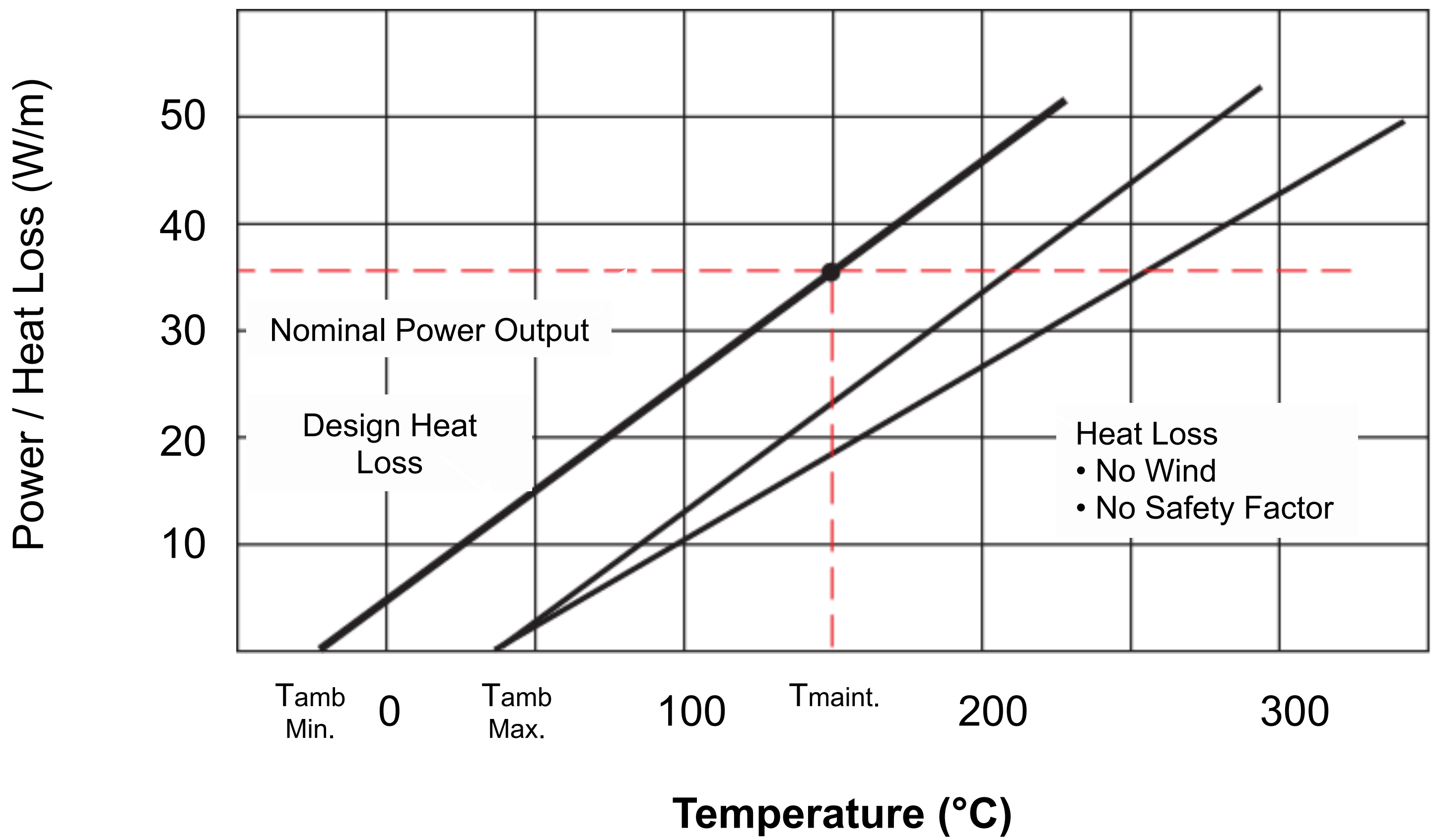
Uncontrolled Pipe Temperature Example



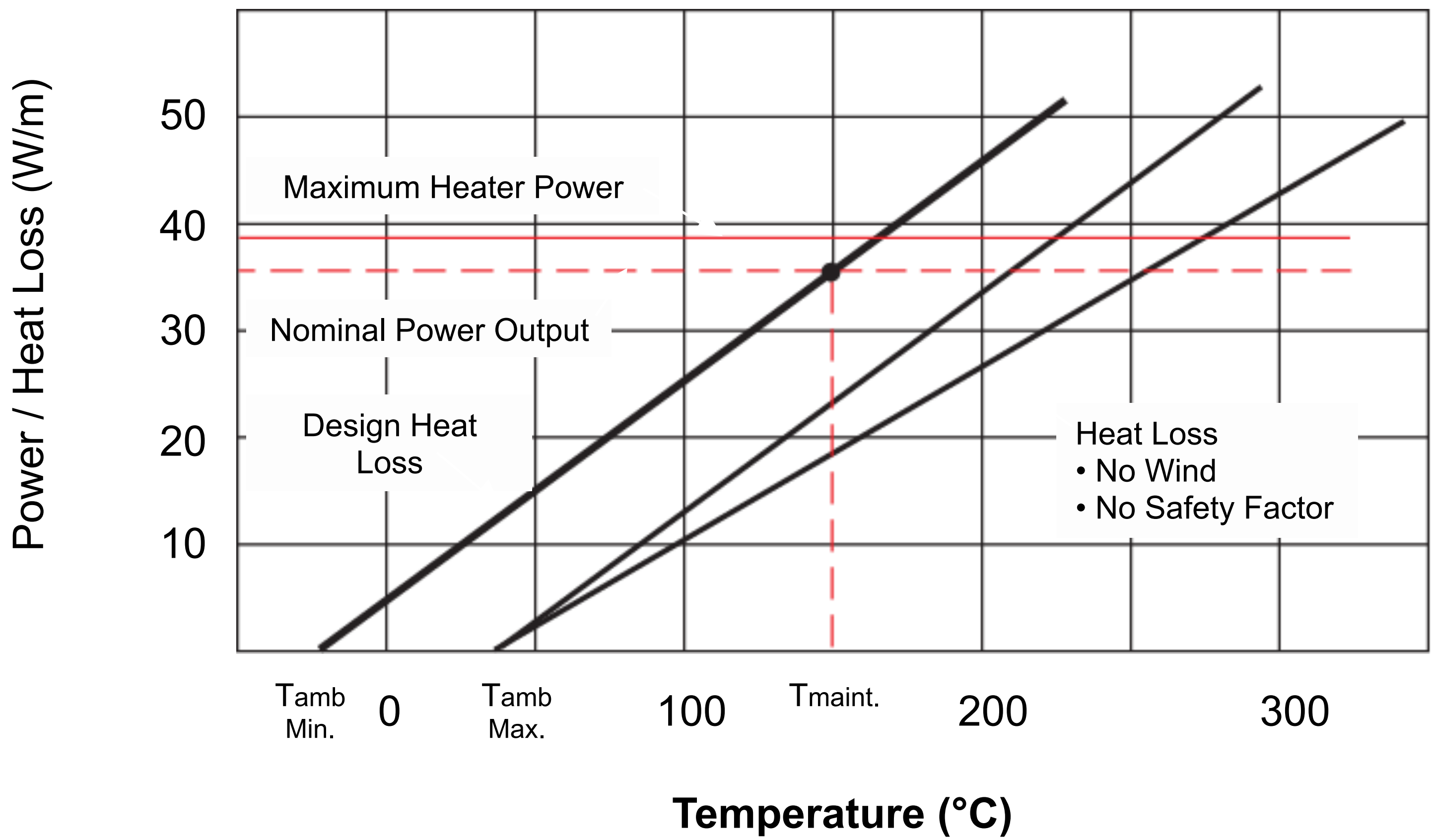
Uncontrolled Pipe Temperature Example



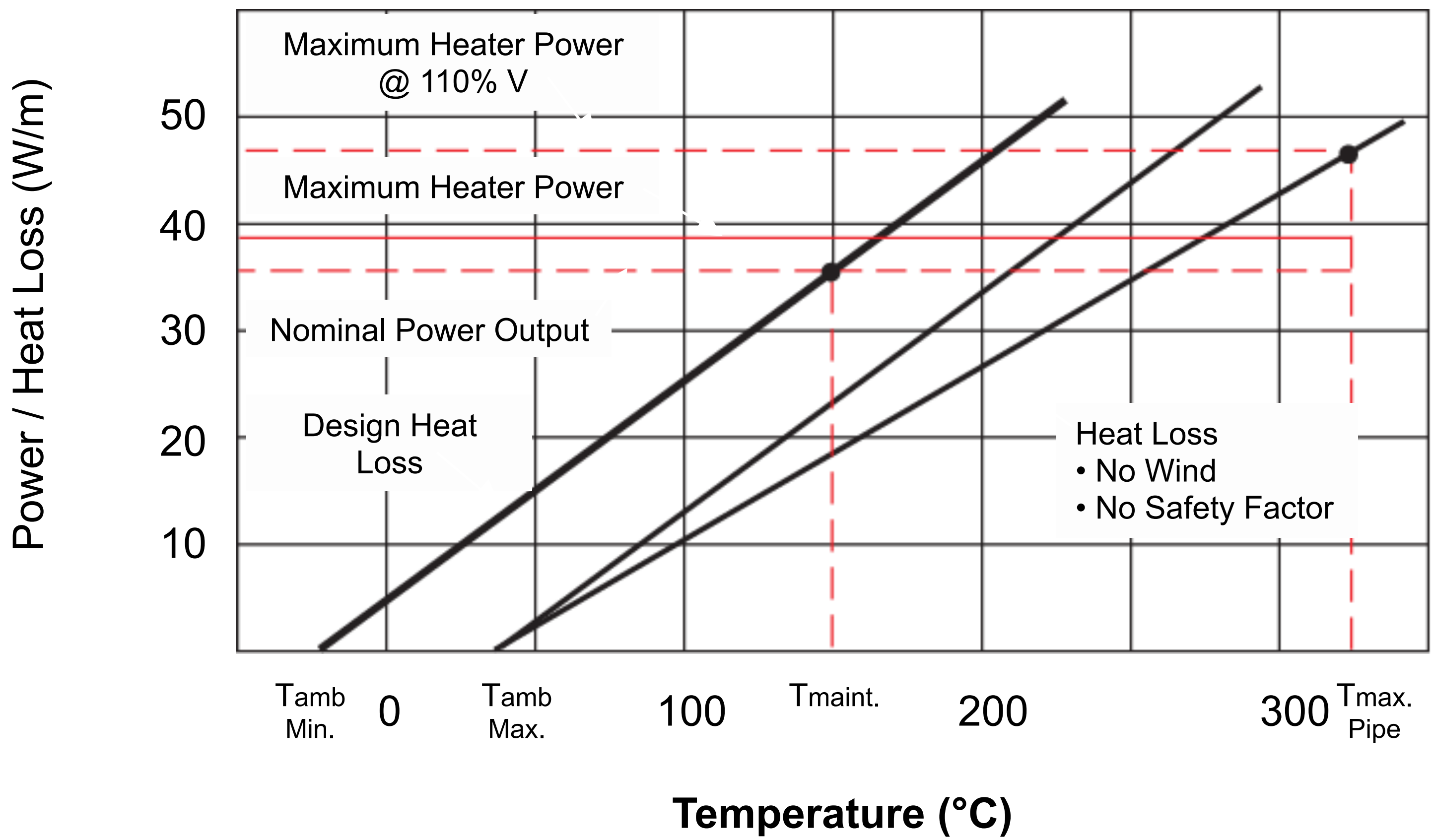
Uncontrolled Pipe Temperature Example



Uncontrolled Pipe Temperature Example



Uncontrolled Pipe Temperature Example



Predicted Max Sheath Temperature

The manufacturer's software must calculate the max runaway pipe temperature and ΔT between the tracer and the pipe. The sum is the maximum tracer sheath temperature.

$$T_{SH} = W/UC + T_{PR}$$

If max process temperature is used if higher than runaway pipe temperature

$$T_{SH} = W/UC + T_{PM}$$

Systems Approach - pipe

Performed primarily for constant-wattage and power-limiting heating cables. Can be used for S/R as well.

Verification for the manufacturer to predict maximum sheath temperature for:

- Max tolerance power output
- 110 % of rated voltage
- No wind
- Ambient temperature of 40 C

Heating cable installed per mfg instructions

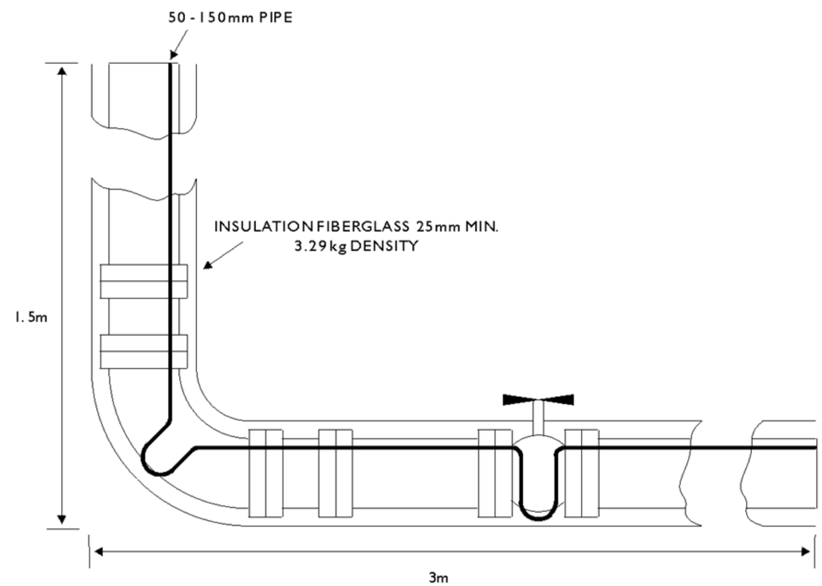


Figure 6—Verification of sheath temperature using systems approach

Systems Approach - plate

Performed primarily for constant-wattage and power-limiting heating cables. Can be used for S/R as well.

Verification for the manufacturer to predict maximum sheath temperature for:

- Max tolerance power output
  - 110 % of rated voltage
  - No wind
  - Ambient temperature of 40 C
- Pipe systems test performed to establish max pipe temp

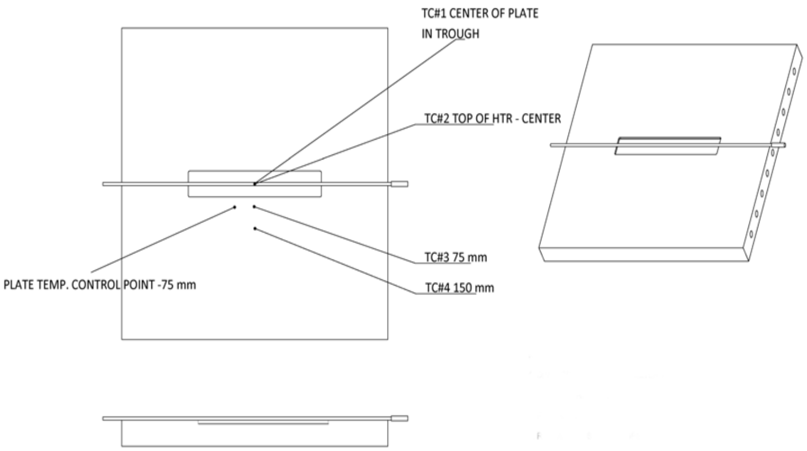


Figure 7—Verification of sheath temperature, plate test

Controlled Design per IEEE 515

Controlled design reduces max sheath temp through the use of the control/limiter set-point instead of the runaway pipe temperature.

Controlled design- This approach requires the use of a temperature control device to limit the maximum pipe temperature. When using a temperature controller without failure annunciation, a separate high-temperature limit controller to de-energize the heating device shall be included in with either a manual reset or annunciation. Alternately, a single temperature controller with failure annunciation can be used.

Controlled Design per IEEE 515

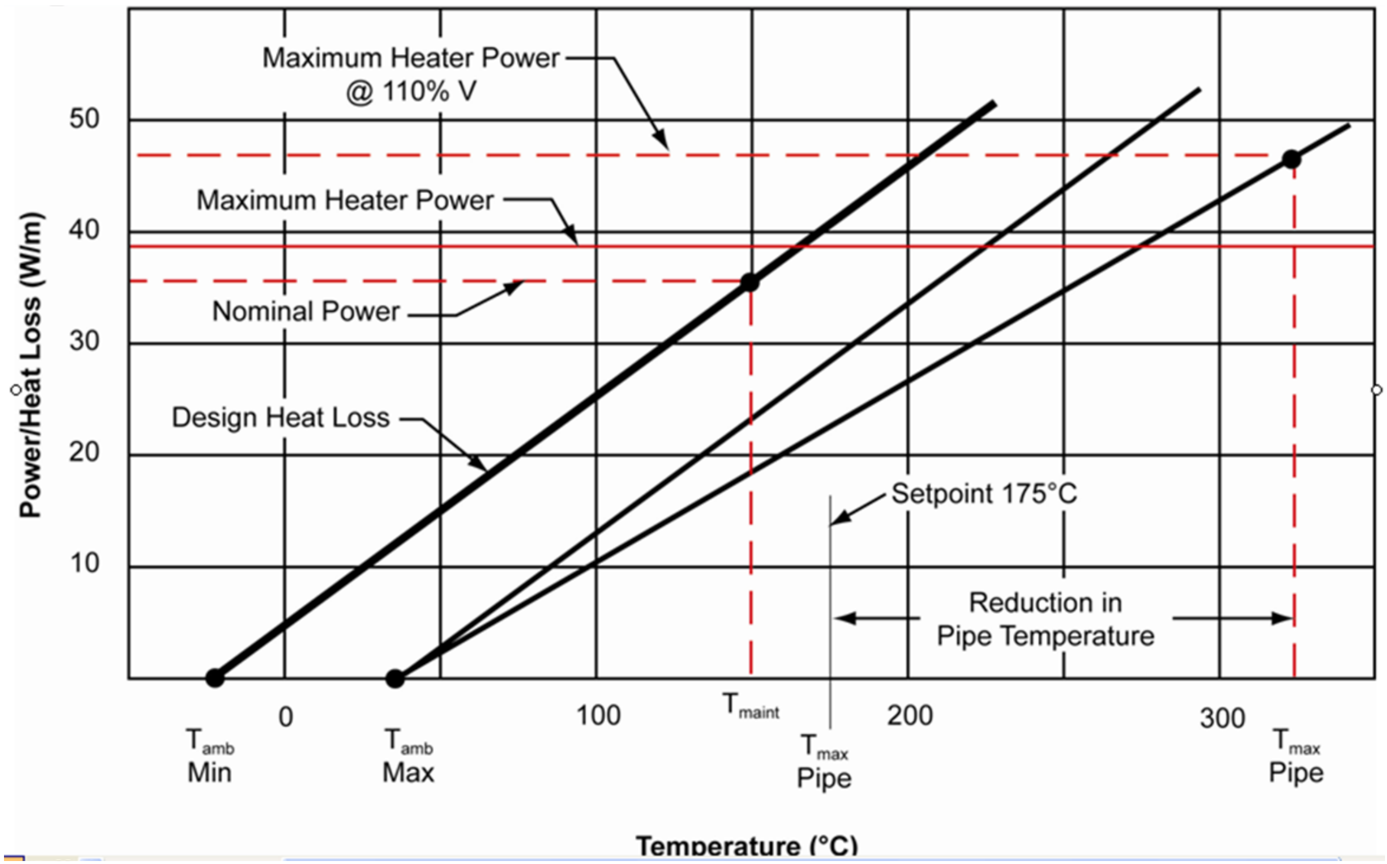
6.4.5.2.3 Controlled design approach

This method is a systems approach that requires the use of a temperature control device(s) in which the manufacturer has demonstrated the ability to predict sheath temperatures by conducting tests in accordance with 4.2.1. Use 40 °C maximum ambient temperature, unless a higher ambient temperature is specified. See Table 6 and Table 7.

The application of temperature control varies by area classification as follows:

- Zone 0 = no electrical trace heating allowed
- Division 1 = temperature controller and high-temperature limiter
- Zone 1 = temperature controller and high-temperature limiter
- Zone 2 = temperature controller
- Division 2 = temperature controller

Controlled Design Example



Sensor Location Approaches

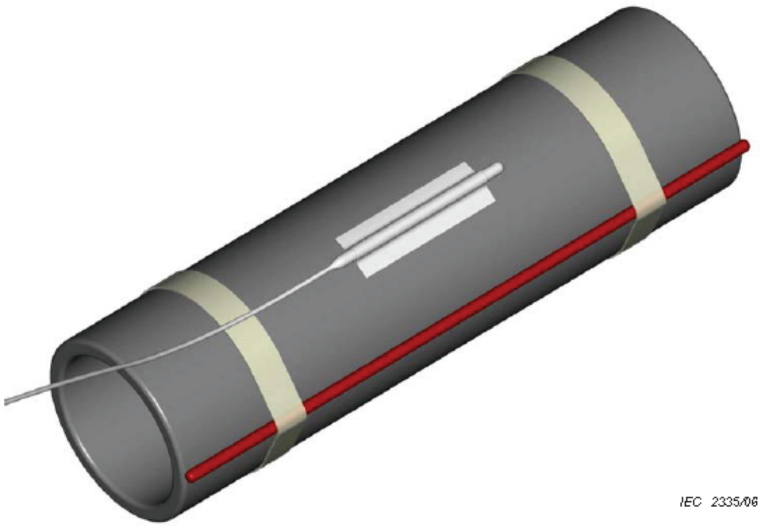


Figure 7 – Typical installation of control sensor and sensor for temperature limiting control

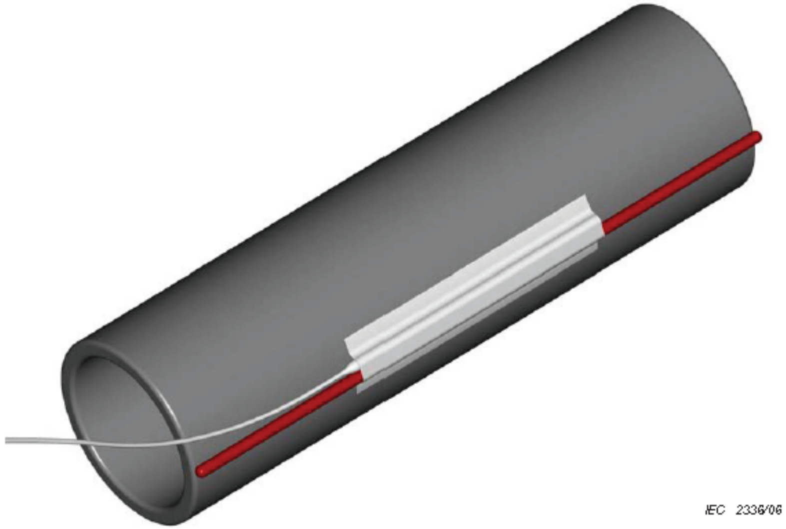
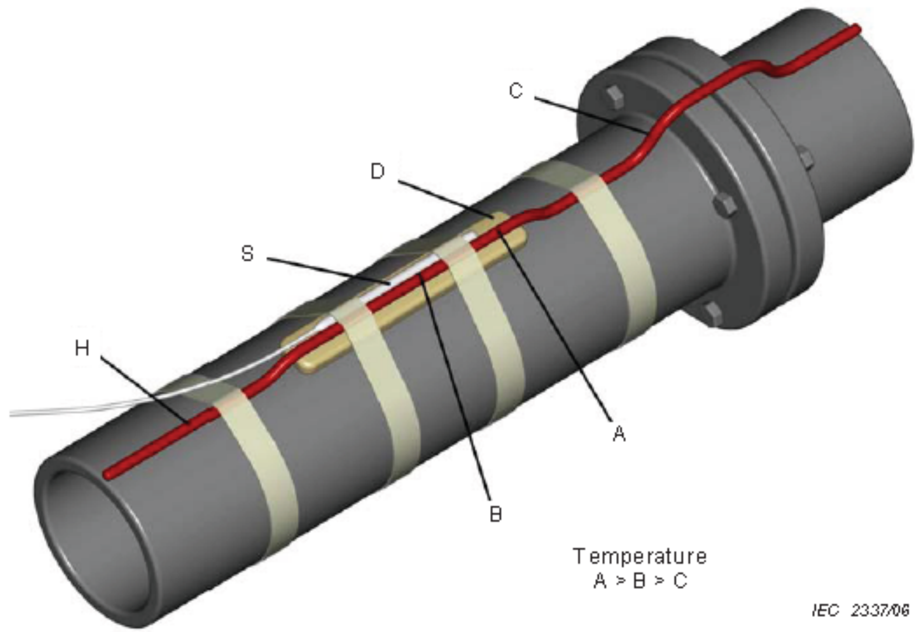


Figure 8 – Limiting device sensor on surface of trace heater

Sensor Location Approaches



Key

H trace heater

S temperature sensor

A temperature of artificial hot spot

B temperature at measurement point

C point with poor thermal coupling (characteristic hot spot)

D thermal insulation between trace heater and heated surface

Figure 9 – Limiting device sensor as artificial hot spot

CSA C22.2 No.130-03 Requirements for Resistance Heating Cables

- **C.7 Temperature Classification**
- **C.7.1**
- There are three methods that can be used to limit the sheath temperature and establish a temperature
- classification:
- a) the product classification approach;
- b) the systems approach; and
- c) controlled design applications.

CSA C22.2 No.130-03 Requirements for Resistance Heating Cables

4.7 Temperature Controls

Temperature switches and controls, when integral to the heating device set, shall comply with the applicable standards, such as C22.2 No. 24, when used as follows:

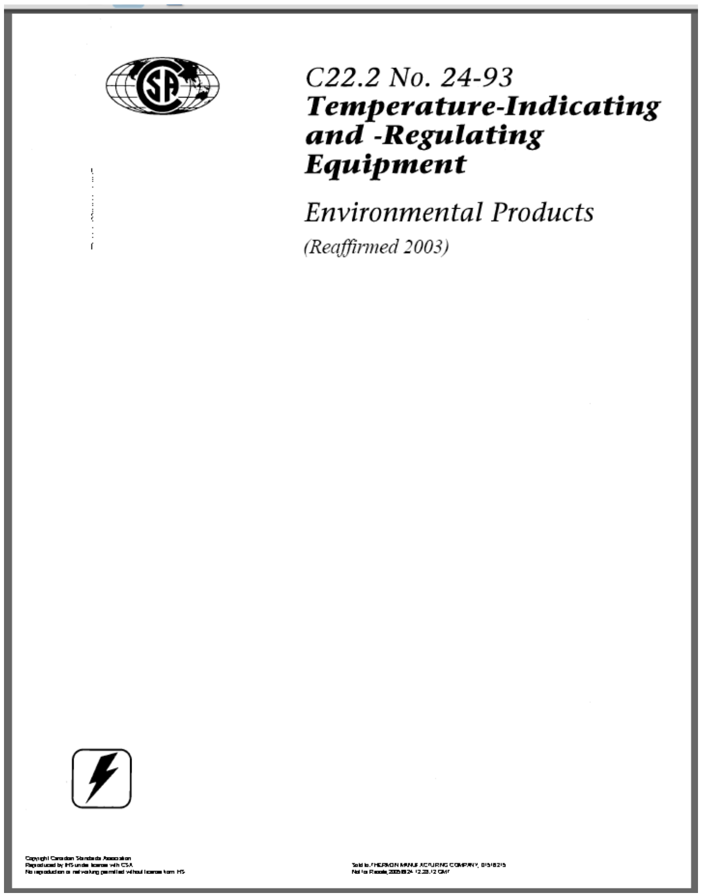
a) a combination temperature-limiting and -regulating device — *250,000 cycles' endurance;*

b) a temperature-regulating device used with a separate temperature-limiting device — 100,000 cycles' endurance;

c) a temperature-limiting device used with a separate temperature-regulating device — 100,000 cycles' endurance; and

d) a manual reset device — 6000 cycles.

CSA C22.2 No. 24 Temperature-Indicating and Regulating Equipment


C22.2 No. 24-93
Temperature-Indicating and -Regulating Equipment
Environmental Products
(Reaffirmed 2003)

Testing for Temp Controls:

- Extreme temp cycling
- Max rated current
- Calibration
- Overload endurance
- Cycling (on/off) endurance

Changes in Revised IEEE 515-2011

- Braid coverage was changed from 80% to 70% - harmonize with IEC 60079-30
- The room temperature impact test was added – harmonize with CSA 130-03
- For Zone 1 the mechanical type test loads were aligned with Zone 2/Division 2 levels and the chemical resistance test is no longer required – align with worldwide stds for Zone 1

Changes in Revised IEEE 515-2011

- Systems Approach added an alternate plate test for verification of max heating cable sheath temperature prediction
- Controlled Design
  - Added the sensor on the heating cable and "artificial hot spot" controlled design options – harmonize with IEC 60079-30
  - Required verification of the temperature offset using the systems approach pipe sculpture
  - Added Zone 1 requirements

What is next for HT Standards

- Joint development effort between IEEE 515 and IEC 60079-30 for one IEEE/IEC standard for heat tracing, *for hazardous locations*
  - Working Group members composed of 515 WG members and 79-30 MT members
  - Currently at CD comment stage
- IEEE 515.1 is being balloted
- IEC 62395 is in CD stage

What is next for the CEC

CSA Canadian Electrical Code System

- The Canadian Electrical Safety System consists of the “Part I Code” for Installation Rules and the “Part 2 Standards” for Product Certifications
  - Quite rigid in keeping Product requirements out of the Installation Code
  - EHT Certification reqts are in CSA C22.2 No.130-03
- The IEEE and IEC standards are somewhat different
  - IEEE 515 contains Product Certification requirements, and some Design and Installation guidance
  - IEC 60079-30 is specific to explosive atmospheres and also has Design and Installation guidance.
    - IEC 60079-14 contains Installation requirements for hazardous locations (Appendix for Electrical Tracing)

CSA C22.1, CEC Part I, Section 62

- Nov. 2011 - a **major revision** to CEC Section 62 has been initiated
  - Intent is to complete much of the work by June 2014 for publishing in the 2015 CEC
- Vince Rowe retired as Chair, replaced by Tim Driscoll
- CSA ICTH – Integrated Committee on Trace Heating
  - CSA Std. C22.2 (CEC Part II) No. 130, Certification standard for Trace Heaters and Panels
  - Section 62 Task Force
    - Ideas/suggestions for CEC Section 62 changes
- Created a joint committee of Section 62 and ICTH committees for this CEC **major revision**

Scope of CEC Section 62

- Re-Defined Scope as essentially the same as it currently is
  - Some changes – indicated as *red italicized below*
- Fixed Electric Space Heating
  - Any heating system *including Surface Heaters*, that results in heating of indoor rooms, directly or *indirectly*
- Fixed Electric Surface Heating
  - Pipelines *(including "gut" i.e. Internal)*, Tanks, Roads, Sidewalks, Roofs, Gutters, and similar
  - Freeze protection, De-icing, Temperature Maintain (elevated)
  - Pipeline Resistance *(change to Impedance), and add Skin Effect and Induction Heating*
- Other
  - Saunas, and *add Immersion Heaters*

CEC Section 62 Revisions

- Re-organize
  - Move existing clauses around to meet “Scope” adjustments
  - Consolidation of clauses (e.g. into general section where possible)
- Technical revisions
  - Corrections, simplify (e.g. minimize detailed prescription)
  - Harmonize as much as possible with NFPA 70 (NEC)
  - Include identified additions (e.g. Skin Effect Heating)
  - Review Definitions (i.e. Special Terminology)
- Update Appendix B, Notes on Rules

Summary

- The three standards that apply to heat tracing in hazardous areas are CSA 130-03, IEEE 515 and IEC 60079-30
  - Developed based on IEEE 515-1983
  - Stair-step approach in harmonization
  - Basically all three are the same
- H/T standards set requirements for durability and performance in explosive atmospheres areas
- Recent changes in IEEE 515 have been primarily for sheath temp determination with stabilized and controlled designs

Summary

- Further harmonization in progress with IEEE/IEC joint development effort for explosive atmosphere H/T standard
- Canada
  - Update for CSA 130-03 under consideration
  - IEEE 844 (Skin Effect Systems) being revised for possible adoption by CSA
  - Major revision project for the CEC Section 62 has been initiated

Questions ?

Controlled Design (Limiter Reqmts)

A high-temperature limiter shall operate independently from the temperature controller. A high-temperature limit function shall include the following features:

- De-energize the heating device when the set point of the high-temperature limiter is reached
- Annunciation when the high-temperature limit function is activated
- The high-limit function requires acknowledgment to be reset
- The high-limit set point of the device must be locked mechanically or electronically to prevent unauthorized access
- A safety function that de-energizes the circuit if the temperature sensor malfunctions
- Resetting possible only after the normal operating conditions have been returned, or if the switching state is monitored continuously

Controlled Design (Sensor Options)

The three control design methods for limiting the maximum sheath temperature with a high-temperature limiter are as follows:

- By limiting the maximum pipe temperature. The limit sensor is mounted directly on the pipe. Refer to 6.4.
- By using a high-temperature limiter with the sensor attached to the trace heater that is mounted directly on the pipe. Each application requires correlation for the specific trace heater, power output level, and high-temperature limiter/sensor characteristics. Refer to 6.4.2.1.
- By creating an artificial hot spot. A high-temperature limiter with the sensor attached to the trace heater that is located on an insulation spacer on the pipe. Each application requires correlation for the specific trace heater, power output level, high-temperature limiter/ sensor characteristics, and insulation spacer. Refer to 6.4.2.1.

TRACING OPTIONS & APPLICATION OPTIMIZATION

What You Will Learn

- Trace Heater Types – advantages and limitations
- Which type to use for an application
- Special design considerations for S/R Trace Heaters
- Key aspects in design of pipe and vessels heating
- Options for T-rating compliance
- Control options
- Key factors for installation and commissioning
- Maintenance and troubleshooting

Approach in Presentation

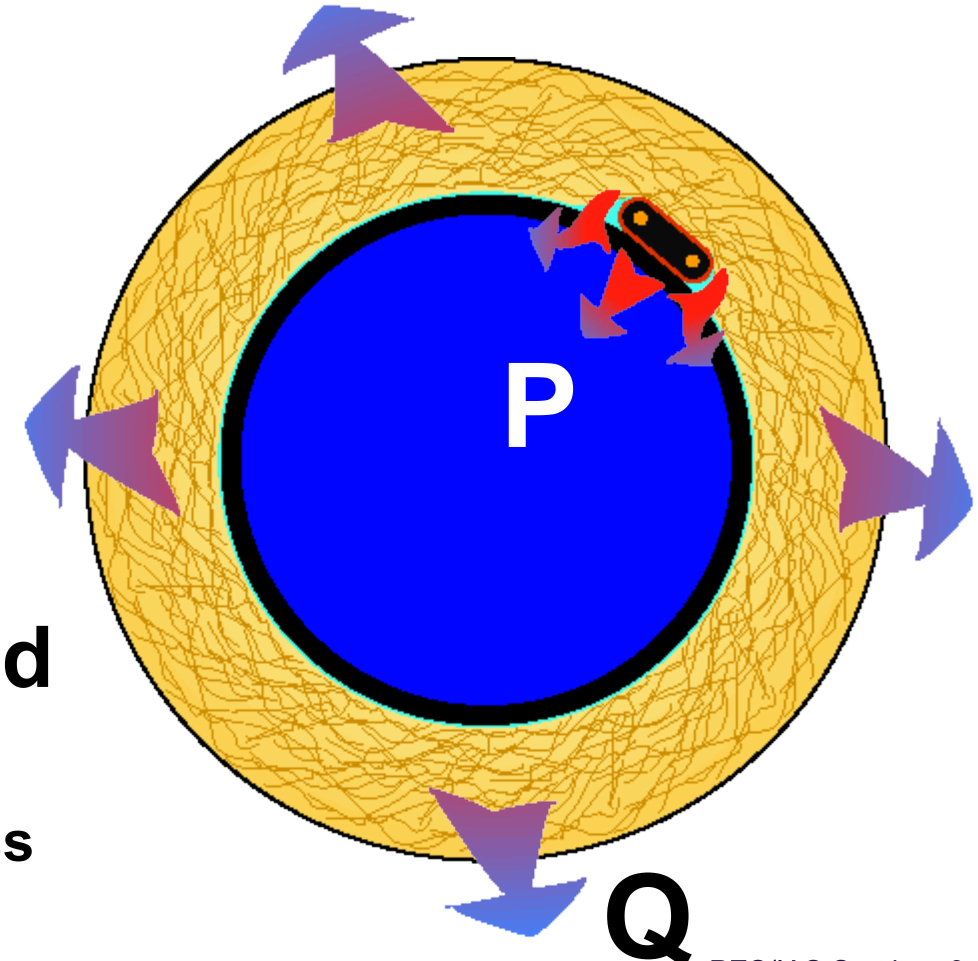
- Technical explanation
- Recommendations
- Reference IEEE 515, CSA 130, IEC 60079-30
- Examples of design software

Why Heat Trace?

$T_{pipe} > T_{amb}$

$P_{in} = Q_{loss}$

Heat must be added to make up for Q_{loss}



Where Heat Tracing is Needed

Freeze Protection
(winterization)
Maintain Viscosity
Prevent Condensation

Process Plant Applications

- Steam Supply and Condensate Lines
- Safety Showers
- Instruments and Sample Lines
- Vessels & Tanks
- Pump Manifolds
- Fire Protection Lines
- Process Fluids
- Crude Oils and Fuel Oils
- Molten Sulfur
- Asphalt/Bitumen
- Caustic Lines
- Service Air & Water
- Cryogenic Storage Tank Foundations

Application/Product Optimization

- Many heating and Trace Heater technologies
- No one type or approach is best for all applications
- Trace Heating approach should be optimized for the application

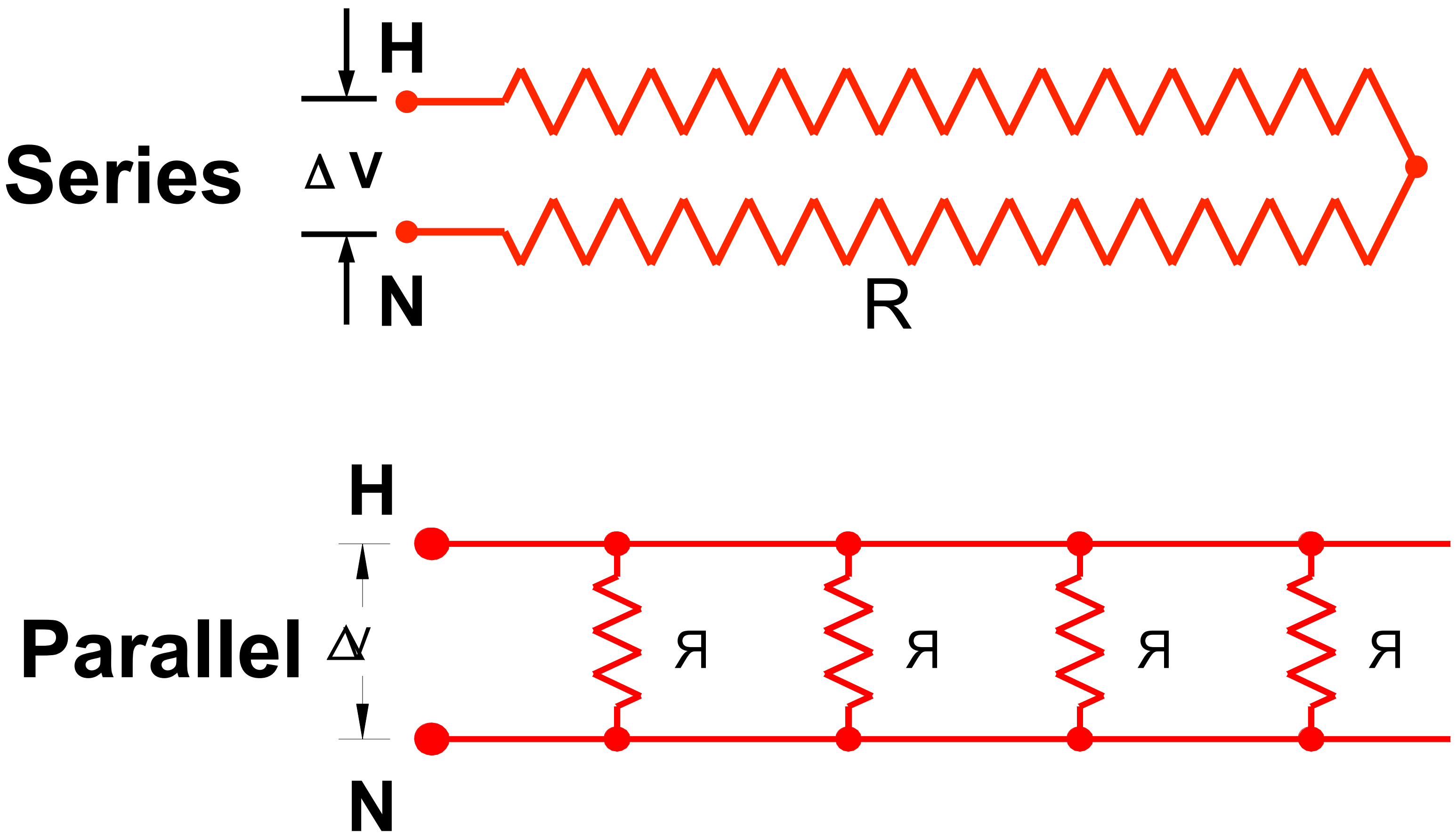
Trace Heater Product Types

- MI Heating Cables
- Polymer Insulated Heating Cables
- Zone Heating Cables
- Self-Regulating Heating Cables
- Power-Limiting Heating Cables
- Skin Effect Heating System

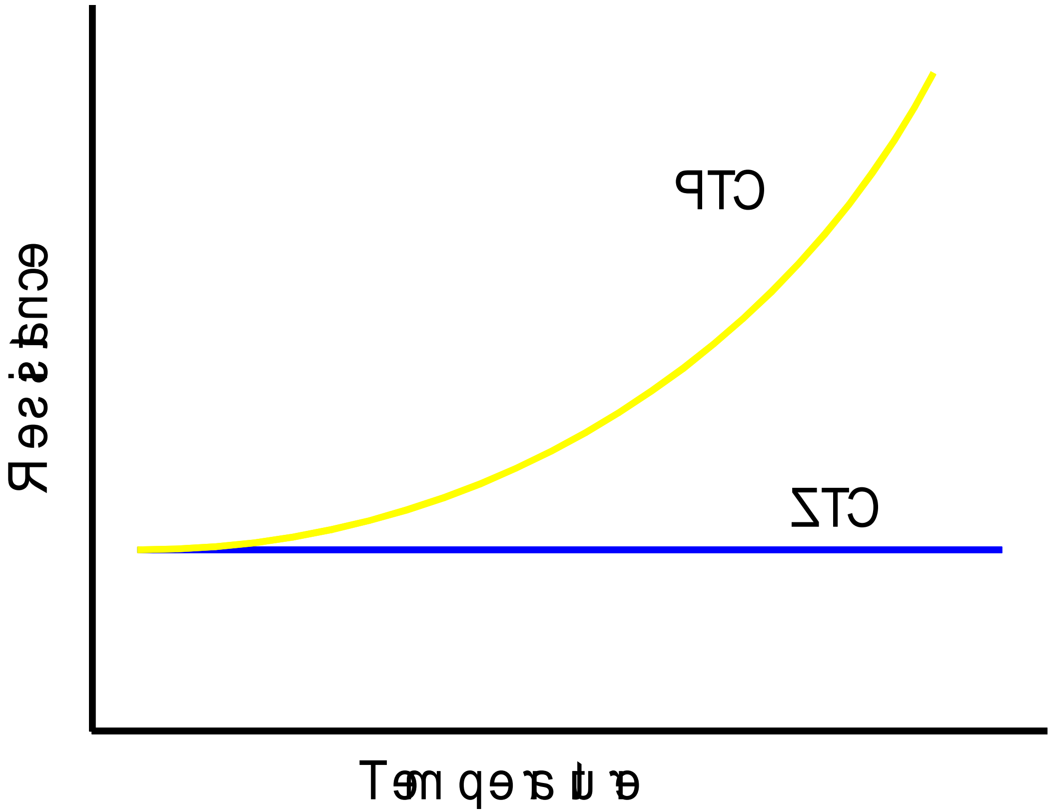
The Difference in Trace Heater Types

- Electrical Configuration
- Element Type
- Dielectric Insulation

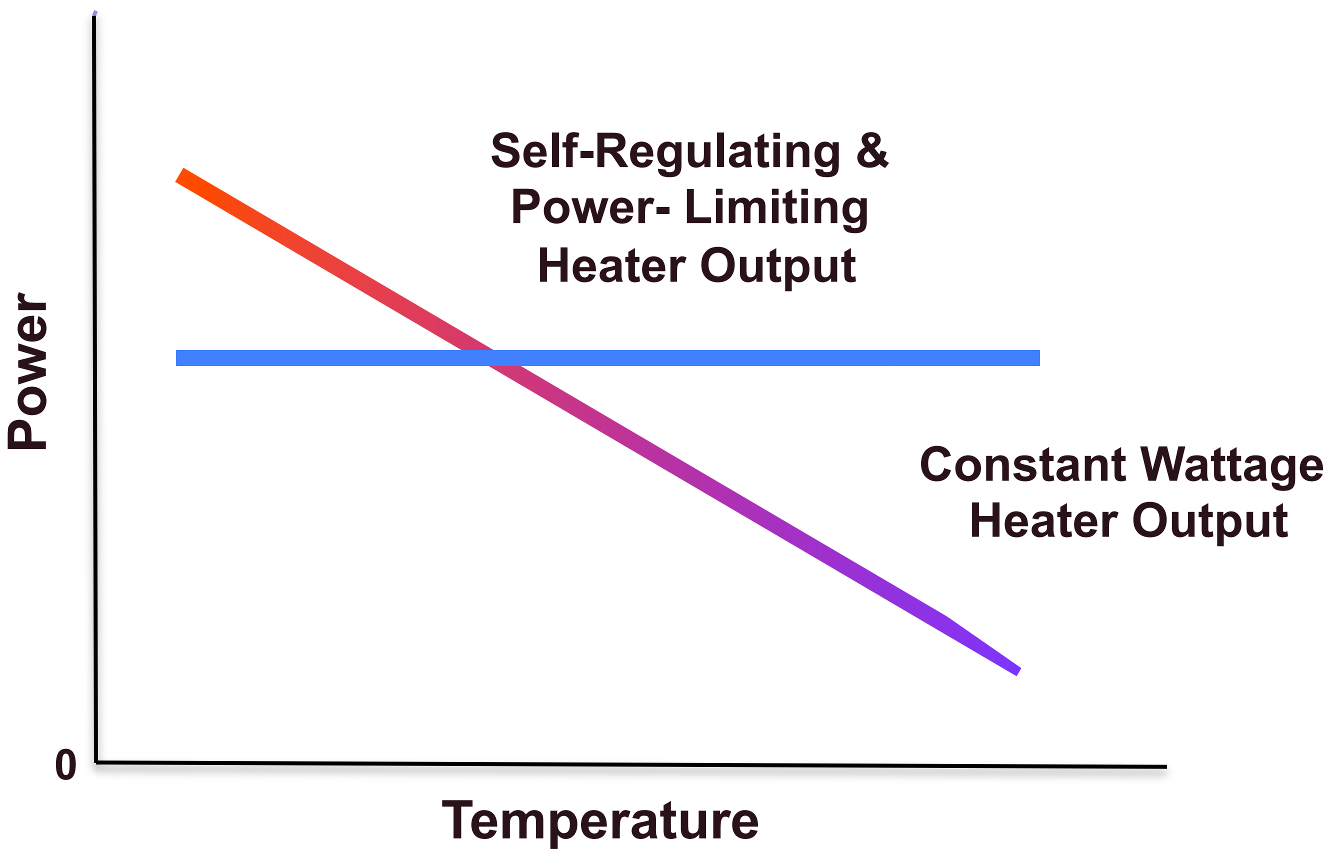
Trace Heater Electrical Configuration



Heating Element Types



Heat Output


Self-Regulating &
Power- Limiting
Heater Output
Constant Wattage
Heater Output
Power
0
Temperature

Temperature Ratings

- Maximum Maintenance Temperature
- Maximum Exposure Temperature
  - Continuous – Power OFF
  - Intermittent
    - Power OFF
    - Power ON

(Series Constant Wattage)

- Advantages:
  - High Exposure Temperature Capabilities (1100° F), (593°C)
  - High Maintenance Temperature (up to 800° F), (426°C)
  - High Watt Densities (up to 80 w/ft.),(266 w/m)
  - Long Circuit Lengths (up to 4,000 ft.), (1220 m)
  - Rugged
  - Uniform Power Along Entire Length
  - Easy to Monitor
  - CID1/CID2 and Zone 1/ Zone 2 Certifications

(Series Constant Wattage)

- Limitations:
  - Field Measurements Required - Generally Custom Fabricated Circuits
  - Very Difficult Field Fabricated -Difficult to Repair
  - MgO Dielectric Extremely Sensitive to Moisture
  - Relatively Inflexible - Difficult to Install
  - Short Circuit Lengths - May Require Transformer
  - T-Rating for Hazardous Areas is Design-Based

(Series Constant Wattage)

- Advantages:
  - Maintain up to (300° F),(150 ° C)
  - Withstand Exposure to (500° F),(260 ° C)
  - Long Circuit Lengths up to (5000 ft.),(1525m)
  - Uniform Power Along Entire Length
  - Easy to Monitor
  - Can be Field Terminated and Spliced
  - Flexible - Easy to Install
  - CID2 & Zone 1 & 2 Certifications

(Series Constant Wattage)

- Limitations:
  - Overlapping is Not Recommended
  - Power Output is Circuit-Length Dependent (Designs Require Pipe Measurements)
  - Short Circuit Lengths are Not Practical
  - T-Rating for Explosive Atmospheres is Design-Based

Zone (Parallel Constant Wattage) Trace

- Advantages:
  - Operate at Standard Voltages (Heater Selection is Easy)
  - No Start-Up Current
  - Field Fabrication (Cut-to-Length)
  - Flexible - Easy to Install
  - CID2, & Zone 1 & 2 Certifications

Zone (Parallel Constant Wattage) Trace

- Limitations:
  - Overlapping is Not Recommended
  - Medium Length Circuits (<1,500 ft.),(455m)
  - Require Some Care During Installation
  - T-Rating for Explosive Atmospheres is Design-Based

Self-Regulating Tracing (Parallel PTC)

- Advantages:
  - Field Fabrication (Cut-to-Length)
  - Operate at Standard Voltages
  - Flexible - Easy to Install
  - Adjust Power Output to Surroundings
    - PTC Heating Element
    - Cannot Overheat
  - CID1/CID2 , & Zone 1 & 2 Certifications
  - T-Rating for Explosive Atmospheres is Independent of Application

Self-Regulating Tracing (Parallel PTC)

- Limitations:
  - Medium Length Circuits (<1,000 ft.), (300m)
  - Higher Start-Up Currents
  - Lower Power Densities at Higher Maintenance Temperatures
  - Heater Element has Temperature Exposure Limitations

Power-Limiting Tracing (Parallel PTC)

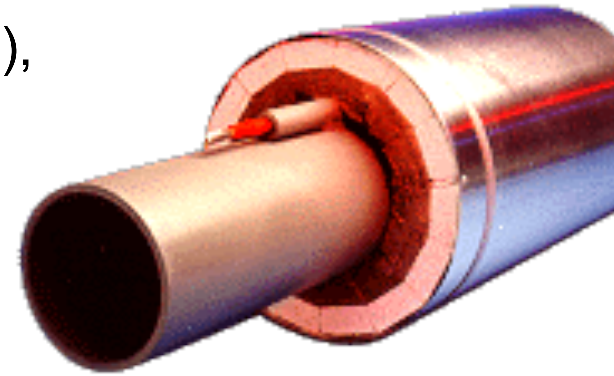
- Advantages:
  - Maintain up to (300° F),(150°C)
  - High Exposure Temperature (up to 500° F), (260°C)
  - Power Reduces as Temperature Increases
    - PTC Heating Element
  - Operate at Standard Voltages
  - Field Fabrication Cut-to-Length
  - Can be Overlapped
  - Flexible - Easy to Install
  - CID1/CID2 & Zone 1& 2 Certifications

Power-Limiting Tracing (Parallel PTC)

- Limitations:
  - Medium Length Circuits (<1,000 ft.),(300m)
  - Require Some Care During Installation
  - T-Rating for Explosive Atmospheres is Design-Based

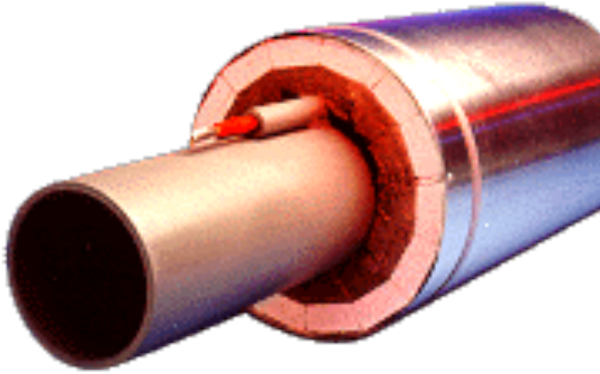
Skin Effect Current Tracing

- Advantages:
  - Very Long Circuit Lengths (up to 7.5 Miles), (12km)
  - Few Power Connection Points - Reduced Costs
  - High Maintenance Temperature (300° F) (150°C)
  - High Power Densities (up to 50 w/ft.),(167w/m)
  - High Exposure Temperature (500° F),(260°C)
  - Very Rugged - High Durability



Skin Effect Current Tracing

- Limitations:
  - Special Transformer Required
  - Factory Design Necessary
  - Not Practical for Complex Piping
    - Valves
    - Flanges



Heat Tracing Product Types

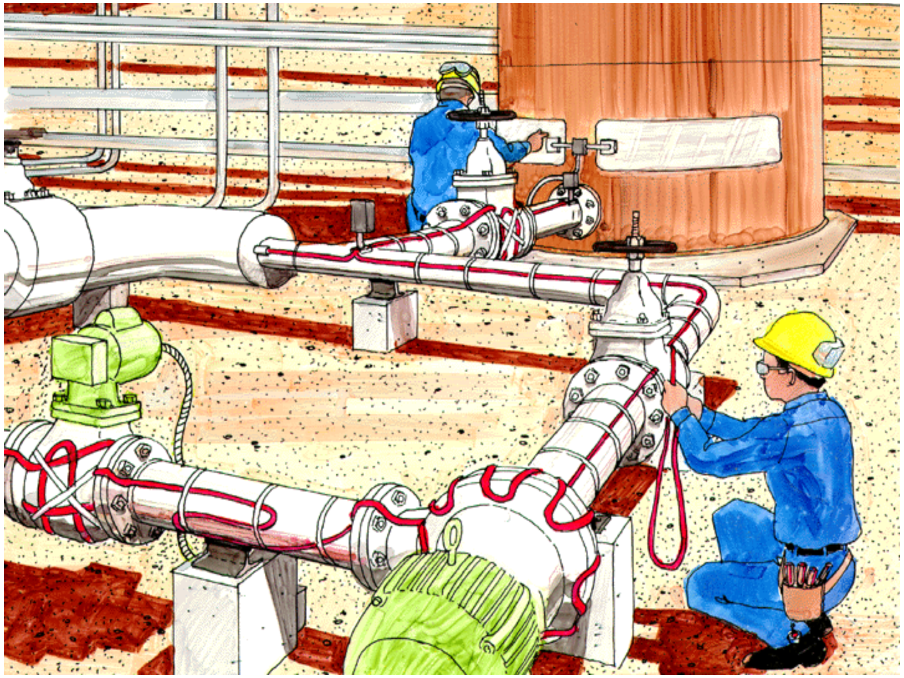
- MI Heating Cables
- Polymer Insulated Heating Cables
- Zone Heating Cables
- Self-Regulating Heating Cables
- Power-Limiting Heating Cables
- Skin Effect Heating System

Which one to use???

Identify the Application

- In-Plant Complex Piping
- Interconnecting Piping
- Product Transfer Pipelines
- High Temperature Applications

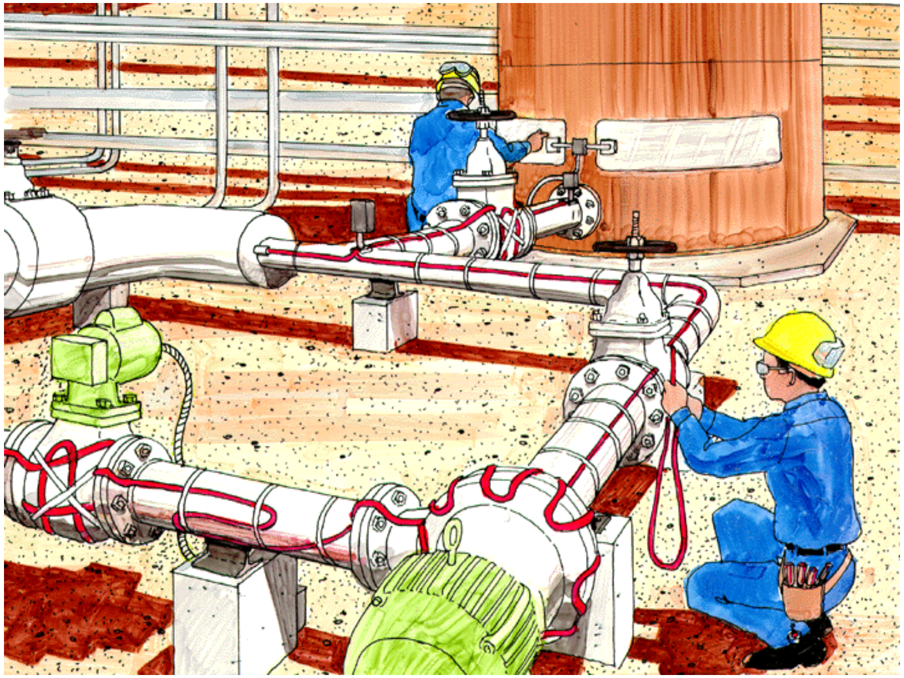
In-Plant Complex Piping



Typically Consists of:

- Piping Runs Less Than (500ft),(150m)
- Multiple Pipe Diameters
- Numerous Inline Equipment
  - **Valves**
  - **Pumps**
  - **Strainers**

In-Plant Complex Piping



Self-Regulating Heating Cable

- Infinitely Cut-to-Length
- Cannot Overheat
- Can be overlapped Arrangements
  - **Pumps**
  - **Valves**
  - **Inline Equipment**
  - **Numerous Pipe Supports**

Self-Regulating Cables

Primary Application: Complex Piping Within Process Units

Uses: Freeze Protection and Low to Moderate Temperature Maintenance

Max. Maintain 150°F, 65°C

Max. Exposure 185°F, 85°C

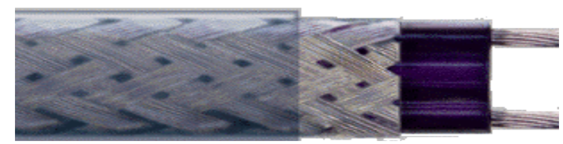
T-Rating: T6

Uses: Process Temperature Maintenance and Freeze Protection

Max. Maintain 250°F, 121°C

Max. Exposure 415°F, 212°C

T-Rating: T3/T2



Uses: Process Temperature Maintenance and Freeze Protection

Max. Maintain 300°F, 150°C

Max. Exposure 450°F,232°C

T-Rating: T3

Maintain and Exposure Temperatures Determine Cable Selection

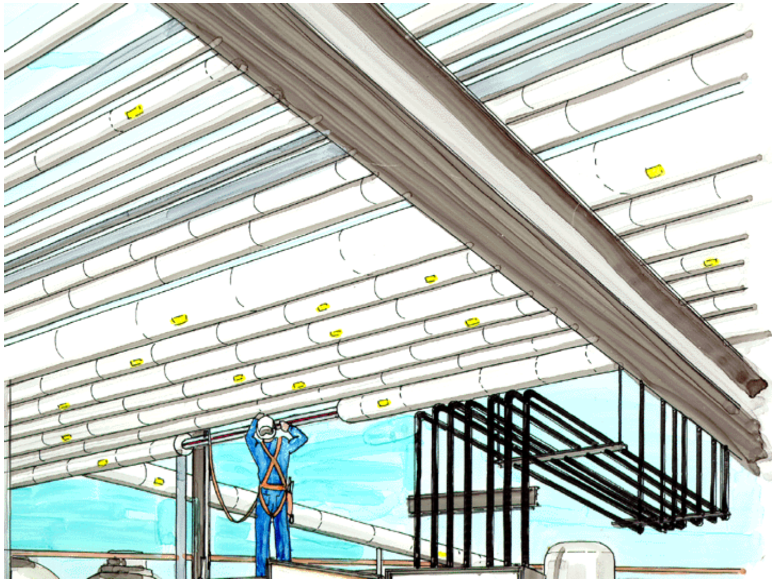
Interconnecting Piping

Typically Consists of:

- Pipe Runs 500ft. to 5,000ft.

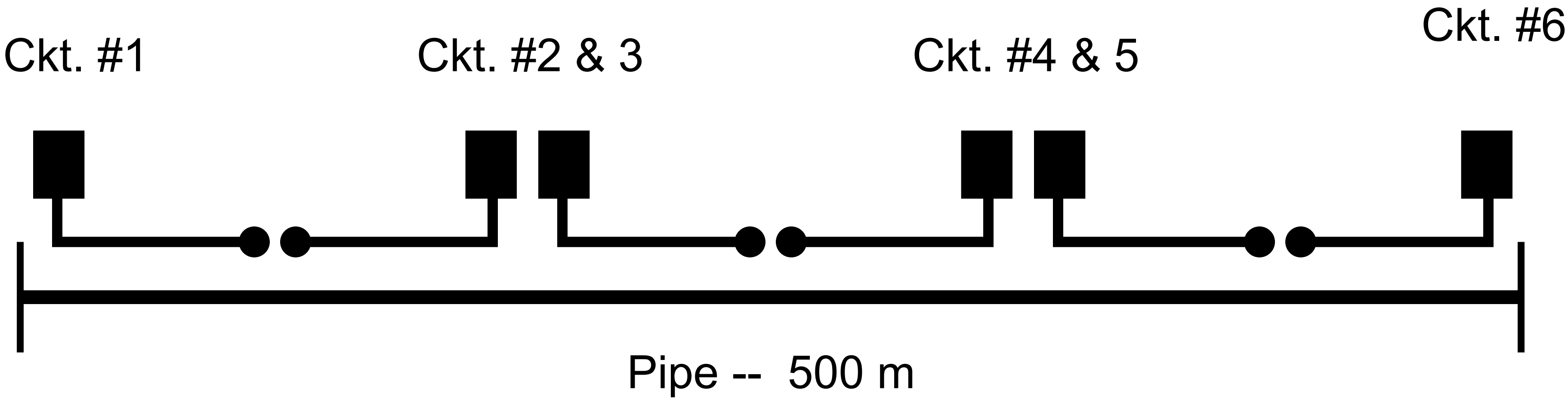
  150m to 1525m

- Minimal Inline Equipment
- Consistent Heat Loss Along Entire Length

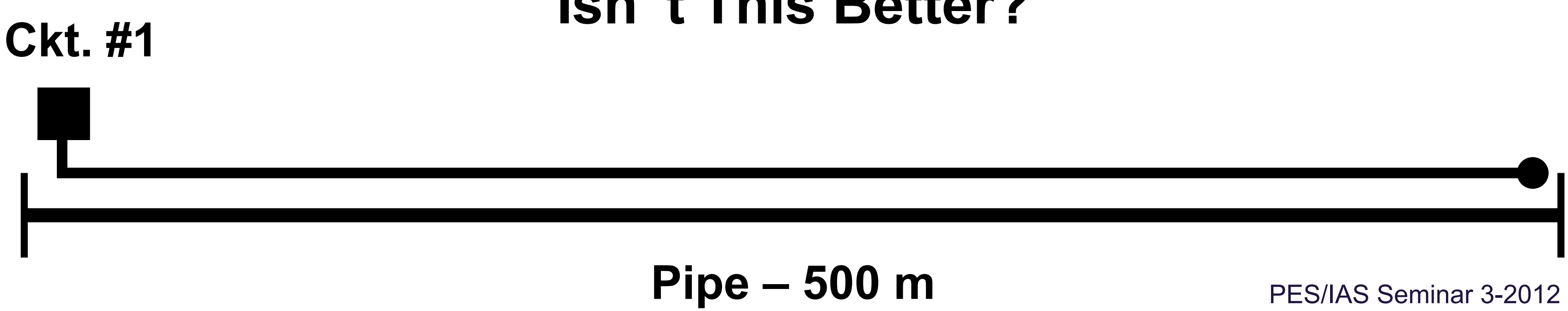


Long Line Trace Heating

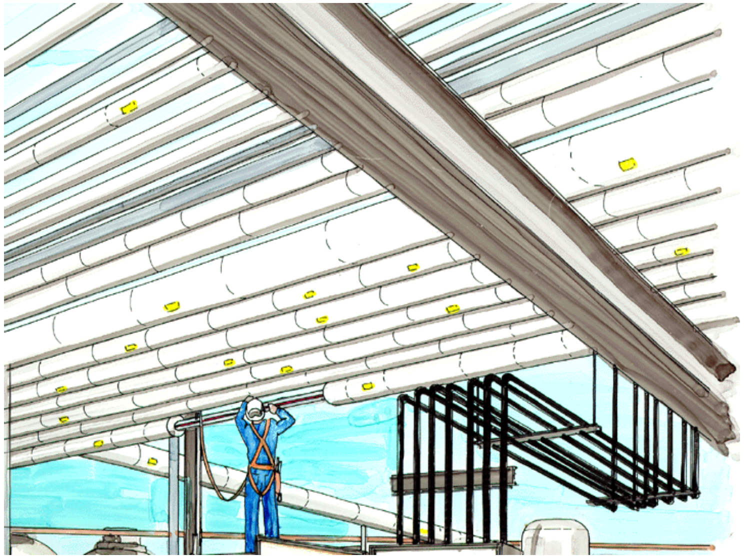
Does This Happen?



Isn't This Better?



Interconnecting Piping



Series Constant Wattage Heating Cables

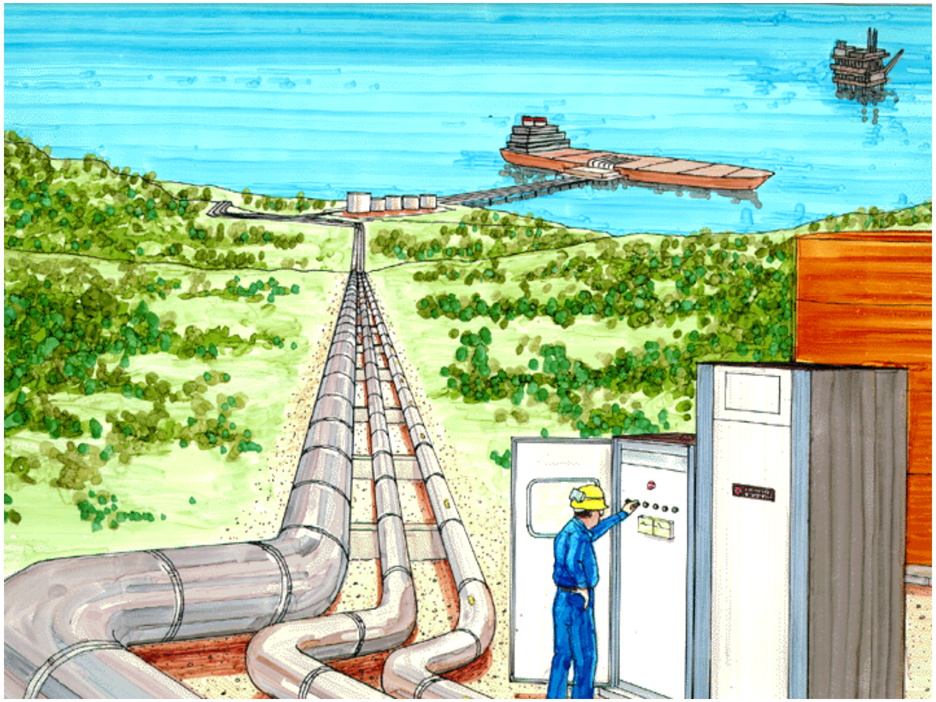
- 1,500ft. to 5,000ft, 450m to 1525m Circuits
  - **Single Phase**
  - **Three Phase**
- Uniform Power Along Entire Circuit Length
- Over sizing of Power Distribution Not Necessary
- Easy to Monitor

Interconnecting Piping
Series Constant Wattage Cable

Primary Application: Freeze Protection and Temperature Maintenance of Interconnecting Piping

- Characteristics :
  - Maintains up to 230 °F (110°C)
  - Withstands up to 400°F (204°C) (power-off)
  - 2 and 3 Conductor Versions

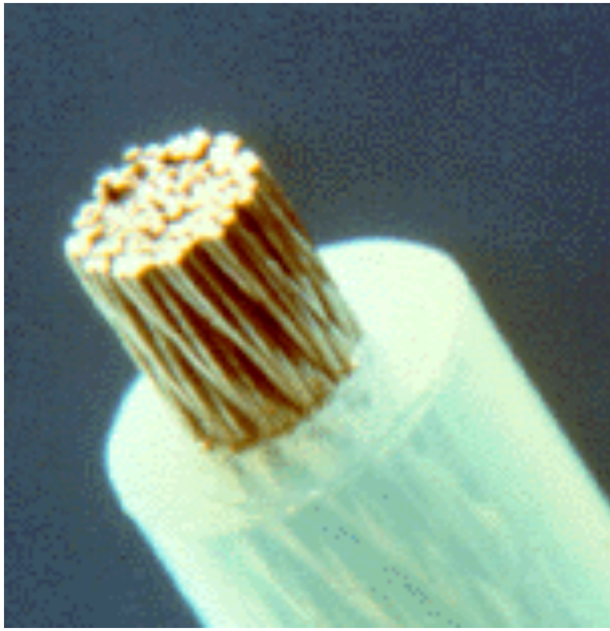
Product Transfer Piping



Typically Consists of:

- Pipe Runs 1,000ft, 300m to Several Miles (kms)
- Minimal Inline Equipment
- Consistent Heat Loss Along Entire Length
- Power Availability Only at Ends

Skin Effect Systems



- Skin Effect Conductor
  - Sized for Specific Application Based on:
    - Circuit length
    - Power (heat) requirements
- Electrical Insulation
  - Fluoropolymer and Polyolefin
    - Specific polymer based on application temperature requirements
    - Insulation thickness based on voltage
  - Additional Scuff Jacket Where Required

Product Transfer Piping

Skin Effect Systems are Adaptable to Site Requirements

Below Grade

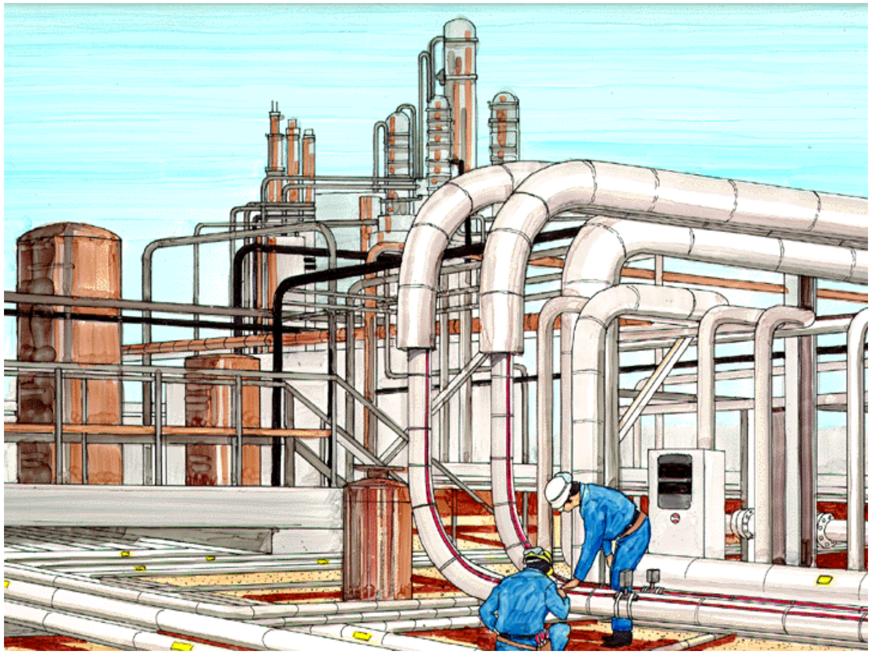
Above & Below Grade

Above Grade

High Maintain or Exposure Temperatures

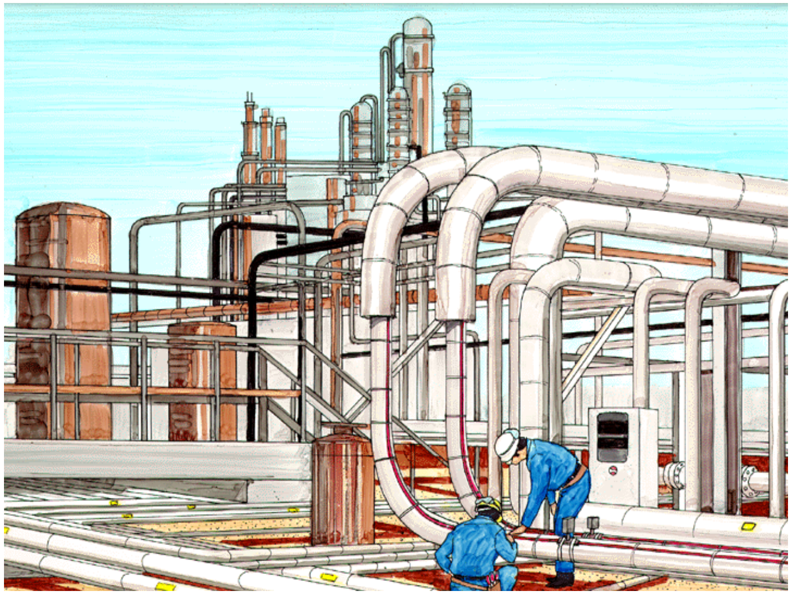
Typically Consists of:

- Process or Byproduct Lines
- Short to Moderate Runs
- High Watt Per Foot Requirements



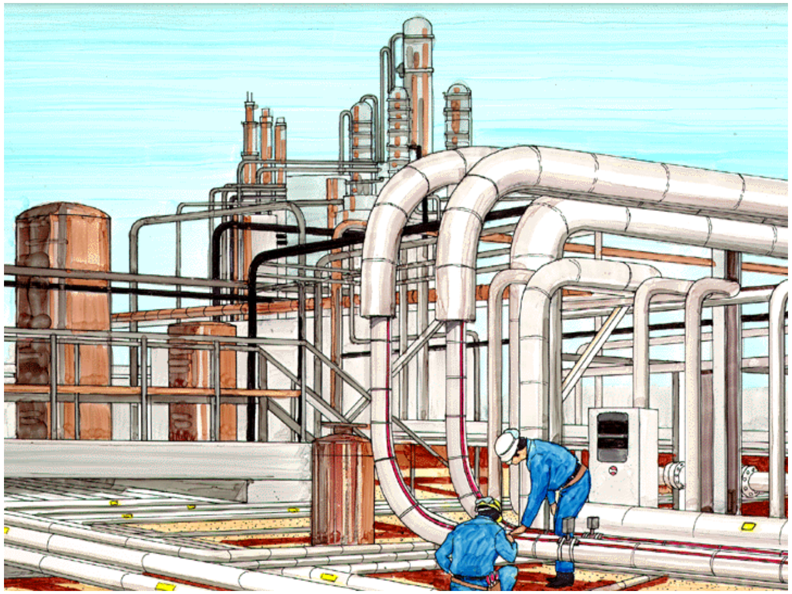
High Maintain or Exposure Temperatures

- Power-Limiting Heating Cables
  - Maintain temperature between 180 - 300 °F, (82-150°C)
  - Cut-to-Length Circuitry
  - Can be overlapped



High Maintain or Exposure Temperatures

- Mineral Insulated (MI) Heating Cables
  - Maintain between 300 - 800°F, (150-425°C)
  - Maximum temp exposures greater than 500 °F, (260°C)
  - Watt densities greater than 20 W/ft, (65w/m)



Recommend the Best and Most Cost Effective Solution

- In-Plant Complex Piping
- Interconnecting Piping
- Product Transfer Pipelines
- High Temperature Applications
- FrostHeave Prevention
- Deicing and Anti-icing

Heat Tracing Cable Selection Guide

	Temperature Considerations				
Job Site Considerations/ Applications	Temperatures 40° to 150°F (4° to 66°C)	Temperatures 150° to 250°F (66° to 121°C) with or without Steam	Temperatures 50° to 150°F (10° to 66°C) with Steam to 366°	Temperatures 200° to 300°F (93° to 149°C) Exposures 400° to 500°F (204° to 260°C)	Exposures Higher than 500°F (260°C)
In-Plant Complex Piping Circuits shorter than 500ft (150m)	Self-Regulating Cable			Power-Limiting Cable	Mineral Insulated Cable
Interconnecting Straight Piping Circuits from 500ft. (150m) to 1000ft. (300m)	Parallel Constant Wattage Cable			Power-Limiting Cable	Mineral Insulated Cable
Interconnecting Piping Circuits from 1000ft.(300m) to 5000ft.(1500m)	Flexible Series Heating Cable				Mineral Insulated Cable
Product Transfer Lines Circuits longer than 5000ft. (1500m)	Skin Effect Heating Cable				Mineral Insulated Cable

Questions ?