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Introduction

This draft standard is based on European discussions in which the UK has taken an active part. Your comments on this draft are welcome and will assist in the preparation of the consequent British Standard. Comment is particularly welcome on national, legislative or similar deviations that may be necessary.

Even if this draft standard is not approved by the UK, if it receives the necessary support in Europe, the UK will be obliged to publish the official English Language text unchanged as a British Standard and to withdraw any conflicting standard.

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1	2	(3)	4	5	(6)	(7)
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/ Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



31/1110/CDV

COMMITTEE DRAFT FOR VOTE (CDV) PROJET DE COMITÉ POUR VOTE (CDV)

Project number Numéro de projet		IEC/IEEE 60079-30-2/Ed1					
IEC/TC or SC: TC 31 CEI/CE ou SC:		Secretariat / Secrétariat GB					
☐ Submitted for parallel voting in CENELEC ☐ Soumis au vote parallèle au CENELEC	Date of circulation Date de diffusion 2014-04-18		Closing date for voting (Voting mandatory for P-members) Date de clôture du vote (Vote obligatoire pour les membres (P)) 2014-07-18				
Also of interest to the following committees Intéresse également les comités suivants		Supersedes document Remplace le document 31/993/CD and 31/1003A/CC					
Proposed horizontal standard Norme horizontale suggérée ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the TC/SC secretary Les autres CE/SC sont requis d'indiquer leur intérêt, si nécessaire, dans ce CDV à l'intention du secrétaire du CE/SC							
Functions concerned Fonctions concernées <table border="0"><tr><td>☐ Safety Sécurité</td><td>☐ EMC CEM</td><td>☐ Environment Environnement</td><td>☐ Quality assurance Assurance qualité</td></tr></table>				☐ Safety Sécurité	☐ EMC CEM	☐ Environment Environnement	☐ Quality assurance Assurance qualité
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Title : IEC/IEEE 60079-30-2/Ed1: Explosive atmospheres - Part 30-2: Electrical resistance trace heating - Application guide for design, installation and maintenance

Introductory note

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPLOSIVE ATMOSPHERES –

Part 30-2: Electrical resistance trace heating – Application guide for design, installation and maintenance

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International Standard IEC/IEEE 60079-30-1 has been prepared by MT 60079-30 of the IEC technical committee 31: Equipment for explosive atmospheres, in cooperation with the Petroleum & Chemical Industry Committee of the IEEE Industrial Applications Society under the IEC/IEEE Dual Logo Agreement.

NOTE A list of IEEE participants can be found at the following URL: (to be provided prior to publication)

This Part 30-2 is to be used in conjunction with IEC/IEEE 60079-30-1:XXXX, *Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements*.

The list of all parts of IEC 60079 series, under the general title *Explosive atmospheres*, can be found on the IEC website.

This edition cancels and replaces the first edition of IEC 60079-30-2 published in 2007 and constitutes a technical revision.

The revisions include a general review and updating of the first edition of IEC 60079-30-2, harmonization with IEEE Std. 515, and the following significant changes:

- the re-location of trace heater product design methodology and requirements to IEC/IEEE 60079-30-1;
- the re-location and/or duplication of information on installation, maintenance, and repair to the MTs under SC31J for their addition into IEC 60079-14, IEC 60079-17, and IEC 60079-19;
- the inclusion of more detailed information on safety showers and eyewash units;
- the introduction of Annexes from IEEE Std. 515

The significance of changes between IEC 60079-30-2 Edition 1 and IEC/IEEE 60079-30-2 Edition 2 are as listed below:

Changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
Addition of clarification for the exclusion of areas coverage classifications of EPLs Ga and Da	1	X		
Addition of requirements for the Division method of area classification that may be applied by some users	1			C1
Relocation of heat loss design requirements to IEC/IEEE 60079-30-1	6.3	X		
Addition of safety shower and eyewash station design requirements	6.16			C2
Addition of Annex for an example of a design data record	Annex A	X		
Addition of Annex for a checklist of installation requirements	Annex B	X		
Addition of Annex for an example of a trace heater commissioning record	Annex C	X		
Addition of Annex for an example of a maintenance schedule and log record	Annex D	X		
Addition of Annex for pipe heat loss considerations	Annex E	X		

		Type		
Addition of Annex for vessel heat loss considerations	Annex F	X		
Addition of Annex for heat up and cool down considerations	Annex G	X		
Addition of Annex for a method to determine the equivalent thickness of insulating cements	Annex H	X		

NOTE: The technical changes referred to include the significance of technical changes in the revised IEC Standard, but they do not form an exhaustive list of all modifications from the previous version.

252 Explanations: A) Definitions

253 **Minor and editorial changes** clarification
 254 decrease of technical requirements
 255 minor technical change
 256 editorial corrections

257 These are changes which modify requirements in an editorial or a minor technical way. They
 258 include changes of the wording to clarify technical requirements without any technical change,
 259 or a reduction in level of existing requirement.

260 **Extension** addition of technical options

261 These are changes which add new or modify existing technical requirements, in a way that
 262 new options are given, but without increasing requirements for equipment that was fully
 263 compliant with the previous standard. Therefore, these will not have to be considered for
 264 products in conformity with the preceding edition.

265 **Major technical changes** addition of technical requirements
 266 increase of technical requirements

267 These are changes to technical requirements (addition, increase of the level or removal)
 268 made in a way that a product in conformity with the preceding edition will not always be able
 269 to fulfil the requirements given in the later edition. These changes have to be considered for
 270 products in conformity with the preceding edition. For these changes additional information is
 271 provided in clause B) below.

272 **NOTE:** These changes represent current technological knowledge. However, these changes
 273 should not normally have an influence on equipment already placed on the market.

274 B) Information about the background of 'Major Technical Changes'

275 C1 – The requirements for the Division method of area classification are applicable only for
 276 users of this standard intending qualification for these areas.

277 C2 – The design requirements for safety showers and eyewash units have been included for
 278 harmonization and for added safety.

279 The text of this standard is based on the following IEC documents:

FDIS	Report on voting
31/XXX/FDIS	31/XXX/RVD

280
 281 Full information on the voting for the approval of this standard can be found in the report on
 282 voting indicated in the above table.

283 International standards are drafted in accordance with the ISO/IEC Directives, Part 2

284 The IEC Technical Committee and IEEE Technical Committee have decided that the contents
285 of this publication will remain unchanged until the stability date indicated on the IEC web site
286 under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the
287 publication will be

- 288 • reconfirmed,
- 289 • withdrawn,
- 290 • replaced by a revised edition, or
- 291 • amended.

292

293 The National Committees are requested to note that for this publication the stability date
294 is 2020

295 THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE
296 DELETED AT THE PUBLICATION STAGE.

297

298

EXPLOSIVE ATMOSPHERES –

Part 30-2: Electrical resistance trace heating – Application guide for design, installation and maintenance

1 Scope

This part of IEC 60079 provides guidance for the application of electrical resistance trace heating systems in areas where explosive atmospheres may be present, with the exclusion of those classified as requiring EPL Ga/Da (traditional relationship to Zone 0 and Zone 20 respectively). This standard also provides guidance for explosive atmospheres incorporating the Division method of area classification that may be applied by some users of this standard.

NOTE Information on the Division method is given in NFPA 70® and CSA C22.1.

It provides recommendations for the design, installation, maintenance and repair of trace heating systems including associated control and monitoring equipment. It does not cover devices that operate by induction heating, skin effect heating or direct pipeline heating, nor those intended for stress relieving.

This part supplements the requirements specified in IEC/IEEE 60079-30-1.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment - General requirements*

IEC 60079-14, *Explosive atmospheres – Part 14: Electrical installations design, selection, and erection*

IEC 60079-17, *Explosive atmospheres – Part 17: Electrical installations inspection and maintenance*

IEC 60364-1, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC/IEEE 60079-30-1, *Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60079-0 and IEC/IEEE 60079-30-1 apply.

NOTE Some definitions provided in IEC 60079-7 are identical to definitions in this standard. Additional definitions applicable to explosive atmospheres are in IEC 60050-426.

4 Application considerations

4.1 General

This standard supplements the requirements of IEC 60079-14 and IEC 60079-17.

Where trace heating systems are to be installed in explosive atmospheres, full details of the area classifications shall be specified. The specification shall state, as applicable, the required equipment protection levels Gb, Gc, Db, and Dc (traditional relationship to Zone 1, Zone 2, Zone 21, and Zone 22 respectively), and/or the Division 1 and Division 2 explosive atmospheres, the gas or dust groups, and temperature classification. Where special considerations apply or where site conditions may be especially onerous, these conditions shall be detailed in the trace heating specification.

Where trace heating systems are to be installed on mobile equipment or skid units (e.g. relocatable structures), the specification for these trace heating systems should accommodate the worst conditions in which the trace heating system may be used.

Where any parts of the trace heating system are likely to be exposed, those parts should be suitable for the environment.

4.2 Corrosive areas

All components of electric trace heating systems should be examined to verify that they are compatible with any corrosive materials that may be encountered during the lifetime of the system. Trace heating systems operating in corrosive environments have a higher potential for failure than in non-corrosive environments. Deterioration of the thermal insulation system is made worse by corrosion of the weather barrier and the possibility of moisture leaks soaking the thermal insulation.

4.3 Process temperature accuracy

4.3.1 Type I

A Type I process is one for which the temperature should be maintained above a minimum point. Ambient sensing control may be acceptable. Large blocks of power may be controlled by means of a single control device and an electrical distribution panel board. Heat input may be provided unnecessarily at times and wide temperature excursions should be tolerable. Energy efficiency may be improved through the use of dead-leg control techniques (see 6.14).

4.3.2 Type II

A Type II process is one for which the temperature should be maintained within a moderate band. Control by mechanical thermostats is typical.

4.3.3 Type III

A Type III process is one for which the temperature should be controlled within a narrow band. Electronic controllers using thermocouple or resistance-temperature detector (RTD) process temperature sensors facilitate field (work site) calibration and provide maximum flexibility in the selection of temperature alarm and monitoring functions. Heat input capability may be provided to preheat an empty pipe or raise the fluid temperature, or both, within a specified range and time interval. Type III systems require strict adherence to flow patterns and thermal insulation systems.

4.4 Installation considerations

If failure of any part of the trace heating system can result in a safety or process problem, then the trace heating system may be considered to be a critical component of the total

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process. The temperature control and circuit monitoring requirements of an application may be defined according to the temperature control types described in 4.3.

When trace heating is critical to the process, circuit monitoring for correct operation, malfunction alarms, and back-up trace heaters should be considered. Spare or back-up controllers can be specified to be automatically activated in the event of a fault being indicated by the monitoring/alarm system. Back-up trace heaters may allow maintenance or repairs to be performed without a process shutdown and may be used to enhance reliability.

5 Thermal insulation

5.1 General

The selection, installation and maintenance of thermal insulation is a key component in the performance of an electrical trace heating system. The thermal insulation system is normally designed to prevent the majority of heat loss with the trace heating system compensating for the remainder. Therefore, problems with thermal insulation have a direct impact on the overall system performance.

The primary function of thermal insulation is to reduce the rate of heat transfer from a surface that is operating at a temperature other than ambient. This reduction of energy loss may

- reduce operating expenses;
- improve system performance;
- increase system output capability.

Prior to any heat loss analysis for an electrically traced pipeline, vessel or other mechanical equipment, a review of the selection of the insulation system is recommended. The principal areas for consideration are as follows:

- selection of an insulation material;
- selection of a weather barrier (cladding);
- selection of the economic insulation thickness with consideration for optimum trace heater design;
- selection of the proper insulation size.

Information about the equivalent thickness of insulating cements is given in Annex H.

5.2 Selection of insulating material

The following are important aspects to be considered when selecting an insulation material. These factors should be considered and the selection optimised according to the operator's criteria:

- temperature rating;
- thermal conductivity, λ , of the insulation;
- mechanical properties;
- chemical compatibility and corrosion resistance;
- moisture resistance;
- health risks during installation;
- fire resistance;
- toxicological properties when exposed to fire;
- costs.

Insulation materials commonly available include:

- expanded silica;
- mineral fibre;
- cellular glass;

- 426 – urethane;
- 427 – fibreglass;
- 428 – calcium silicate;
- 429 – polyisocyanurate;
- 430 – perlite silicate.

431 For soft insulants (mineral fibre, fibreglass, etc.), actual pipe size insulation may be used in
432 many cases by banding the insulation tightly. Care should be taken to prevent the trace
433 heater from being buried within the insulation, which may cause damage to the trace heater or
434 may restrict proper heat transfer. As an alternative, the next largest pipe size insulation that
435 can easily enclose pipe and electric trace heater is also acceptable. Rigid insulation (calcium
436 silicate, expanded silica, cellular glass, etc.), may be pipe-size insulation if board sections are
437 cut to fit the longitudinal joint. This type of installation technique is commonly referred to as
438 an extended leg installation. Alternatively, the next largest insulation size may be selected to
439 accommodate the trace heater. In all cases, the insulation size and thickness should be
440 clearly specified.

441 5.3 Selection of weather barrier (cladding)

442 Proper operation of an electrically trace heated system depends upon the insulation being
443 dry. Electric tracing normally has insufficient heat output to dry wet thermal insulation. Some
444 insulation materials, even though removed from the piping and force dried, never regain their
445 initial characteristics after once being wet.

446 Straight piping may be weather-protected with metal jacketing, polymeric, or a mastic system.
447 When metal jacketing is used, it should be smooth with formed, modified “S” longitudinal
448 joints. The circumferential end joints should be sealed with closure bands and supplied with
449 sealant on the outer edge or where they overlap (see Figure 1).

450 Jacketing that is overlapped or otherwise closed without sealant is not effective as a barrier to
451 moisture. A single, unsealed joint can allow a considerable amount of water to leak into the
452 insulation during a rainstorm, therefore specifications for elastomeric water sealing of
453 cladding should be suitable for long term exposure to the environmental conditions.

454 The type of weather barrier used should, as a minimum, be based on a consideration of the
455 following:

- 456 – effectiveness in excluding moisture;
- 457 – corrosive nature of chemicals in the area;
- 458 – fire protection requirements;
- 459 – durability to mechanical abuse;
- 460 – cost.

461 5.4 Selection of economical thickness to provide optimum trace heating design

462 At a minimum, an economic consideration of the insulation weighs the initial costs of the
463 materials and installation against the energy saved over the life of the insulation. It should be
464 noted that the actual insulation thicknesses do not always correspond exactly to the nominal
465 insulation thickness. When choosing the insulation size, considerations should be made as to
466 whether or not the actual pipe-size insulation is suitable for accommodating both pipe and
467 trace heater.

468 The insulation thickness selected for economic consideration of non-traced portions of a
469 system does not necessarily provide for an optimum or acceptable trace heating system
470 design and installation. Consideration of the electric trace heating design should be made in
471 conjunction with the selection of insulation. Selection of an optimum insulation thickness for
472 electric traced lines can do the following:

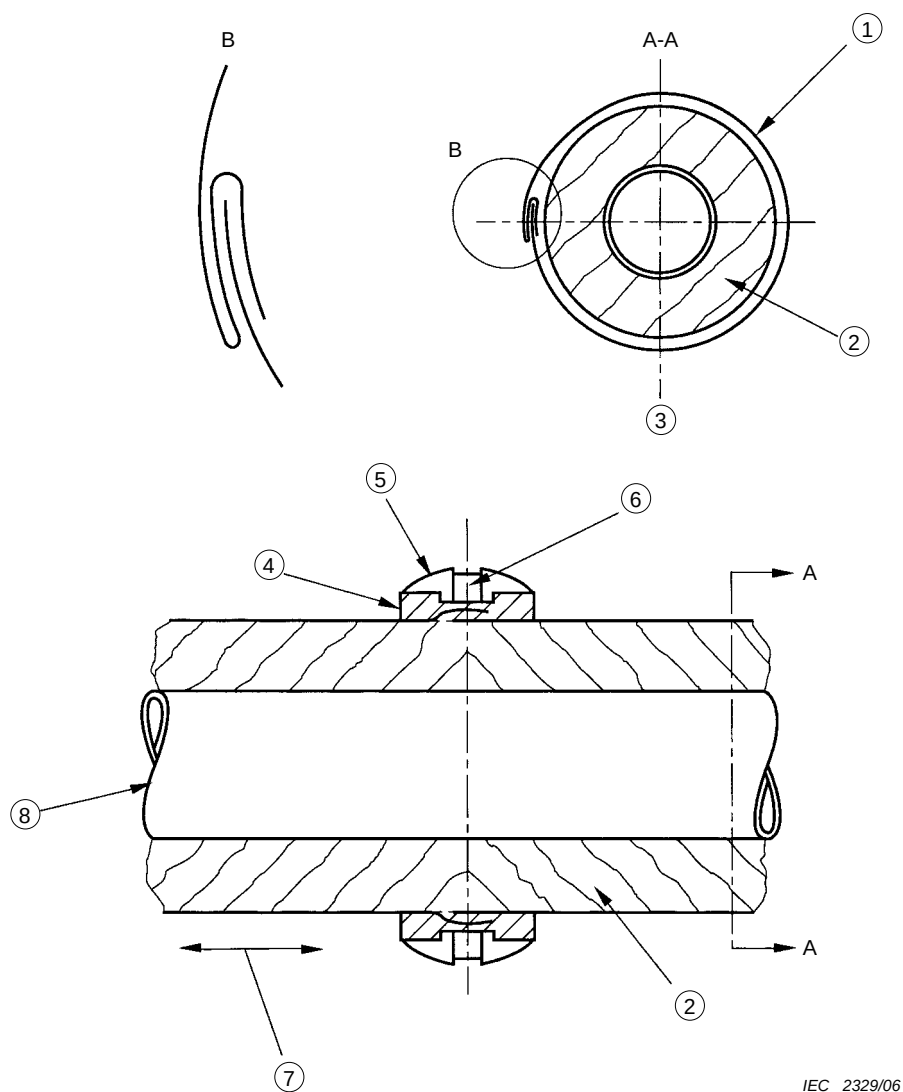
- 473 – Reduce the power output level necessary for each trace heater
- 474 – Increase the length of trace heater circuits

- 475 – Decrease the number of circuits required
- 476 – Decrease the total power required for electric trace heater systems

477 **5.5 Double insulation**

478 The double insulation technique may be employed when the pipe temperature exceeds the
479 maximum allowable temperature of the trace heater. Prevention of the freezing of condensate
480 in high-temperature steam lines when these lines are not in use is a typical application. It
481 consists of locating the trace heater between two layers of insulation surrounding the pipe.
482 The essence of the double-insulation technique is to determine the correct combination of
483 inner and outer insulation type and thickness that results in an acceptable interface
484 temperature for the trace heater. This relationship is illustrated in Figure 2. Note that
485 maximum ambient temperature conditions should be considered in this determination.
486 Consideration should be given to joint installation and alignment of the inner insulation to
487 account for thermal expansion of the piping.

488

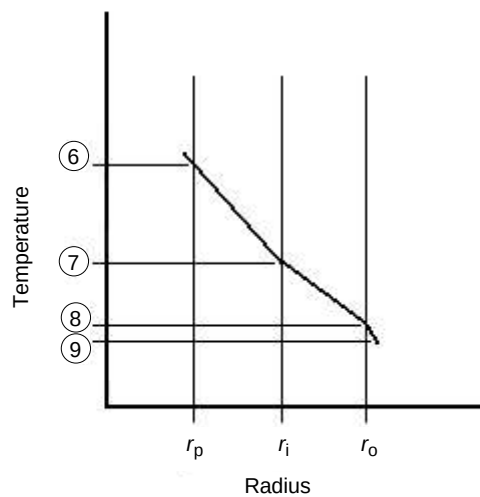
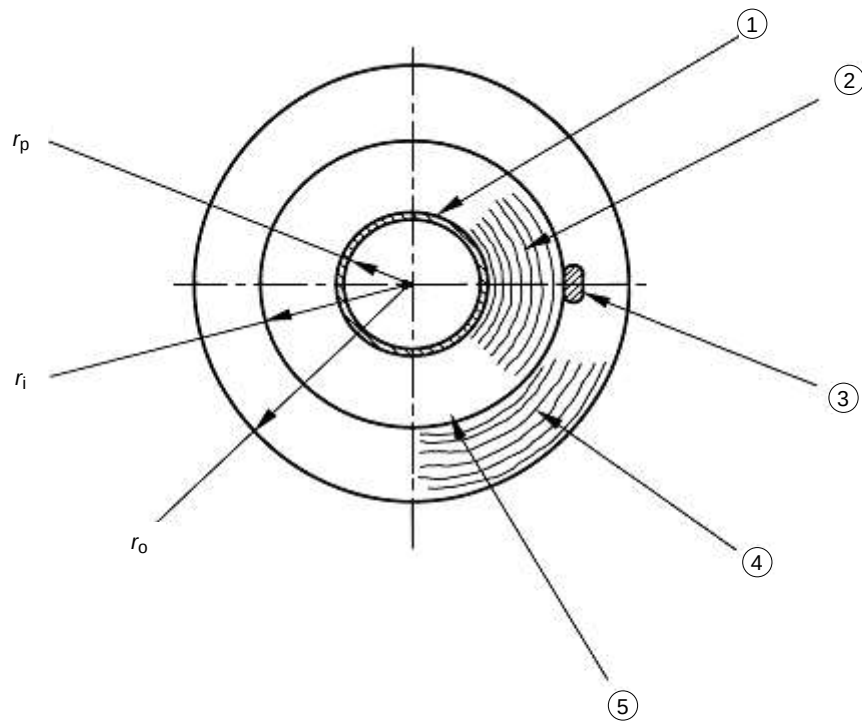


IEC 2329/06

Key

- | | |
|-------------------------------|-------------------|
| 1 metal jacket | 5 closure band |
| 2 insulation | 6 insulated strap |
| 3 metal jacket insulated pipe | 7 movement |
| 4 mastic sealer | 8 pipe |

Figure 1 – Thermal insulation – Weather-barrier installation



IEC 2330/06

495

496 **Key**

- | | |
|--------------------------|--|
| 1 pipe | 6 maximum temperature pipe |
| 2 inner insulation layer | 7 interface temperature |
| 3 trace heater | 8 outer insulation surface temperature |
| 4 outer insulation layer | 9 ambient temperature |
| 5 metal foil (aluminium) | |

497

498

Figure 2 – Typical temperature profile

499

6 System design

6.1 Introduction

Each trace heating application imposes unique demands on the designer to achieve the desired temperature and maintain it within the specified conditions. Trace heating systems necessarily interface with other specified items of equipment such as thermal insulation and the electrical supply available to power the system. The final system is an integration of all these component parts so the values of these interface items have to be known and controlled in order to design systems that perform as required.

The design of any trace heating system should conform to all IEC/IEEE requirements for the use of electrical equipment and with the requirements of this standard. Consideration should be given as to the maintenance of the systems and process equipment, to energy efficiency, and to testing the installed systems for operational satisfaction and safety.

Considerations that affect the efficiency of trace heating design are insulation thickness and supply voltage. Insulation type selection is generally made based on temperature and environmental conditions. The insulation thickness selected for traced lines should be made in conjunction with the trace heater selection, to provide an optimum trace heating design. See 5.4 for additional discussion of this topic. Selection of the supply voltage to be applied to trace heating circuits can greatly influence the overall power supply and economics of the system.

When designing trace heating systems for use in explosive atmospheres, additional constraints are imposed due to the requirements and classification of the area under consideration.

The details of each circuit design should be recorded on a form such as the example indicated in Table A.1 and retained.

Information about design for heat loss calculations and examples is provided in Annex E for pipes and in Annex F for vessels.

6.2 Purpose of, and major requirement for, trace heating

Trace heaters should be selected and installed so as to provide sufficient power for:

- a) compensation of heat loss when maintaining a specified temperature of a workpiece at the specified minimum ambient temperature; see calculation method in IEC/IEEE 60079-30-1; or
- b) raising the temperature of a workpiece, and its contents when specified, within a specified time period; see calculation method in 6.6; or
- c) a combination of a) and b).

The trace heater selection shall consider the determination of the maximum possible system temperature under worst case conditions as specified in IEC/IEEE 60079-30-1. The methods employed include the product classification method, stabilized design, and controlled design.

The temperature may be reduced, for example, through adjustments to the system parameters, by the use of multiple tracers to reduce the power produced per unit length, or by the selection of the temperature control system. The excess of installed power over the power as required, and the way in which trace heaters are applied, installed and operated shall not be the cause, not even after evaluation of worst-case conditions, of any unacceptable risk in explosive atmospheres.

The manufacturer of the trace heating is required to establish the design calculations and methods. The end user is constrained to the design calculations and methods specified by the manufacturer.

6.3 Training

Persons involved in the design of electric trace heating systems should be suitably trained in all techniques required.

6.4 Selection of trace heater

For a particular application, there are some basic design characteristics that should be reviewed to determine the choice of trace heater(s). These are as follows.

- a) The maximum withstand temperature of the trace heaters shall be greater than the maximum possible workpiece temperature (which may be greater than the normal maintain temperature).
- b) Trace heaters should be suitable for operation in the environmental conditions specified, for example, a corrosive atmosphere or a minimum ambient temperature.
- c) Trace heaters shall be certified for use in the particular explosive atmosphere.

For any application, there is a maximum allowable power density at which a trace heater can be used without damaging either the workpiece or its contents. This is particularly critical in certain cases, such as with lined pipes, vessels containing caustic soda or with heat sensitive materials. The maximum allowable power density shall be recorded in the system documentation. Multiple tracing or spiralling of a single trace heater may be required.

6.4.1 Site-fabricated trace heaters

Site-fabricated trace heaters are permissible provided:

- installation personnel are trained in the special techniques required;
- trace heaters are certified for site-fabrication
- the installation instructions supplied by the manufacturer cover site-fabrication
- trace heater(s) pass the field (site work) tests specified in 8.5.5;
- trace heater(s) is/are marked in accordance with IEC/IEEE 60079-30-1.

Trace heater(s) not excluded by the above considerations are technically suitable for the application, but it is still necessary to determine the maximum allowable power density of each. This is a function of the construction, the maximum withstand temperature, the maximum operating temperature and maximum permissible temperature of the workpiece and thermal insulation.

For each particular trace heater, the maximum allowable power density shall be determined from the manufacturer's data that is based on tests specified in IEC/IEEE 60079-30-1. The value used shall be chosen so that the maximum withstand temperature is not exceeded. The limiting value of maximum allowable power density for each trace heater is either the value chosen from the manufacturer's data or that specified for the process, whichever is the lower. However, the power density may be further limited by the need for multiple tracing.

The designer may then select the type, length or size and loading of the trace heater. The actual installed load should be not less than the design loading and the actual power density not greater than that obtained above. The type of trace heater and the values of installed load and power density should be recorded in the system documentation.

6.4.2 Specific types of trace heating

The series and parallel types of trace heating are generally defined by their electrical characteristics.

Series trace heaters typically use the electrical conductor as the heating element, so the voltage supply and circuit length become critical parameters in the design of each circuit. Series trace heaters with polymeric insulation are particularly suited for installations with long circuit lengths. Series trace heaters with mineral insulation (MI) and metallic sheaths are particularly suited for very high process temperature maintenance. Parallel trace heaters typically consist of two parallel conductors with a separate polymeric or metallic heating element that draws voltage from the conductors. These are characteristically used for freeze protection, and for process temperature maintenance of complex piping installations. The constant wattage type typically has a spirally wound metallic heating element.

The PTC type typically consists of a polymeric heating element extruded between the conductors. The power-limiting type typically falls between the previous types, with higher output at higher operating temperatures than the PTC type, and with lower operating temperatures than the constant wattage type.

6.5 Maximum temperature determination

It is important that the maximum sheath temperatures of trace heaters are determined accurately for all applications in explosive atmospheres. It is imperative that the circuit designer follows all guidelines, specifications, and design methodology provided by the manufacturer in accordance with IEC/IEEE 60079-30-1. Some examples are:

- a) applications such as non-metallic piping where the maximum temperature of the trace heater may approach the maximum withstand temperature of the workpiece, the thermal insulation, or other components of the system;
- b) applications that have no control or ambient sensing control, and that have potentially high tracer sheath temperatures at equilibrium;
- c) critical applications where a high degree of process temperature accuracy is required;
- d) applications in explosive atmospheres where it is assumed that the controlling thermostat is not functioning, such that the tracer sheath temperature cannot exceed the ignition temperature or T-rating of the gas, vapour, or combustible dust expected in that location.

It is important that the circuit designer understands that there are three possible measures for protecting the tracing system from exceeding the high-limit temperature – the PTC characteristic of the trace heater, the use of a limiter or control device, and by stabilized design calculations. The methods and limitations for the evaluation of maximum temperature are provided in IEC/IEEE 60079-30-1.

When multiple trace heaters (especially on installations with multiple flow conditions) are grouped together under a single temperature control device, each design condition shall be analysed as a stabilized design.

6.5.1 PTC characteristic

Trace heaters that significantly reduce power with an increase in temperature can be assigned temperature classes by testing (as given in IEC/IEEE 60079-30-1). In many applications further temperature limiting control measures are not necessary, provided that the temperature class of the trace heater is lower in temperature than that specified for the application. Nevertheless the limiter and stabilized design measures can be applied to operate the system in a narrower band of process temperatures.

6.5.2 Stabilized design

Stabilized design is based on the principle of determining the maximum workpiece and trace heater sheath temperatures under a worst-case set of conditions. This is a calculation of the equilibrium conditions that occur when the heat input equals the system heat loss. The worst-case set of conditions include:

- a) maximum ambient temperature, typically assumed to be 40 °C unless otherwise specified;
- b) no wind (still air);
- c) use of a conservative or minimum value for the thermal conductivity of the thermal insulation;
- d) no temperature control as per the design or to simulate a failed temperature controller;
- e) the trace heater is operated at its stated operating voltage plus 10 %;
- f) the trace heater is assumed to be operating at the upper limit of the manufacturing tolerance, or at the minimum specific resistance for series trace heaters.

Specific requirements for stabilized designs are found in IEC/IEEE 60079-30-1. Testing for stabilized design is also defined in IEC/IEEE 60079-30-1. Typically the maximum sheath temperature of the trace heater is calculated from formulae derived from the evaluation of empirical data and by the theoretical approach described in the Annex of IEC/IEEE 60079-30-1 for the trace heater product design verification methodology. Alternatively, design programs that calculate the maximum sheath temperature on the basis of these worst-case parameters may be used.