Standard's Requirements

for Electrical Resistance Trace Heaters according to DIN EN 60079-30-1

by Frank Merkel

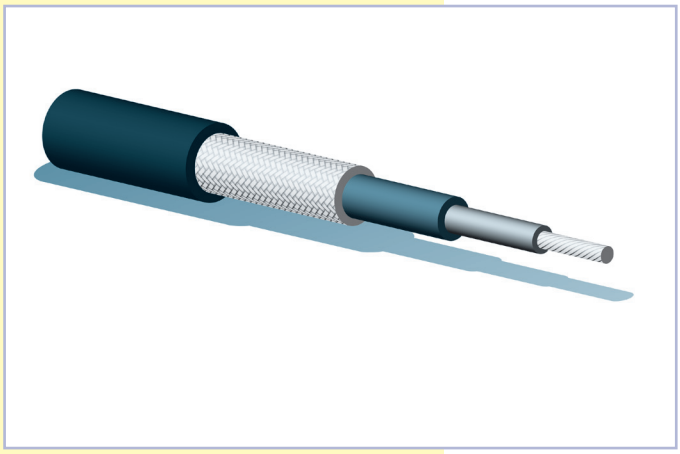


Figure 1: Heating cable cross-section

Electrical resistance trace heaters are used for heating fittings, conduits and tanks. Resistance trace heaters (hereinafter referred to as ›resistance heaters‹) are understood as meaning, according to the standard DIN EN 60079-30-1, the ›use of electrical trace heaters, trace heater pads or trace heater panels and auxiliary components applied from outside, in order to increase or maintain the temperature of the contents of pipe networks, tanks and associated equipment.‹ [1]

The functional principle is very simple: A cable-like heating element produces and transmits heat based on Ohm's law ($P=U \times I=U^2/R=I^2xR$). The field of application ranges from frost protection to the prevention of condensation in gas analysis and to the heating of media for production and processing.

This is where electrical resistance heaters are more suitable than the previously frequently used vapour-operated trace heaters as they work extremely economically and more accurately in terms of temperature. In practice, electrical resistance heaters are often the basis for an optimum process sequence and have become indispensable in many areas and applications in today's industry.

It is not always easy to find the right trace heater solution for special applications, since the electrical resistance heaters available on the market (for example, heating cables, heat traces, parallel heat traces, self-limiting heat traces, etc.) have widely differing heating characteristics and only give the desired result when suitably selected and properly applied. The fields of application for resistance heaters are as varied as the quotations on the market. A good overview and extensive practice-related information on this specialist area are given in the VIK recommendation (Association of the Industrial Energy and Power Industry, Germany) ›VE 25 Electrical Trace Heaters‹ [2]. This recommendation was compiled by an ad-hoc study group ›Electrical Trace Heaters‹, a joint VIK and NAMUR (NAMUR is an international user association of automation technology in process industries) commission, and published in 2003. Representatives from renowned manufacturers for electrical trace heating systems and ›notified bodies‹ have contributed their expert knowledge and created a very extensive and practice-oriented composition.

When electrical resistance heaters are used in hazardous areas, apart from the technical component, the basic requirements and safety specifications of the corresponding Ex standards must also be observed. Not every resistance heater is suitable or admissible for use in hazardous areas, but each one must always be carefully selected and considered from two sides during planning and construction. On the one hand, a basic feature is its suitable application in the process and, on the other hand, the inclusion of type-specific properties of the electrical resistance heater a) when operated in accordance with its intended use and b) during malfunction.

If the electrical resistance heater can be used in stabilized design (DIN EN 60079-30-1 [3]), an additional protective system for temperature limitation can be omitted, as design and operation ensure that the temperature will always stay below the critical limiting temperature of the corresponding temperature class in the hazardous area even under unfavourable operating conditions.

If, however, the application requires a higher heating power, making a stabilized application no longer possible, due to the resulting higher operating temperature, it is no longer possible to do without an additional temperature limiting device. The critical limiting temperature will be exceeded in normal operation as well as in case of error, thus becoming a source of danger in the hazardous area.

These and further basic process property requirements and safety-relevant protective measures must be taken into account when planning an electrical resistance heater for operation according to its intended use in hazardous areas.

Many directives, European and international standards and recommendations deal with this topic and must be taken into account when planning and designing electrical resistance heaters.

Two important and basic standards for electrical resistance heaters for use in hazardous areas are:

> DIN EN 60079-30-1 (VDE 0170-60-1):12-2007 ›Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements‹
> the draft version of DIN EN 60079-30-1 (VDE 0170-60-1):05-2012 ›Hazardous areas – Part 30-1: Electrical resistance trace heating - General requirements, type tests and design requirements‹

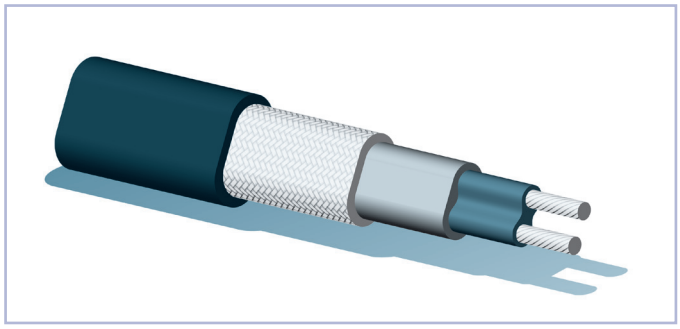


Figure 2: Structure of a self-limiting heating tape

> and DIN EN 60079-30-2 (VDE 0170-60-2):12-2007 ›Explosive atmospheres – Part 30-2: Electrical resistance trace heating – Application guide for design, installation and maintenance ‹
> and the draft version of DIN EN 60079-30-2 (VDE 0170-60-2):08-2012 ›Hazardous areas – Part 30-2: Electrical resistance trace heating – Application guide for design, installation and maintenance‹

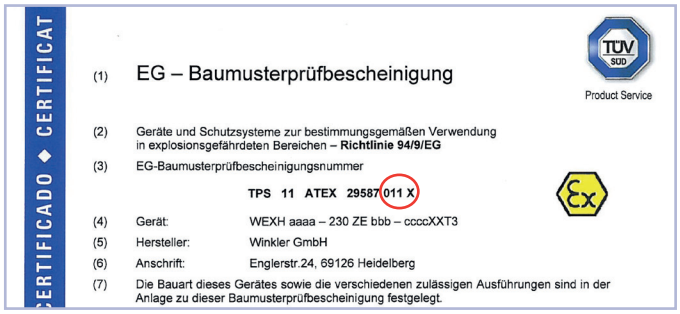
These European standards give a comprehensive overview of the minimum requirements and test requirements (Part 1), and the application guidelines for design, installation and maintenance (Part 2) of electrical resistance heaters that may be used in explosive atmospheres. They are divided into two independent standards, but must be applied together. Part two contains supplementary information for practical application.

Both standards apply to the use of electrical resistance heaters in zones 1 and 2, but not for zone 0, since a frequently or constantly occurring explosive atmosphere is to be expected there, and is why more rigorous requirments apply there.

These standards also contain additional information about the requirements of connection components and about control methods required for safe operation in accordance with the intended use.

The manufacturers of resistance heaters must carry out extensive tests and certifications on their products, before they receive certification in the form of an EC Type Examination Certificate from a ›notified body‹, which makes them suitable for use in explosive atmospheres, and allows them to be marketed.

When selecting the proper resistance heater, particular attention must be paid to any possible limitations or predefined operating conditions for use in hazardous areas. They can have a significant effect on safe operation (e.g. maximum heat conductor load in W/m, maximum operating and use temperatures, special installation requirements or mounting information, etc.). ➔


CERTIFICADO ◆ CERTIFICAT

(1) EG – Baumusterprüfbescheinigung

TÜV SÜD Product Service

(2) Geräte und Schutzsysteme zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen – **Richtlinie 94/9/EG**

(3) EG-Baumusterprüfbescheinigungsnummer

TPS 11 ATEX 29587 011 X

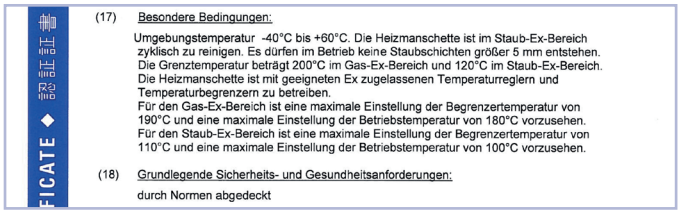
(4) Gerät: WEXH aaaa – 230 ZE bbb – ccccXXT3

(5) Hersteller: Winkler GmbH

(6) Anschrift: Englerstr.24, 69126 Heidelberg

(7) Die Bauart dieses Gerätes sowie die verschiedenen zulässigen Ausführungen sind in der Anlage zu dieser Baumusterprüfbescheinigung festgelegt.

Figure 3: Example of an EC Type Examination Certificate (front page): with certification number and X marking


FICATE ◆ 認証証書

(17) Besondere Bedingungen:

Umgebungstemperatur -40°C bis +60°C. Die Heizmanschette ist im Staub-Ex-Bereich zyklisch zu reinigen. Es dürfen im Betrieb keine Staubschichten größer 5 mm entstehen. Die Grenztemperatur beträgt 200°C im Gas-Ex-Bereich und 120°C im Staub-Ex-Bereich. Die Heizmanschette ist mit geeigneten Ex zugelassenen Temperaturreglern und Temperaturbegrenzern zu betreiben.
Für den Gas-Ex-Bereich ist eine maximale Einstellung der Begrenzertemperatur von 190°C und eine maximale Einstellung der Betriebstemperatur von 180°C vorzusehen.
Für den Staub-Ex-Bereich ist eine maximale Einstellung der Begrenzertemperatur von 110°C und eine maximale Einstellung der Betriebstemperatur von 100°C vorzusehen.

(18) Grundlegende Sicherheits- und Gesundheitsanforderungen:

durch Normen abgedeckt

Figure 4: Example of an EC Type Examination Certificate (back page): chapter 17 Special conditions

A general basic safety requirement of the standard DIN EN 60079-30-1 is as follows: ›Electrical resistance trace heating within the scope of this standard shall be designed and constructed so as to ensure electrical, thermal and mechanical durability and reliable performance. Electrical resistance trace heaters and integral components shall comply with or be excluded from the requirements of IEC 60079-0, as listed in Table 1.‹ [4]

The following requirements are listed in this standard: [4]

> Resistance heaters must be provided with a metal braid or jacket covering at least 70% of the surface.
> The mechanical protection of the insulation layers must be demonstrated by means of an impact and deformation test.
> The highest permissible operating temperature in degrees centigrade must be given. All materials used in the test must withstand at least the highest operating temperature stated by the manufacturer + 20 Kelvin.
> If resistance heaters are fitted with additional mechanical protection, in order to satisfy the requirements of the standard, a label must be affixed to the product indicating that this protection may not be removed on site or that the product may not be operated without it.

Terminations and connections of resistance heaters can be identified as integrated part of a trace heater or identified separately. Integrated components of a resistance heater must be checked according to DIN EN 60079-30-1 and applied according to DIN EN 60079-30-2. Separate components are regarded as Ex equipment or independent Ex components, according to DIN EN 60079-0. [5]

Terminations and connections must be in general subjected to the same tests as the resistance heaters, because they are also used together and thus are subjected to the same environmental and operational conditions. Exceptions are possible, but require special mounting and installation instructions, and possible restrictions for operating the resistance heater. This is indicated in the EC Type Examination by the marking X appended to the certification number (e.g. TPS 11 ATEX 29587 011 X) and in paragraph 17 – Special conditions (see Figures 3 and 4).

A further minimum requirement is that it must be possible to isolate all line conductors from the supply, and that an over-current protection and an earth fault protection must be present. Particularly when operated in TT and TN systems, a protective device must be fitted that guarantees immediate isolation in the event of a high-impedance earth fault and short-circuit faults. An earth-fault protective device, (FI trip level = 30 mA) shall be used for this.

Temperature monitoring of the resistance heater

A trace heating system shall be designed so that the sheath temperature of the trace heaters under standard conditions and in the case of a foreseeable error is limited to the temperature classification (T1 – T6) or ignition temperature. The standard also requires certain safety margins from the maximum operating temperature, which are minus 5 K at temperatures below or equal to 200 °C and minus 10 Kelvin at temperatures above 200 °C.

This requirement can be satisfied either by means of a stabilized design or by using a temperature monitoring system at the resistance heater.

A stabilized design is available when the maximum surface temperature of the resistance heater is stabilized under the limiting temperature without an additional temperature limiter even under unfavourable operating conditions.

The controlled design includes a temperature controller or limiting device. External temperature sensors shall be used with intrinsically safe circuits (Ex i). The temperature controller or limiting device shall de-energize the resistance heater in sufficient time before it exceeds the maximum permissible operating temperature.

The temperature limiter must have the following characteristics:

- Resetting possible only by hand
- Resetting possible only after the normal operating conditions have been returned, or if the switching state is monitored continuously
- Reset only possible by tool or key
- Secured and locked temperature setting to prevent unauthorized access or manipulations
- A safety function that de-energizes the circuit if the temperature sensor malfunctions

Temperature class	Maximum permissible surface temperature of the equipment °C	Ignition temperatures of the combustible materials °C
T1	450	> 450
T2	300	> 300 ≤ 450
T3	200	> 200 ≤ 300
T4	135	> 135 ≤ 200
T5	100	> 100 ≤ 135
T6	85	> 85 ≤ 100

Table 1: Temperature classes

If the temperature monitoring system is not delivered by the same manufacturer that delivered the resistance heater, sufficient information and specifications for the selection and installation of the latter must be provided, in order to give the user the opportunity to procure compatible systems.

Type test of resistance heaters

According to the standard DIN EN 60079-30-1, the following very extensive tests are required, and must be carried out not only on the actual resistance heater, but also on the terminations andconnections, since the latter must be considered integrated parts of the resistance heater. [6]

Required tests:

- Dielectric test [chapter 5.1.2]
- Electrical insulation resistance test [chapter 5.1.3]
- Flammability test [chapter 5.1.4]
- Impact test [chapter 5.1.5]
- Deformation test [chapter 5.1.6]
- Cold bend test [chapter 5.1.7]
- Water resistance test [chapter 5.1.8]
- Water resistance test of integrated components [chapter 5.1.9]
- Verification of rated output [chapter 5.1.10]
- Thermal stability of electric insulating material [chapter 5.1.11]
- Thermal Performance Test [chapter 5.1.12]
- Determination of maximum sheath temperature [chapter 5.1.13]
  - Systems method Design verification procedures [chapter 5.1.13.2]
  - Product classification method [chapter 5.1.13.3]
- Verification of start-up current [chapter 5.1.14]
- Verification of the electrical resistance of electrically conductive covering [chapter 5.1.15]

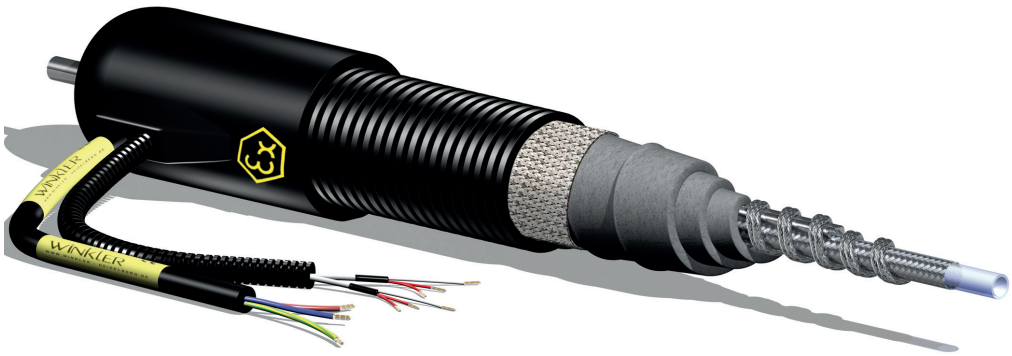


Figure 5: System-certified analyser heating line

Figure 6: System-certified heating jacket

Figure 7: Heating hose with resistance trace heater

Due to their safety-critical application range in explosive atmospheres, where safety is the top priority, the extensive requirements and inspections parameters of resistance heaters are very rigorous. Resistance heaters must withstand the mechanical requirements during mounting/installation reliably and without defects.

Marking of resistance heaters

The resistance heaters shall be clearly and permanently surface marked in accordance with DIN EN 60079-0. [7]
For resistance factory-fabricated heaters, the following information is important:

> Type of protection increased safety ›e‹ and, where appropriate, other types of protection
> Serial or batch number
> Operating or rated voltage
> Output power of the operating or rated voltage
> Month and year of manufacture
> Applicable ambient conditions (example IP degree of protection / application range)

System documentation (Instructions for installation)

For safe operation in accordance with the intended use, it is essential that detailed and comprehensive installation and operating instructions in the language of the operator are enclosed. The installer/operator must find the following information clearly stated in these instructions:

> Information on the intended purpose, the so-called operation in accordance with the intended use
> Information on any additional components that may be used
> Statement that ›Earth fault equipment protection is required for each circuit‹
> Information on important installation and maintenance modalities
> Statement that ›The electrically conductive covering of this trace heater must be connected to a suitable earthing terminal‹.
> Statement that ›The presence of the trace heaters shall be made evident by the posting of caution signs or markings at appropriate locations and/or at frequent intervals along the circuit‹

Conclusion

Although a resistance heater is a relatively simple and manageable piece of equipment that follows a basic physical law (Ohm's law) its application in explosive atmospheres requires extensive planning because of the legal regulations, standards and provisions for safe operation in accordance with its intended use.

When energized, the electric resistance of the heat conductor producing heat and could cause a potential source of danger (source of ignition). Therefore it is necessary to carefully select and plan the resistance heater. When connecting the heat lead with the cold lead, risks of ignition (sparks) must be taken into account. The top priority when using electric resistance heaters in hazardous areas is to avoid

any potential source of ignition. Therefore, no danger may be caused, not only in normal operation, but also in a foreseeable case of error or multiple foreseeable cases of error, as they may have serious consequences in extreme cases, for example in an explosion. This means that, in addition to the required electro-technical expert knowledge, extensive and especially current knowledge in the area of explosion protection are required. By way of example, DIN EN 60079-14 (VDE 0165-1) Explosive atmospheres – Part 14: Electrical installations design, selection and erection may be mentioned. In Appendix F of that document, the knowledge and competences of the responsible persons, craftsmen and planners are listed. [8]

Manufacturers who have their whole product line subjected to a basic and extensive certification by a ›notified body‹, in order to obtain an EC Type Examination Certificate, and include in their delivery extensive system documentation for operation in accordance with the intended use, will have great opportunities in the future in the increasingly unclear market of electric resistance heaters. They are referred to as system-certified explosion protected products (see Figures 5 and 6), for which the manufacturer only receives an EC Type Examination Certificate instead of a separate certificate for each ex-relevant component.

The aim of all these efforts in the area of electric resistance heaters is epitomized by the European Directive 94/9/EC:
›Member States shall take all appropriate measures to ensure that the equipment, protective systems and devices referred to in Article 1 (2) to which this Directive applies may be placed on the market and put into service only if, when properly installed and maintained and used for their intended purpose, they do not endanger the health and safety of persons and, where appropriate, domestic animals or property.‹ [9]

In brief: Safety is the top priority.

References

[1] DIN EN 60079-30-1 (VDE 0170-60-1):12-2007 Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements. Chapter 3.38, page 9

[2] VIK recommendation: VE 25 ›Electrical Trace Heaters‹ VIK Association of the Energy and Power Industry (Version 07/2003)

[3] DIN EN 60079-30-1 (VDE 0170-60-1):12-2007 Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements. Chapter 3.28, page 8

[4] DIN EN 60079-30-1 (VDE 0170-60-1):12-2007 Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements. Chapter 4.1, pages 9 to 10

[5] DIN EN 60079-0 (VDE 0170-1):03-2010 Explosive atmospheres – Part 0: Equipment - General requirements (Chapter 13, page 38)

[6] DIN EN 60079-30-1 (VDE 0170-60-1):12-2007 Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements (Chapter 5, page 11)

[7] DIN EN 60079-30-1 (VDE 0170-60-1):12-2007 Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements (Chapter 6, page 23)

[8] DIN EN 60079-14 (VDE 0165-1) Explosive atmospheres – Part 14: Electrical installations design, selection and erection, Appendix F

[9] Directive 94/9/EC of the European Parliament and Council dated 23 March 1997 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres. Article 2, Paragraph 1