THE ROLE OF STANDARDS IN PREDICTING TRACE HEATING SHEATH TEMPERATURES

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Abstract- Often misunderstood, Standards play a key role in predicting trace heating sheath temperatures for applications in explosive atmospheres. This paper will examine the accuracy and application of using the procedures outlined in the current IEC and IEEE Standards. Accurately predicting trace heating sheath temperatures is a key component in the safety, reliability and cost of a trace heating installation. The type test outlined in the current IEC and IEEE Standards are also a key component in third party certification of trace heating for use in explosive atmospheres. This paper will also address the procedures used by certification bodies and test laboratories in verifying the accuracy of a manufacture's design calculations and installation recommendations.

Index Terms - Trace Heating, Heat Tracing, Explosive Atmospheres, Standards, Type Test, Certification Bodies, Test Labs

I. INTRODUCTION

The concept of establishing a T-Rating for trace heating involves an clear understanding of the test requirements from national and international standards, the heat transfer and thermodynamic relationships of the equipment, and thermal insulation and the specific trace heating product characteristics. Over the years the Type Tests in standards have been used to confirm the manufacturers' knowledge and ability to predict trace heating sheath temperatures. Laboratory test data, developed according to the type test found in standards is compared to those temperatures determined by the manufacturer or designers. The methods used by manufacturers and designers are often very sophisticated proprietary software programs that analyze the design information. The role of Notified Body-Test Labs is to evaluate the manufacturer/designers capability to predict maximum sheath temperatures and thus establish a "T-rating" for specific designs or evaluate a specific product "T- rating for trace heaters.

II. EVOLUTION OF SYSTEMS TEST

In the absence of industry standards the first certification of trace heating for explosive atmospheres was provided by conducting tests which represented actual installation conditions. The tests were first witnessed and verified by Underwriters Laboratories under their "Listing by Report" process during the early 1970's. The purpose of the test was to verify the manufacture's ability to predict heat tracing sheath temperatures and establish a 'T' Rating. These tests became known as the Pipe Sculpture Test. The Pipe Sculpture Test was formalized in 1983 with the publication of IEEE 515 Standard for the Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications. Also in 1983 British Standard 6351 Electric Surface Heating Part 1: Specification for Electric Surface Heating Devices was published. This standard used a different approach to maximum temperature determination. A plate test apparatus designed to test a variety of surfaces heaters was developed to confirm the maximum surface temperature for specific devices under varying load conditions. In January 2001 IEC 62086, Electrical Apparatus for explosive gas atmospheres, Electrical Resistance Trace Heating Parts 1 and 2 were published. This standard was based on IEEE 515 and adopted the Pipe Sculpture Test. This standard was revised and published as IEC 60079-30 Explosive Atmospheres Electrical Resistance Trace Heating, Parts 1 and 2 in January 2007. At the time of the writing of this paper IEC 60079-30 and IEEE 515 are being revised under a joint development process with the goal of publishing one International Standard for Electrical Resistance Trace Heating for use in Explosive Atmospheres.

III. THEORY

Understanding and documenting the basic theory and equations used in predicting sheath temperatures is critical in the development of a test apparatus and evaluating the results of the test. The discussion in this paper will focus on sheath temperatures for trace heating cables. The specific examples addressed will be for Mineral Insulated (MI) Type trace heating cables installed on piping systems. Other surface heating devices use the same basic concepts with the formulas modified to address the different physical geometries. The basic starting place is to determine the maximum "work piece" (pipe or equipment) temperature.

Equation 1 is the basic formula for determining the maximum temperature of a cylindrical geometry (pipe) at the maximum trace heater output and at the maximum ambient temperature.

$$T_{pr} = \frac{W}{\pi}\left[\frac{1}{D_1 \times h_i} + \frac{\ln(D_2/D_1)}{2 \times k} + \frac{1}{D_2 \times h_{co}} + \frac{1}{D_2 \times h_o}\right] + T_a$$

Equation (1)

where

T_{pr} is the maximum runaway pipe, or tube, temperature (°C),

W is the maximum heating device output at operating voltage and maximum pipe or tube, temperature (W/m), and

T_a is the maximum ambient temperature (°C).

Knowing the maximum pipe or (workpiece) temperature the maximum sheath temperature for metallic pipes can be calculated using Equation 2.

$$T_{sh} = \frac{W}{U \times C} + Tp \qquad \text{Equation (2)}$$

where

T_{sh} is the heating device surface temperature (°C),

W is in W/m for trace heaters

C is the trace heater circumference (m)

U is the overall heat-transfer coefficient (W/m^2·°C), and

T_p is the pipe or workpiece temperature (°C).

The U in Equation 2 is the most important and probably least understood element in the determination of trace heating sheath temperatures. The variable U or overall heat transfer coefficient can be affected by the geometry, temperature, emissivity of the trace heater, method of attachment of the trace heater, and is a combination of conductive, convective and radiation heat transfer modes. Trace Heating manufacturers devote significant resources to empirically determine the value to be used for U in calculation of sheath temperatures for the many products and product applications.

The maximum runaway pipe temperature, $T_{pr,}$ or equilibrium pipe temperature with no control is shown graphically in Fig. 1. It is based on the conservative conditions of (1) ambient temperature of 40°C; (2) tracer power output is the maximum of the manufacturer's tolerance at 110% of rated voltage, and (3) heat loss with no wind condition and no safety factor. The maximum runaway pipe temperature is found at the intersection of the maximum power line and the heat loss line for the above conditions.

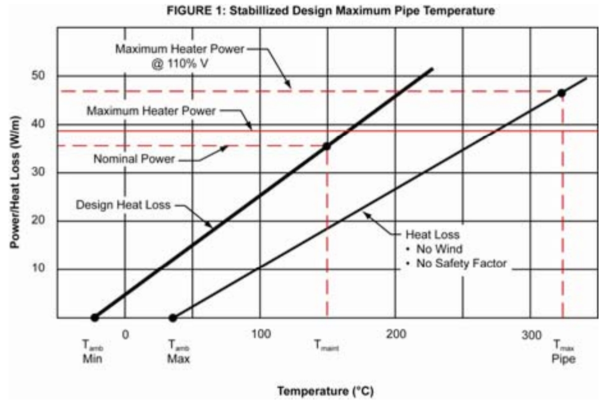


Fig. 1 Stabilized Design Maximum Pipe Temperature for Constant Power Trace Heaters

Fig. 1 illustrates the compounding effect of these conservative conditions. The resulting maximum runaway pipe temperature, T_{pr}, is then used in equation (2) to calculate maximum tracer sheath temperature, T_{sh}, and compare it to the area T-rating or Auto Ignition Temperature (AIT). The above can be assumed to be correct for cylindrical pipes. However, if the piping system consists of flanges, valves and other piping fittings, and additional cable is added to offset the increased heat loss, then the maximum workpiece temperature must be determined to accurately predict the maximum sheath temperature.

Also, if the maximum process temperature, T_{pm}, is higher than the maximum runaway temperature, the maximum process temperature must be used in calculating maximum sheath temperature using the following equation:

$$T_{sh} = \frac{W_m}{U\,C} + T_{pm} \qquad \text{Equation (3)}$$

Standards IEC 60079-30 and IEEE 515 also provide for a "controlled design method". A temperature control device is used to limit the maximum pipe temperature. When the sensor is located on the pipe away from any influence from the heat tracers, T_{pr}, in equation (1) becomes the set point of the temperature control device. With a lower pipe temperature the resulting tracer sheath temperature will be much lower. Figure 2 shows the pipe temperature reduction using the "controlled design method".

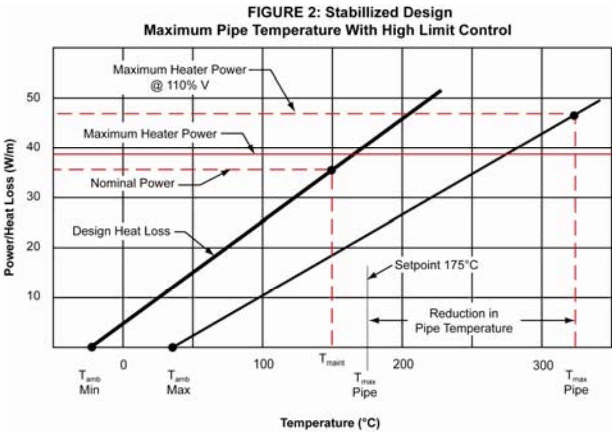


Figure 2: Stabilized Design Maximum Pipe Temperature with High Limit Control

A temperature limiter technique may also be used to limit the maximum sheath temperature. In this case the sensor may be located on the trace heater or at an artificial "hot spot". For these cases an offset temperature must be empirically determined and used in Equation 4 to predict trace sheath temperature.

$$T_{sh} = T_L + \Delta T_{offset} \qquad \text{Equation (4)}$$

where

T_L= Set point of the temperature limiter

ΔT_{offset} is the emperically determined temperature difference between the set point of the temperature control device and the actual maximum trace heater sheath temperature.

ΔT_{offset} is a function of variables such as:

- geometry and mass of heating device and sensor
- power output of the heating device
- heat transfer coefficient
- control system hysteresis
- position of the sensor relative to the workpiece and insulation
- position of the sensor relative to possible heat sinks of the workpiece
- position of the sensor relative to hotspots like crossing trace heaters

Because of these variables it is important that the position and method of installation of the sensor are described in the manufacturer's installation instruction manual.

The preceding discussion provides the theoretical basis for predicting maximum tracer sheath temperature.

IV. SYSTEMS METHOD

A. Pipe Sculpture

The pipe sculpture in the Systems Method test included in IEEE 515 and IEC 60079-30 provides verification of the manufacturer's design methodology and calculations for maximum tracer sheath temperature for a stabilized design. This pipe sculpture consists of a representative piping system with components such as a valve and flanges. The manufacturer's trace heater installation techniques on this representative system will affect the resulting sheath temperatures. Figure 3 shows the pipe sculpture in IEEE 515 and IEC 60079-30.

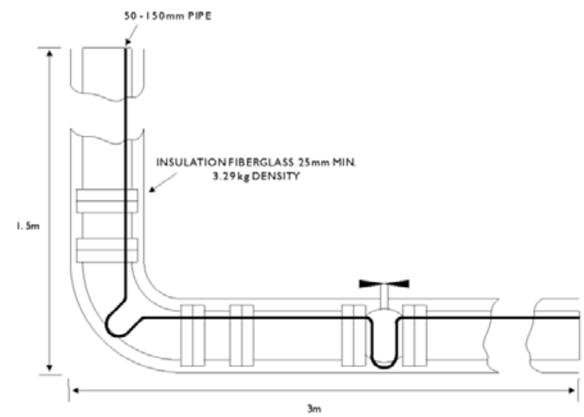


Figure 3

Thermocouples are placed on the trace heater at anticipated "hot spots". If the trace heater is allowed, by the manufacturer's installation instructions to cross over itself, a thermocouple is placed on the tracer at the cross over location. Usually direct contact between the tracer and pipe or work piece is difficult to accomplish on a flange or valve body. A thermocouple is placed on the trace heater at a location where the tracer is not in contact with the flange or pipe. The resulting test trace heater maximum sheath temperatures shall not exceed the manufacturer's calculated value by more than 10K. This 10K is to allow for measurement uncertainty of the test conditions. Sheath temperatures are not allowed to exceed the 'T' Class determined on an actual application. To satisfy this requirement the manufacturers must make sure that the overall heat transfer coefficient , U, or ΔT between the tracer sheath and workpiece used to predict maximum sheath temperature adequately accounts for lack of contact or trace heater cross over. The pipe sculpture test also verifies the manufacturer's ability to correctly model thermal insulation conditions, still air convective heat transfer, heat loss with no safety factor and predict "run away" equilibrium pipe temperatures to meet stabilized design conditions. The systems test also provides a means to verify a manufacturer's ability to predict tracer maximum sheath temperature for the "controlled design" approach. The trace heater is installed per the manufacturer's installation procedures. The temperature controller sensor is installed on the pipe, tracer, or artificial "hot spot" per the manufacturer's procedures. Instead of using maximum pipe equilibrium temperature to predict maximum tracer sheath temperature the temperature controller set point is used for the calculation. As with the stabilized design requirement, the resulting trace heater maximum sheath temperatures must be no higher than 10 K above the manufacturers predicted maximum sheath temperature.

For the case where the manufacturer's recommends a over limit controller, and the sensor to be installed on the trace heater or artificial ”hot spot”, this test also verifies the manufacturer's ability to predict the temperature offset as shown in Equation 4.

B. Plate Test

IEC 60079-30 states that an alternative to the pipe sculpture test may be considered. In some instances this was a test similar to the plate test in BS 6351. Recently, IEEE WG 515 has incorporated the plate test as an alternative test for establishing ΔT between the tracer sheath and work piece in the recent IEEE 515 revised (Nov. 2010 Ballot Draft) . It consists of the tracer installed on a metallic plate (aluminum or stainless steel) with provisions for a 5mm air gap between the trace heater and the plate. The measured ΔT between the tracer sheath and work piece is added to the measured maximum equilibrium pipe or work piece temperature from the pipe sculpture test. The resulting sheath temperature shall not exceed the manufacturer's calculated value by more than 10K. This 10K is to allow for measurement uncertainty of the test conditions. Sheath temperatures are not allowed to exceed the ‘T’ Class determined for an actual application.

Figure 4

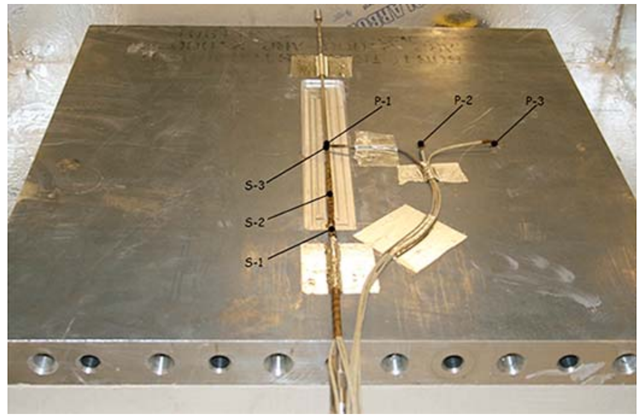


Figure 5

V. Pipe Sculpture and Plate Test Data and Analysis

A. Standards Type Test Data

Sheath Temperature type test outlined in detail in IEC 79-30 Part 1 and IEEE 515 (Nov. 2010 Ballot Draft) were conducted over a range of trace heater power outputs and pipe and or plate temperatures. The pipe sculpture test apparatus is seen in Fig 4 and the plate test and its associated thermocouple layout is seen in Fig 5. The critical locations for thermocouple for the pipe sculpture are the flange region shown in Fig 6.

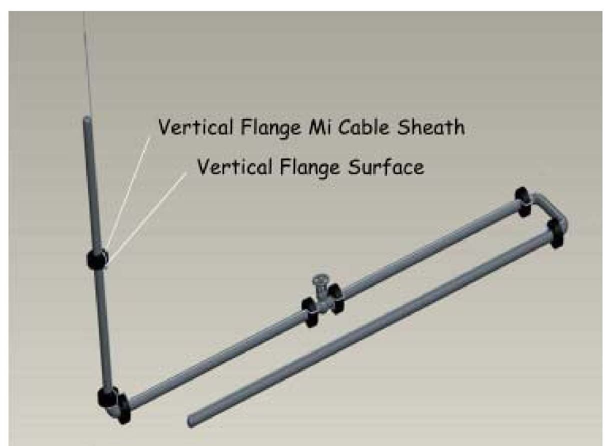


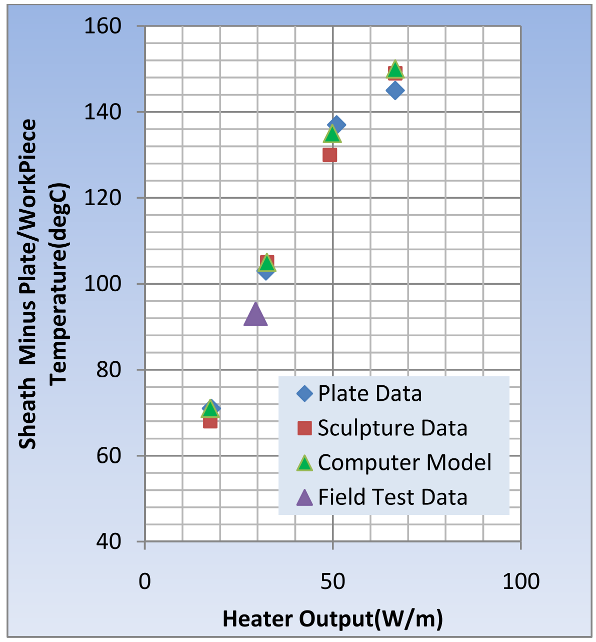
Figure 6

The power outputs of the trace heaters were set for the pipe sculpture and plate test at approximately 16, 32, 49, and 65 Watts/meter (5, 10, 15, 20 watts/ft). The temperature data for each power output level on the pipe sculpture and plate test is listed below.

Plate			
Tplate (degC)	Tsheath (degC)	Delta T (degC)	Heater Output (W/m)
189	334	145	66.6
159	296	137	51
124	227	103	32.2
81	152	71	17.7
Sculpture			
Tworkpiece (degC)	Tsheath (degC)	Delta T (degC)	Heater Output (W/m)
206	355	149	66.6
156	286	130	49.2
122	227	105	32.5
79	147	68	17.4
Computer Model			
Tworkpiece (degC)	Tsheath (degC)	Delta T (degC)	Heater Output (W/m)
206	356	150	66.6
156	291	135	49.9
123	228	105	32.5
80	151	71	17.4

Test Data Summary

The pipe sculpture was allowed to run until thermal equilibrium and then data recorded. The temperature of the plate was set at the maximum pipe/equipment temperature experienced on the pipe sculpture test, for each wattage. It is extremely important to recognize that the maximum pipe/equipment temperature on the pipe sculpture test without control was found to be at the flange on a vertical rise. This "hot spot" is due to the additional cable added to the flange to offset the increased heat loss at this location and the lack of contact between heat tracer and the pipe or flange, see figure 6 In addition it is industry practice to overlap the pipe and thermal insulation at this point which increase the temperature; this is normal practice in the trace heating industry.



Graphical Analysis

B. Analysis of Test Data

Considering experimental error the maximum trace heater sheath temperatures recorded on the pipe sculpture and plate test are almost equivalent when the plate temperature is at the same temperature as the maximum pipe/equipment temperature on the pipe sculpture.

For additional verification a computer model for predicting trace heating sheath temperatures with the specific data from the pipe sculpture was used to perform theoretical calculations. The computer calculations and test data have similar results.

C. Field Test Data

To validate experimental data and test techniques a chemical manufacturing company with extensive installations of MI Type trace heating cable installations agreed to allow temperature and power measurements to be taken during operating conditions. A circuit was selected that would mechanically resemble the pipe sculpture test. The following data was recorded.

Pipe Size: 3"
Insulation: 1.5" Perlite
Heater Length: 68.6 Meters
Applied Voltage (Measured): 187 V
Measured Circuit Current: 10.8 Amps
Calculated Power Density: 29.44 W/m

Horizontal Flange
Temperature (Measured): 26 °C
Sheath Temperature (Measured): 118 ° C

As can be seen in the graphical analysis the field data and the experimental data are very similar.

VI. Approval Process (at the Certification Body)

A. Market responsibilities

It is the responsibility of the legal entity which brings a product to the market to ensure that the regulations for that market are met. This legal entity might be the manufacturer but could also be a legal representative of that manufacturer. For ease of reading the legal entity which brings a product to the market is referred to as manufacturer for the rest of this paper.

The manufacturer has to analyze his market and find out what the applicable legal regulations are. On most markets the legal regulations refer to international standards such as IEC 60079-30, IEEE515 or their nationalized versions.

The IEC 60079-30 standard is to be applied in combination with the IEC 60079-0 standard “Explosive atmospheres - Part 0: Equipment - General requirements” for use in Zone 1 or Zone 2 potentially explosive atmospheres. Compliance with these IEC standards may be certified under the IECEx System in the Certified Equipment Scheme.

Because of the parallel voting agreement between IEC and CENELEC these IEC standards can also be used as the basis for ATEX certification. Additionally the European national differences will have to be incorporated. These national differences are listed in the coversheets which CENELEC attaches to the IEC standards in order to publish the complete package as EN standards. For ATEX these national differences apply only to the marking of the equipment and instruction manuals. There are no additional technical or testing requirements.

The IEEE515 standard is to be applied in combination with the US National code for use in Zone 1, Zone 2 and Division 1 and Division 2 Hazardous area in the US and other countries, and operating plants, applying the same US Standards.

The scope of this part of the paper is limited to the two standards, IEC 60079-30 and IEEE 515. But, for completeness it should be mentioned that other standards exist for certain markets. For example CSA 22.2 No. 130-03 for Canada, this standard shows similarities, with IEC 60079-30 and IEEE515 but also differences, and therefore the information given in this paper does not entirely apply to the Canadian standard.

The manufacturer has to select the relevant standard for design of the equipment. In most countries third party approval by Certification Bodies is required. As such, the role of the Certification Body and its Test Laboratory is to assess and certify that the manufacturer has correctly designed its products against the standards he has selected.

By most regulations, (certainly under ATEX and within the IECEx Scheme), the Certification Body and the Test Laboratory have to be qualified or accredited to perform these assessment and certification activities.

B. Standards Requirements

Before 2011 the application of the plate test was only allowed within the scope of IEC 60079-30, because IEC 60079-30 allows alternative test methods to the pipe sculpture test agreed between the Certification Body and the manufacturer. Most Certification Bodies have been accepting the plate test method based on BSI 6351 part 1.

Since 2011 the latest (draft) revision of IEEE515 does include the necessary requirements allowing the use of the plate test as alternative to the pipe sculpture test in order to determine worst case temperature difference between workpiece and trace heating sheath temperature.

The current joint development of IEC 60079-30 and the latest version of IEEE515 are a major improvement in terms of development and certification cost for manufacturers, but also an improvement for Certification Bodies since the instructions for testing are much less ambiguous. This joint development is facilitated by both IEC and IEEE at the same time and will lead to one standard with the number IEC-IEEE 60079-30 part 1 and part 2.

C. Selection of Maximum Sheath Temperature Test Method

Once the appropriate standards are applied and corresponding Certification Body is selected by the manufacturer the selection of test methods can take place.

A Certification Body qualified and accredited to IEC 60079-30 and/or IEEE515 is required to understand all test methods and their thermodynamic principles. IEC 60079-30 allows a custom maximum sheath temperature test to be agreed between the Certification body and the manufacturer. To date the pipe sculpture and hot plate test are the only tests which have demonstrated reliability in predicting the maximum sheath temperature.

Practically, maximum sheath temperature test results from the past might show higher temperature test results with either one of the test methods. It may depend on the design and construction of the trace heater. A detailed study of a number of test results large enough to draw conclusions about this topic has not been determined by the Certification Bodies. However the 30+ year history of using the pipe sculpture test and industry experience does give considerable creditability to using this test method to verify the manufacturer’s ability to predict maximum workpiece and trace heater sheath temperatures. Both test methods can be used for Zone 1 and Zone 2 Explosive Atmospheres (also Division 1 and Division 2

Hazardous Areas in case of IEEE 515). The difference in testing for both Zones (or both Divisions in case of IEEE 515) is the Voltage applied to the test specimens. For controlled temperature designs there are differences in requirements for the equipment limiting the temperature of the trace heating in Zone 1 and Zone 2.

The temperature test methods are also applicable for very cold environments. In both IEC 60079-30 and IEE515 the ambient temperature is defined to be the temperature outside of the thermal insulation. The ambient temperature has influence on the workpiece temperature and therefore the maximum surface temperature of the trace heater, but might very well be overruled by the process temperature of the workpiece in an operating plant. Cold environments are addressed in both IEC 60079-30 and IEEE515. These standards contain mechanical and start-up current tests to be performed at those cold conditions. Further explanation of these tests would go beyond of the scope of this paper.

Test Laboratories are qualified according to IEC/ISO 17025 and other applicable requirements. The acceptance of the test method proposed by the manufacturer depends on the following factors:

1. Determination, if the proposed test method matches the application as described in the instruction manual or other approval documentation provided by the manufacturer.
2. The availability of a testing facility.
3. The test equipment of the testing facility is required to be compliant with the requirements of IEC 60079-30 or IEEE515.
4. The measurement equipment is required to be appropriately calibrated as required by ISO/IEC 17025.
5. Personnel are required to be appropriately qualified to perform the individual tests as required by ISO/IEC 17025.
6. The sampling method is required to comply with the requirements of ISO/IEC 17025.
7. The reporting is required to comply with the requirements of ISO/IEC 17025.

The required test apparatus are often very specific. The physics behind the test methods usually guarantee only representative and repeatable test results when the tests are performed on the manufacturers test equipment at the manufacturer's premises.

Under most certification schemes, testing at manufacturer's site is allowed only if the Certification Body or its Test Laboratory sends a qualified employee or qualified representative under contract to perform the tests at the manufacturer's premises or witness the tests performed by the manufacturer's personnel.

In most cases witness testing is preferred in order to avoid problems with local employment regulations and liability issues.

D. Determination of Samples and Test Conditions

The determination of samples and test conditions and parameters are agreed between the Certification Body and manufacturer prior to the performance of the tests.

The Certification Body often uses the manufacturer's instruction manual and data sheets to determine appropriate, often critical, samples and test conditions.

In many cases it is too complex and unrealistic to test each and every option of the trace heating equipment. A selection of trace heaters which will cause the "worst case test" (highest sheath temperatures) is determined. For example:

- samples with the highest and lowest power output rating
- samples , having specific properties, such as:
    - different trace heater sheath materials
    - trace heater sheath dimensions larger or smaller than the dimensions of the sample having the highest and lowest power output rating.

The samples shall be within the upper half of the heating device's thermal output tolerance or test conditions shall be considered to achieve similar results.

Different trace heater designs or constructions cannot be mixed. For each different design or construction these tests have to be performed.

In order to determine if the manufacturer is able to predict the maximum pipe temperature or trace heating sheath temperature, sheath temperatures are validated by sampling varied parameters such as power densities and pipe temperatures as agreed between the certifying agency and the manufacturer.

E Assessment of Prediction Method by Manufacturer

The Certification Body assesses the capability of the manufacturer to predict the maximum sheath temperature of the trace heater.

The Certification Body requires the manufacturer to provide the maximum trace heater sheath temperature predictions for the samples being tested, under the test conditions and test parameters agreed earlier in the assessment process.

The design formulas mentioned in the IEC 60079-30 and/or IEEE 515 are used by the Certification Body together with the results of the temperature tests for general comparisons with the manufacturer's calculations.

However, many manufacturers use sophisticated computer design programs or calculation sheets in order to calculate the values mentioned in Figure 1. These computer programs may also determine many more parameters important to design of trace heating circuits such as power supply systems and selection of the appropriate current protection devices.

Since these programs use:

- More sophisticated algorithms than the formulas mentioned in the standards
- May work with databases containing experimental test results for special applications
- May calculate using many iterations

The Certification Body can only do a rough check of the manufacturer's methods and accuracy for determining maximum sheath temperatures.

For the Certification Body the proof of the sheath temperature predictions are the tests results of the pipe sculpture or in combination with the plate test results.

The parameters presented in the calculation are important for the Certification Body in order to check if the actual tests correlate to the previously provided design calculations.

For checking the pipe sculpture temperature test the following parameters are important:

- Power output of the trace heater
- Insulation thickness and material
- Trace heater dimensions
- Maintenance temperature
- Maximum pipe and workpiece temperature
- Maximum sheath temperature

For checking the hot plate temperature test the following parameters are important:

- Power output of the trace heater
- Maximum workpiece temperature (determined from the pipe sculpture test
- Maximum sheath temperature
- Trace Heater dimensions

F. What is Witnessed (NB's objectives)

Prior to or at the beginning of the witness test session the laboratory is assessed to comply with the regulations for which the Certification Body is qualified or accredited. For example the requirements of IEC/ISO 17025 as listed above.

It is the Certification Bodies' responsibility to check if the samples of trace heating used for the temperature tests have the power output rating or resistance as agreed during the sample selection. The Certification Body will witness the power output tests or resistance and ensure that the samples used for the temperature tests are either:

- The same samples used for the verification of power output
- Or determine the samples have been selected from the same production batch

The pipe sculpture and hot plate tests are witnessed in parallel or afterwards. The parameters of the design calculations mentioned above are correlated to the test fixtures of the pipe sculpture test and/or hot plate test.

The final objective of this exercise is to determine how well the manufacturer can predict the maximum sheath temperature of the trace heating system.

Crucial to the reliability of these test methods and in fact the complete certification against IEC 60079-30 and IEEE515 are the instruction manuals of the manufacturer. Trace heating is mostly supplied as separate parts which have to be assembled and installed in the field. The temperature tests are performed per the parameters defined by the manufacturer in his instruction manual. Therefore the safety of the Trace Heating is depending very much on the quality of the instruction manual. Therefore Certification Bodies or Notified Bodies qualified for certifying against IEC 60079-30 do assess the instruction manuals of the manufacturers very carefully and include these documents in the controlled test documentation for certification. More information about instruction manuals can be found in "Importance of Instruction Manuals for use with Hazardous Area Equipment" (1)

G. T-ratings on Trace Heating Certificates

The T-ratings mentioned in hazardous area marking for divisions as well as Zones are indicators for the maximum surface temperature the equipment on which the marking is applied can attain.

Zones	Divisions	Max. Surface Temperature
T1	T1	450 °C
T2	T2	300 °C
	T2A	280 °C
	T2B	260 °C
	T2C	230 °C
	T2D	215 °C
T3	T3	200 °C
	T3A	180 °C
	T3B	165 °C
	T3C	160 °C
T4	T4	135 °C
	T4A	120 °C
T5	T5	100 °C
T6	T6	85 °C

T-classes

The T-rating on certificates of trace heating equipment, which are based on stabilized or controlled design, usually contain a range of achievable T-classes, since the T-class depends on the actual application.

The engineer specifying the trace heating for use in a hazardous area has to ensure that the maximum surface temperature (sheath temperature) stays below the auto ignition temperature. The general requirements for equipment approval standards call for a safety margin of 10 K for T1 and T3 and 5 K for T3 through T6. This means, that the predicted maximum sheath temperature by the manufacturer should always be lower than the maximum surface temperature correlating to the above mentioned T-classes.

Temperature tests are crucial for hazardous area certification of trace heating. Due to material costs and the costs of installation, the industry strives to apply trace heating with the maximum power density of the trace heater. For safety reasons in hazardous area on the power density often has to be limited in order to stay below the auto ignition temperature of the gas mixture which might be present in the atmosphere.

This is the reason why the IEC 60079-30 and the IEEE515 pay so much attention to the determination and verification of the maximum pipe and sheath temperature.

VII. CONCLUSIONS

Test methods in IEEE 515 and IEC 60079-30 provide a means to verify a manufacturer's ability to predict maximum tracer sheath temperatures for explosive atmosphere applications. Detailed testing and experience have shown these test methods to be reliable. Notified Bodies rely on the tests in these standards to certify manufacturer's T-ratings.

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(5) IEC 60079-30-2 Explosive Atmospheres-Electrical Resistance Trace Heating-Application Guide for design, installation and maintenance

IX. VITA

Rudolf Pommé, Certification Manager Explosion Safety with an IECEx Certification Body, IECEx Testing Laboratory and ATEX Notified Body in The Netherlands, fifteen years of experience in application engineering, production, product development and certification of equipment for use in potentially explosive atmospheres in the Petrochemical Industry. He graduated from the Institute of Technology with a Bachelor of Engineering in Applied Science, Industrial Engineering and Management Science. He is a member of NEC31, WG IEEE515, IEC MT 60079-30 and a Liaison with MT17 WG27 for IEC 62395. He participated in three technical papers and one tutorial at PCIC Europe as author, co-author and presenter. One of the papers was presented in 2009 with the title "Importance of Instruction Manuals for use with Hazardous Area Equipment".

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